MULTIMODAL, ASYNCHRONOUSLY SHARED SLIDE SHOWS AS A DESIGN STRATEGY FOR ENGINEERING DISTRIBUTED WORK IN THE NATIONAL AIRSPACE SYSTEM

DISSERTATION

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By

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ABSTRACT

This research focused on the design and evaluation of a multimodal asynchronous communications tool that uses an annotated slide show structure for messages, to support collaborative analysis of post-operations in the National Airspace System (NAS). Voice-based asynchronous annotations communicated between writers working collaboratively have been found to support more extensive discussion of problems in draft documents and to be preferred over text based discussion for some types of feedback. People point naturally when discussing the content of a shared image, and voice synchronized with pointing in asynchronous annotation systems has been found to be more efficient in scheduling tasks, than voice-only, or text only communication. Synchronized voice and pointing has also been shown to focus attention and improve retention of information in multimedia presentation systems. This research involved investigating how different communication modes interact with problem solving and the discussion of distributed information, with a view to improving collaborative post operations analysis within and between the Federal Aviation Administration (FAA) and the major airlines in the United States. More specifically how synchronized voice and pointing annotation over asynchronously shared slide shows composed of post operations graphical and tabular data differs in its effect compared to text based annotation, as collections of flights ranked low by standard performance metrics are discussed by FAA and airline representatives.

A part-task simulation study had 36 AOC dispatchers, chief dispatchers or ATC coordinators from Northwest Airlines communicate with 36 ARTCC (Air Route Traffic Control Center) traffic managers at eight different Centers about performance issues for flights between 9 different city pairs. Each Northwest Airlines participant communicated with one FAA participant, in a one-to-one pairing. A separate slide show consisting of screen captures showing post operations data was created for each city pair. For each slide show, two Northwest Airlines participants were asked to annotate the slides using text, pen marks or arrows, and two were asked to annotate the slides using synchronized voice and pointing, pen marks and arrows. For each slide show, four traffic managers were asked to respond to the annotated message using the same annotation tools the sender used.

The results from this research show that:

1. The communications mode failed to show an effect on the number and type of ideas generated for improving performance.
2. The most common strategy proposed was a change of route.
3. Almost all the dispatchers' ideas were responded to by traffic managers in both modes: 27 out of 27 for text mode participants and 27 out of 29 for voice and pointing mode participants.
4. The dispatchers' combined problem solving and message creation time was shorter (ANOVA, $\alpha < 0.05$) when working in the voice and pointing mode than the text based mode, as was the dispatcher-traffic manager pairs' total combined problem solving and message creation time (ANOVA, $\alpha < 0.01$). The average task time was 18 minutes 1 second for the voice and pointing mode dispatchers and 28 minutes for the text mode dispatchers (a difference of 9 minutes 59 seconds or 55%). The average dispatcher-traffic manager pair task time was 35

minutes and 41 seconds for the voice and pointing mode and 53 minutes and 22 seconds for the text mode. This is a difference of 17 minutes 41 seconds or 50%.

5. In both communication modes the dispatchers normally did not comment on the time of day, time of year, or the number of flights involved on the first slide they made a comment, even though that information was always in the image. The city pair involved was also only mentioned by 5 out of 18 dispatchers working in the text mode and 11 out of 18 dispatchers working in the voice and pointing mode. There was a difference between the two modes in this regard with more dispatchers mentioning each of these categories in the voice and pointing mode (although only the difference between the number mentioning the city pair and time of year were statistically significant at $\alpha < 0.05$). This is significant because this information contributes towards diagnosing the cause of the flights per performance, and some participants indicated that by stating it was difficult to solve the problem without some of this information.

6. 18/18 (100%) of the dispatchers in the voice and pointing mode made deictic gestures during the creation of their messages. 17/18 (94%) of the traffic managers responding in this mode also made deictic gestures.

7. 15/18 (83%) of the dispatchers and 9/18 (50%) of the traffic managers working in the voice and pointing mode still created static annotations to the objects or locations they referenced with deictic gestures.

8. 9/15 (60%) of the dispatchers and 9/9 (100%) of the traffic managers working in the voice and pointing mode created static annotations while speaking, as opposed to before or after speaking.

9. Dispatchers and traffic managers considered the system they used to be usable and valuable, but dispatchers using the text mode rated the usability and utility

of the system higher on average than dispatchers using the voice and pointing mode, whereas for traffic managers the reverse was true.

10. The slide image provided a context for comments, but the slide show structure used created a loss of temporal context and comments regarding multiple slides and slides other than the one the comment was placed on meant a slide could not be treated as a disjoint entity. These problems were addressed with a redesign idea to support these contexts.

11. The comments and annotations made provide a vocabulary of syntax and semantics for a more task specific version of the system. Such a system would be tailored for practitioners to work with in this domain, but should be implemented through configuration options to maintain the integrity of the system as a domain free system.

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PUBLICATIONS

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FIELD OF STUDY

Major Field: Industrial & Systems Engineering

Concentration: Cognitive Systems Engineering

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CHAPTER 1

INTRODUCTION

In recent years there have been a number of efforts under the Collaborative Decision Making (CDM) program (Metron, 2001) that have demonstrated the benefits of disseminating both knowledge and goals between organizations in the National Airspace System (NAS[1]), and of collaboratively building decision support tools to assist in the interpretation of the large interrelated dataset produced. This research involved the development and evaluation of the Collaborative SLide ANnotation Tool (C-SLANT), an asynchronous communications tool that was developed to support discussion of data from the CDM product called the Post Operations Evaluation Tool (POET). It is suggested here that slide show based, multi-modal, messaging systems are valuable in this distributed work domain for asynchronous problem solving during post operations analysis, and in other situations where static images contain valuable information and there are knowledge/belief gaps between collaborators, and potential ambiguities in referencing the images.

As discussed in more detail in chapter 2, Ellis, Gibbs and Rein (1991) state that there are at least five key perspectives on groupware: distributed systems, communications, human-

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[1] The FAA defines the NAS as "The common network of U.S. airspace; air navigation facilities, equipment and services, airports or landing areas" (http://www.fly.gov/Glossary_of_Terms/acronyms.html)

computer interaction, artificial intelligence, and social theory. The research presented here focuses on the first three perspectives.

Document Overview

Chapter 2 of this document provides a brief description of distributed work and Computer Supported Cooperative Work (CSCW) research, to help put the research presented here in context.

Chapter 3 describes previous research on multimodal asynchronous communication and annotation systems.

Chapter 4 describes the NAS, in general; distributed work and communications between those on the ground controlling aircraft, and managing airline operations; and the Post Operations Evaluation Tool.

Chapter 5 describes the design rationale for C-SLANT.

Chapter 6 describes the experimental procedures that were used to study the effect of using this multimodal communications tool for collaborative problem solving involving airline dispatchers and FAA traffic managers.

Chapter 7 analyses the results of the data collected and presents the redesign of some C-SLANT features.

Chapter 8 summarizes the significance of this research and implications for designing multimodal asynchronous communications in general.

CHAPTER 2

COMPUTER SUPPORTED COOPERATIVE AND DISTRIBUTED WORK

Introduction

The phrase "computer-supported cooperative work" was coined by Irene Greif and Paul Cashman in 1984 in the call for an invitation-only workshop on CSCW held in Cambridge, Massachusetts (Bannon and Schmidt, 1991). Bannon and Schmidt report that, in a panel discussion at the Conference on Computer-Supported Cooperative Work in 1988, Irene Grief commented that they coined the phrase partly as a shorthand way of referring to a set of concerns about supporting multiple individuals working together with computer systems. Seeking a more precise description, Baecker (1993) defines Computer-Supported Cooperative Work (CSCW) and groupware as follows:

> *Computer-supported cooperative work* (Greif, 1988; Galegher, Kraut, and Egido, 1990; Greenberg, 1991) is computer-assisted coordinated activity such as problem solving and communication carried out by a group of collaborating individuals. The multi-user software supporting CSCW systems is known as *groupware*, although the latter term is sometimes broadened to incorporate the styles and practices in group process and dynamics that are essential for any collaborative activity to succeed, whether or not it is supported by computer. CSCW may also be viewed as the emerging scientific discipline that guides the thoughtful and appropriate design and development of groupware (Greenberg, 1991).

The Time Space Matrix

	Same Time	Different Times
Same Place	face-to-face interaction	asynchronous interaction
Different Places	synchronous distributed interaction	asynchronous distributed interaction

Table 2.1 Groupware time space matrix (Ellis, Gibbs, and Rein, 1991)

Most taxonomy of CSCW technologies distinguishes them in terms of their abilities to bridge time and to bridge space (Baecker, 1993). Table 2.1, is a typical time space matrix, for which Ellis, Gibbs and Rein (1991) provide the following examples:

Same Place, Same Time:	Meeting room
Same Place, Different Times:	Physical bulletin board
Different Places, Same Time:	Real-time document editor
Different Places, Different Times:	Electronic mail

Daly-Jones et al., (1997) attempt to summarize the costs and benefits of synchronous and asynchronous systems, as shown in Table 2.2.

		Synchronous (e.g., telephone)	Asynchronous (e.g., voicemail)
Costs	To Initiator (owner of task)	Frequent failed connections waste time.	Slower pace of interaction makes composition harder work. Slower response may delay task closure. Have to re-instate context on receipt of reply
	To Recipient	Interrupts current task, have to re-instate context after interruption	Slower pace of interaction makes generating common ground harder work.
Benefits	To Initiator (owner of task)	If connection successful: Composition easier; Faster task closure; Context available on reply.	Failed connections not generally a problem
	To Recipient	Fast pace of interaction facilitates generation of common ground.	Fewer interruptions as when to deal with message is under recipient's control. More time to think about response.

Table 2.2 Costs and benefits of synchronous and asynchronous communications (Daly-Jones et al., 1997)

In reality there are few purely synchronous and purely asynchronous systems. Similarly, while Ellis et al., indicate, "Groupware that specifically supports simultaneous activity is called real-time groupware; otherwise, it is non-real-time groupware", the definition would be more accurate if the wording was "attempts to support...". Some attempts at synchronous implementations have actually foundered because the synchronization desired was not achieved. Cognoter (Tartar, Foster and Bobrow, 1991), for instance, is an example because of delays in updating information shared between multiple workstations and synchronizing speech with that information. This system is discussed in more detail later in this chapter.

Systems are classified by typical use, because systems designed for asynchronous communications can actually be used relatively synchronously and vice-versa. For instance, two individuals may actually exchange a number of short E-mail messages with very small intervals of time between them, each person waiting for a response from the other between messages. Chat programs, normally classified as a synchronous communications systems, may similarly be adapted to more asynchronous use, if the system does not require the sender and recipient of messages to actually be online at the same time (e.g. Yahoo Messenger). In general, the synchronization required depends on characteristics such as the balance of information sharing, the urgency of the communication and feedback, how much time is needed to gather information for the next communication, and how acceptable it is to interrupt other tasks being performed by potential communications. There are also significant differences between both asynchronous and synchronous systems due to other factors that are part of the system, such as the nature of the information being communicated itself, and the knowledge, tasks, and goals of the communicating agents themselves.

Table 2.2 is perhaps more usefully viewed as no more than a set of characteristics often found with the synchronous and asynchronous aspects of a communications system. This way, all the costs can be considered as potential negatives and all the benefits as potential positives in a system being developed. Thus, for instance, the pace of interaction, support for establishing and re-instating context, the effort involved in establishing a common ground, and the impact on other work requirements are all issues regardless whether or not the system is labeled as synchronous or asynchronous.

Task and Environment Dimensions

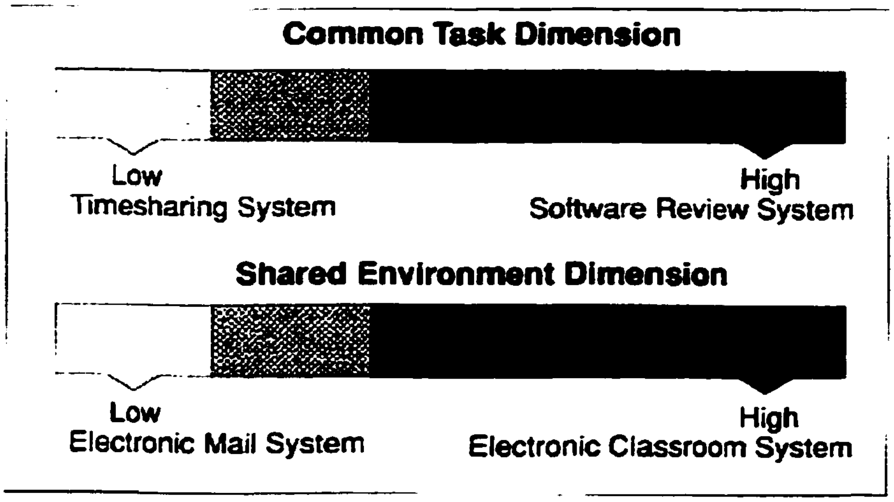


Figure 2.1 Two dimensions of the groupware spectrum (Ellis, Gibbs, and Rein, 1991)

Ellis, Gibbs and Rein (1991) define groupware as:

> "Computer-based systems that support groups of people engaged in a common task (or goal) and that provide an interface to a shared environment." (pg. 10).

Figure 2.1 shows that they consider systems to vary in the extent to which they can be considered to be groupware, and this can be determined by how much the system supports working towards a common goal and working in a shared environment. Thus, with scales like this it is possible to indicate to what extent an application can be considered groupware, but more important is whether the application supports the intended use. For instance, a shared environment is more important if that environment is relevant to the work. If the agents involved actually need to work with distinct data and only need to communicate the results of processing that data, all agents don't need to see all the data. Similarly, they may very appropriately have distinct tasks, so the right selection of groupware features is more important than the number of them.

An Application-Level Technology

Ellis et al present a second taxonomy based on common application functionality that demonstrates the breadth of the groupware domain:

- Message Systems

  The computer-based message system is the most common type of groupware, which in its simplest form just supports the asynchronous exchange of textual messages between groups of users. E-Mail (Electronic Mail) and Newsgroups or Bulletin Board Systems are particularly common. E-Mail systems will be discussed in more detail in Chapter 4.

- Multiuser Editors

  Multiuser editors to support the joint composition and editing of a document can be useful to divide work and share ideas, but it means there must be some coordination of that work. If the work is simple enough it can be divided into disjoint subunits and worked on independently by different authors. Normally, however, it is not that simple and their has to be a system for passing control of a document, or portions of it, from one author to another while keeping track of who has done what and what the constraints are on each author for each session. Software may help in the process by "locking" resources and providing read or write access, conceptually the same as is done with database systems when they are shared between multiple users. Tracking information may also be maintained within the document itself, as is done with Microsoft Word. That system is discussed further in chapter 4.

- Group Decision Support Systems and Electronic Meeting Rooms

  DeSanctis and Gallupe (1985) define a Group Decision Support System (GDSS) as "an interactive computer-based system that facilitates the solution of unstructured problems by a set of decision makers working together as a group". Kraemer and King (1988) state that the key concept behind the GDSS is to increase the speed at which decisions are reached when decision makers attended meetings without reducing, and, it is hoped, enhancing, the quality of resulting decisions. Huber (1984) suggests the "losses" of productivity in group decision making occur because discussions are dominated by certain individuals, low-status members defer to high status members, group pressures lead to conformity of thought, miscommunication among members is common, and insufficient time is spent in problem exploration and generation of alternatives. Huber further suggests that GDSSs can help alleviate these problems by providing a personal computer for each participant, a public display screen for all, computing and communication capabilities that allow for accessing databases and communicating with the group leader and the public display, and software for word processing, data access and management, graphics, and "controls" to permit communications with others or the group. Ellis et al., indicate there are GDSS aids for decision structuring, such as alternative ranking and voting tools, and for idea generation or issue analysis. In their survey of GDSSs, Kraemer and King identify benefits of and barriers to successful GDSSs. They describe "affective" benefits from enlivened meetings involving organized interactions for everyone with the system and a sense of group cohesion during the group learning processes (as the system is taught) and assigned tasks. The technology is perceived as neutral and the meetings are normally very structured and professional. There is an agenda focusing on the issues and decisions and consensus are normally achieved relatively quickly. They also point out the benefits of basic information visualization tools, shared access to information retrieval systems, and modeling and simulation tools. The voting and confidence measurement tools reveal where there is consensus or not and help to measure it. However, Kraemer and King also point out that the successes are not always a function of the technology but the processes themselves, that faster decisions with more consensus are not necessary better decisions, that the process tends to use the prescriptive decision making model, and that many commercial systems have been abandoned. In general, they are positive about the value of GDSSs for helping with parts of the group decision making process, but are less positive about the potential of complete package systems to be used for a variety of group decision making tasks.

- Computer Conferencing

  Ellis et al., describe three ways that computers are used in conferencing:

  - Real-Time Computer Conferencing

    Here the purpose is to share computer applications synchronously. It can be done by adapting the use of an application designed for single users and organizing some turn-taking process, so that everyone has a common view but one person is in control at a time, as is done with Microsoft Netmeeting for instance, or by using applications specifically developed for multiple users where each user has their own context. The Colab (Stefik et al., 1987a; Stefik et al., 1987b; Tatar et al., 1991) is an example of the latter approach. Stefik et al., (1987b) state that WYSIWIS (What You See Is What I See) is a foundational abstraction for multiuser interfaces that expresses many of the characteristics of a chalkboard in face-to-face meetings. They also state that in its strictest interpretation, it means that everyone can also see the same written information and also see where anyone else is pointing. After their initial experiences developing Colab as an experimental meeting room at Xerox PARC, in which computers support collaborative processes in face-to-face meetings. Stefik et al., concluded that WYSIWIS is crucial, yet too inflexible when strictly enforced. The Colab was designed for small working groups of two to six people using personal computers connected over a local-area network. Two of its meeting tools were: (1) Boardnoter that most closely imitates the informal functionality of a chalkboard with pointers for each user, pens, an eraser, and pointer icon image that can be placed on the screen, analogous to magnetic arrows; and (2)

Cognoter, a more structured meeting tool for organizing ideas for a presentation, where the meeting process is organized into a sequence of stages: brainstorming, ordering and grouping, evaluation, and outline generation. For both tools they suggested benefits from relaxing the WYSIWIS constraint, including the following:

Issue: The WYSIWIS display of cursors for multiple users is unacceptably distracting.

Design solution: Support local pointing and telepointing.

Issue: Small grain-size updating allows small grain-size collaboration, but is computationally expensive.

Design solution: Broadcast changes to information when the user indicates completion or after a reasonable time interval.

Issue: Teleselections can be confusing if they are displayed in the same way as local selections. Confusion is especially likely in the middle of local operations that require their own selections.

Design solution: Modify the display of teleselected objects so that they are distinguishable from objects locally selected, for example, by using different shades of gray.

Issue: Meetings often need multiple chalkboards, but there is room to show only one on a computer display.

Design solution: Boardnoter provides multiple visible boards by arranging shrunken versions of them as icons in a stampsheet below the chalk tray.

Issue: The screen can be crowded with windows used mainly by other participants.

Design solution: Allow participants to select independently which windows are at full scale.

Issue: When windows are shrunk to the miniature scale of stamps, it is no longer possible to assess quickly the locus of activity or which information has changed since the windows were last viewed at full scale.

Design solution: Unlike conventional icons, stampsheet icons should actively indicate when information is changing.

Issue: Identifying recent changes is also important for full-size windows, when participants refocus on a window.

Design solution: Provide a facility for highlighting recent changes.

Issue: Subgroups need to cause other group members to attend to a particular item without interfering with the activities of other subgroups.

Design solution: Provide a way of using the telepointer to show only within subgroup boundaries.

Issue: Although stampsheets reduce the contention, public and private windows still compete for display space. When a participant adds a new public window to a subgroup, it can occlude windows of other participants.

Design solution: Participants can control the placement of all windows on their displays. New public windows may be repositioned after they appear.

A number of problems occurred with Cognoter that were associated with the an inaccurate model of conversation and these will be discussed in the section on conversation-oriented models.

- Computer Teleconferencing

Teleconferencing can simply involve telephone conferencing or video and audio conferencing. Computer technology can be useful for transferring and managing such communications and this type of technology can help provide some basic presence for individuals communicating at a distance. Ware (2000) reports that it is now generally accepted that in most situations the audio link is more important than the visual one.

  - Desktop Conferencing

    Desktop conferencing uses the workstation as the conference interface, but it also runs applications shared by the participants. Modern desktop conferencing systems support multiple video windows per workstation. This allows display of dynamic views of information, and dynamic video images of participants.

- Intelligent Agents

  Nonhumans participating in an electronic meeting are a special case of intelligent agents. In general, intelligent agents are responsible for a specific set of tasks, and the user interface makes their actions resemble those of other users.

- Coordination Systems

  Ellis et al., indicate that coordination systems can be categorized by one of the four types of models they embrace: form, procedure, conversation, or communication structure oriented.

  - Form-oriented models

    Form-oriented models typically focus on the routing of documents (forms) in organizational procedures. These systems address coordination by explicitly modeling organizational activity as fixed processes (Lochovsky et al., 1988).

  - Procedure-oriented models

    Procedure-oriented models view organizational procedures as programmable processes; hence the phrase "process programming" (Balzer et al., 1989). This approach was first applied to coordination problems in the software process domain and takes the view that software process descriptions should be thought of and implemented as software.

  - Conversation-oriented models

Conversation-oriented models are based on the observation that people coordinate their activities via their conversation (Flores, et al., 1988; Woo 1990). The underlying theoretical basis for many systems embracing the conversation model is speech act theory (Searle, 1969). For example, The Coordinator (Flores, et al., 1988) is based on a set of speech acts (i.e. requests, promises, etc.) and contains a model of legal conversational moves (e.g. a request has to be issued before a promise can be made). As users make conversational moves, typically through electronic mail, the system tracks their requests and commitments.

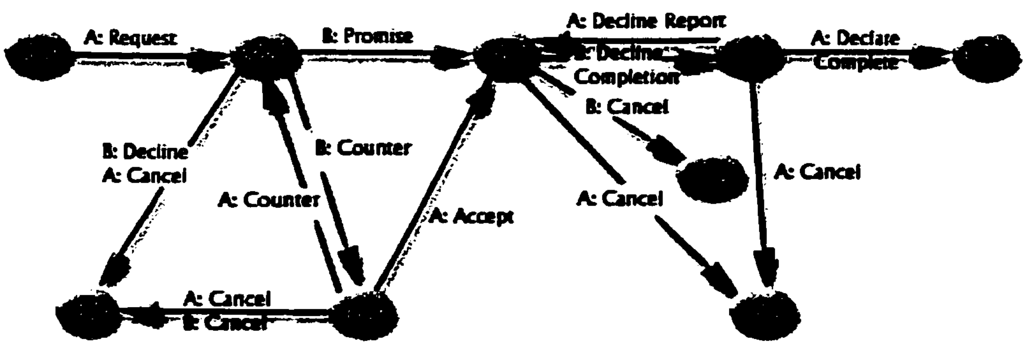


Figure 2.2 A Winograd-Flores Structure for Action-Oriented Conversations based on linguistic acts (http://www.arch.usyd.edu.au/kcdc/journal/vol3/dcnet/avarena/)

Figure 2.2 is an example that shows how this approach can be considered to model different types of conversation with state-transition-diagrams.

Tartar et al., (1991) indicate that the initial observations of Cognoter were hampered by the ability of people who were very familiar with the performance characteristics of the software to compensate for its problems, because when they evaluated it with "real" participants the system was so bad that half the participants stopped using the system altogether and ultimately threatened to walk out. One of the problems identified was described as ambiguous deictic referencing. Because users had different displays, delays in updating screens, and anonymous actions, a change could be made on a user's screen not only causing them to ask "who did that", but also for those asked to not know what "that" was.

Tarter et al., also considered that they unintentionally used an inaccurate model for the conversation they tried to support: "We claim that many of the serious problems in Cognoter stem from a culturally prevalent, easy-to-make assumption that communication consists of bits of verbal or textual material passed whole from one person to the next." (pg. 206). They concluded that the efficiency they gained by avoiding "production blocking" through parallel typing was lost in the increased amount of work that had to be done to maintain communication based on the parcel-post model.

They concluded that a better model would be an interactive model of conversation, such as that offered by the field of psycholinguistics (Clark, et al., 1986; 1989).

Tarter et al., also note the distinction between conversation and literary communication made by Clark and Wilkes-Gibbs (1986) who describe *mutual responsibility* versus *distant responsibility* respectively:

"The participants in a conversation try to establish, roughly by the initiation of each new contribution, the mutual belief that the listeners have understood what the speaker meant in the last utterance to a criterion sufficient for current purposes (p. 33)."

"The speaker or writer tries to make sure, roughly by the initiation of each new contribution, that the addressee should have been able to understand his meaning in the last utterance to a criterion sufficient for current purposes. (p. 35)."

Thus, in the interactive model, both participants are active, even when only one is actually speaking. People nod, complete or reshape one another's phrases, and say "uh-huh" (Duncan 1973). From the speaker's perspective, each conversational move involves not only its own contents but also a projection of what the next move will be. No response from the listener may normally be assumed to mean understanding and acceptance, but if a try-marker (Sacks & Schegloff, 1979) is used where the tone indicates a request for judgment about acceptability, no response indicates trouble such as the other person not listening. Listeners have the ability to make statements explicitly or implicitly which add to accept, reject, question or modify what the speaker has just said. In the interactive model, this listener response is a crucial part of conversation. In fact, Clark and Schaefer (1989) have gone so far as to advance the notion that the basic unit of conversation consists of two parts, a *presentation* and an *acceptance* phase. Together the two constitute a *contribution*. Since, as mentioned above, non-response is in fact a statement, the ability to perform the acceptance portion actively is crucial.

Tatar et al., point out that the writing actions are neither appendages to the verbal conversation nor independent of it. Writing and talking is intricately bound together in a similar fashion to the way a statement and its response are bound together. However, the coordination issues are even more complex because a person can write while talk is occurring. There are therefore more kinds of moves to be made. Tatar et al., go on to point out that the same is true for other media too:

"The study of traditional representational media contains ample evidence that people use the basic 'interactive' conversational paradigm. It is highly structured and dependent on both time and context. While there may be interesting modifications in response to different representational media, we have every reason to believe that the same resources are available for projecting the next move, for making and obtaining listener response, and for mid-course correction." (pg 197).

Tatar et al., were willing to admit that the absence of coordination between speech and writing led to a highly frustrating experience. They also note that they failed to achieve shared references to objects as Clark and Wilkes-Gibbs (1986) have noted is necessary:

"We had hoped that the differences between the displays at Cognoter stations would be transparent to the users or at least be accepted without too much difficulty. However, in fact people were not looking at the same surface (separate screens). This meant that they lost most of the gaze and gesture information and their base-level knowledge of what was being talked about was less than with other representational media." (pg. 202). In addition, because the windows could be controlled separately indexical descriptions such as "It's in the upper left" do not work under these circumstances.

- Communication structure-oriented models

  Communication structure-oriented models describe organization activities in terms of role relationships. For example, in the ITT approach (Holt, 1988), a person's electronic work environment is composed of a set of centers, where each center represents a function for which the person is responsible. Within centers are roles that perform the work and objects that form the work materials for carrying out the function of the center. Centers and roles have connections to other centers and roles, and the role scripts of the interacting roles govern the behavior of the connections.

Ellis et al., point out that there is often merging of these functionalities as, for instance, intelligent message systems can and have been used for coordination and desktop conferencing systems can and have been used for group editing. However, some systems can be classified by a primary emphasis and intent, and this in turn, may depend upon the perspectives of the system designers.

Perspectives

Ellis et al., state that there are at least five key disciplines for perspectives for successful groupware:

- Distributed Systems Perspective

  Because their users are often distributed in time and/or space, many multiuser systems are naturally considered to be *distributed* systems. The distributed systems perspective explores and emphasizes this decentralization of data and control. Essentially, this type of system infers global system properties and maintains consistency of the global state by observing and manipulating local parameters. The investigation of efficient algorithms for distributed databases is a major research area in distributed systems theory. Some of these research results are applicable to groupware systems. For example, implementing electronic mail systems evokes complex distributed systems issues related to robustness: recipients should be able to receive messages even when the mail server is unavailable.

- Communications Perspective

  According to Ellis et al., one of the commonly posed challenges of groupware to communications technology is how to make distributed interactions as effective as face-to-face interactions. Perhaps the correct view of this challenge is that a remote interaction, supported by appropriate technology, presents an alternative medium. While this will not replace face-to-face communications, it may actually be preferable in some situations for some groups because certain difficulties, inconveniences, and breakdowns can be eliminated or minimized. For example, distributed interactions allow participants to access other relevant information, either via the computer or in a book on the shelf, without interrupting the interaction flow. This is analogous to findings on the use of telephone, electronic mail, and other technologies. While none of these replace face-to-face interaction, each has a niche where it is a unique and useful mode of communication. The challenge, then, is to apply appropriate technological combinations to the classes of interactions that will benefit the most from the new medium.

- Human-Computer Interaction Perspective

  This perspective emphasizes the importance of the user interface in computer systems. Ellis et al., described Human-computer interaction as a multidisciplinary field, relying on the diverse skills of graphics and industrial designers, computer graphics experts (who study display technologies, input devices, and interaction techniques), and cognitive scientists (who study human cognitive, perceptual, and motor skills). Ellis et al., note that groupware challenges human-computer interaction researchers to consider factors such as group dynamics and organizational structure, which are not normally considered relevant to user interface design.

- Artificial Intelligence Perspective

  With the emphasis on theories of intelligent behavior, this perspective seeks to develop techniques and technologies for imbuing machines with human-like attributes. The artificial intelligence (AI) approach is usually heuristic or augmentative, allowing information to accrue through user-machine interaction rather than being initially complete and structured. Ellis et al., claim that this approach blends well with groupware's requirements. For example, groupware designed for use by different groups must be flexible and accommodate a variety of team behaviors and tasks.

- Social Theory Perspective

  This perspective emphasizes social theory, or sociology, in the design of groupware systems. Systems designed from this perspective embody the principles and explanations derived from sociological research. The developers of Quilt (Fish et al, 1988), for example, conducted systematic research on the social aspects of writing, and from this research they derived the requirements from their collaborative editing environment. As a result, Quilt assigns document access rights according to interactions between users' social roles, the nature of the information, and the stage of the writing project.

Distributed Systems and Distributed Work

According to Rasmussen et al., (1991), "a system is characterized by distributed decision making to the extent that it lacks a centralized control agent, or decision maker". They also note that as the complexity increases, it becomes impossible to embody the required control structure in a single decision unit. Group decision-making also involves multiple decision makers working together. However, in group decision making there is an attempt to achieve consensus and each member is capable of understanding the problem as a whole, whereas in distributed decision making each member has a model of a limited part of the problem, so the problem becomes coordinating their efforts.

Decker (1987) provides a review of distributed problem-solving techniques in AI systems that can also be applied to human and human-automation systems. The taxonomy has four dimensions:

1. The level of problem decomposition (granularity);
2. The distribution of expertise;
3. The methods for achieving distributed control;

4. The process of communication.

Rasmussen et al., note that most distributed systems attempt to solve course grained problems and that the distribution of expertise involves a range of expertise rather than highly specialized people. They also note that the decomposition can often not be decided *a priori*. Thus, an appropriate decomposition must be decided, which requires communication, and for complex systems that are dynamic over time the decomposition may have to be periodically revisited. Rasmussen et al., note that the level of cooperation between agents varies in different systems, but generally one agent is willing to adjust its goal to accommodate the needs of other decision makers. Again, this requires communication, or an accurate model of what the other decision makers' goals are. The latter approach can be a problem if the model is not accurate, or changes without communication between decision makers. One decision maker's goals may also change because of different situational awareness, so that even if another decision maker has an accurate model of the first decision maker's reasoning, it won't predict the goal correctly because the correct model of reasoning is applied to an inaccurate model of the perceived environment for the first decision maker.

Rasmussen et al., describe communication as the cement of the organization, and the greater the need for coordination and cooperation, the greater the necessity for communication. Decker describes systems whose structure changes during problem solving to take advantage of new opportunities as having a dynamically opportunistic organization. At the same time Decker notes that communications in AI systems normally takes more processing than computation and the same is often true between humans. Thus, the cost of communications must be considered when organizing a group of distributed decision makers.

CHAPTER 3

TEXT-BASED TO MULTIMODAL-BASED ASYNCHRONOUS COMMUNICATIONS

Asynchronous distributed interaction

Asynchronous communications systems are said to "transcend the limitations of time and space" (Baecker, 1993), allowing communications among groups of physically dispersed individuals, where the communication does not take place "at the same time". Although the focus of the research presented in this dissertation is related to computer supported asynchronous communications, that context involves characteristics also found in non-computer based communications, so it is worth considering what has been learned from experience with both non-computer supported asynchronous communications and computer supported asynchronous communications.

Non-computer supported asynchronous communications

Mail systems are a popular example of asynchronous communications. Their value was appreciated long before electronic forms were created, with systems evolving through the generations to provide increasingly rapid, inexpensive, and ubiquitous asynchronous communication. A mail messaging system supports the communication of a message composed of (1) information sufficient for the Message Transfer Agent (MTA) to deliver the message and (2) content, which actually contains that which the sender wishes to communicate to the recipient (Chapman, 1987). Content on paper may involve printed text, handwriting or images. If the message is actually more a parcel than a letter, then additional utility beyond that of a pure communication may be added by including other materials (e.g. a gift). With the invention of audio tape recorders, the sender was given the option of sending an audio message asynchronously through the mail system in the form of an audio tape, that could supplement the normal text based message, or perhaps occasionally be the entire content. Similarly, videotapes can be sent if moving pictures, in addition to audio are desired. By attaching audio tape recorders to telephones, people are provided with answer phone systems where they are able to create entirely audio-based asynchronous communications – with voice mail being in some ways just a more "intelligent" technologically advanced version of this. Facsimile systems are another popular example of asynchronous communications systems, which are useful when paper materials need to be shared quickly and some degradation in the quality of the content is acceptable.

Computer supported asynchronous communications

Computer supported asynchronous communications are possible without specifically designed electronic messaging systems because people can be directed to computer stored information in other ways. Thus, ever since it has been possible to put computer files in the file space accessible by a computer user it has been possible to make that file the content of a computer based communication for specific users, as long as the recipients are somehow told they should take a look at those files. For instance, people adapt File Transfer Protocol (FTP) programs and World Wide Web sites to make them messaging systems, by posting files on the respective server and telling others the address to use to retrieve the files with a suitable client program. Sometimes the file is analogous to the content of a letter and other times it may be considered to be more analogous to the content of a parcel, having utility distinct from a pure communication (e.g. a program).

Electronic Mail

Messaging Handling Systems (MHSs) add value because they not only provide abstraction from computer files to messages and protocol based file transfer processes to "send message" and "check mail" commands, but also because they support the user in managing the collections of messages that are accumulated as messages are received and sent. Even so, as E-mail has become increasingly popular the challenge of avoiding E-mail overload (Whittaker and Sidner, 1996) for the user has also increased.

Older E-mail systems were consistent with older computer interfaces in general – they were text based and their interfaces didn't support abstractions we consider basic today, such as WIMP (windows, icons, mouse, and pull-down menus) and direct manipulation (Zielgler and Fahnrick, 1988; Shneiderman, 1998). For instance, in 1991 Sproull and Kiesler described the E-mail systems of that time as having the following key characteristics:

- E-mail is asynchronous
- E-mail is fast
- E-mail is text-based
- E-mail can be addressed to multiple receivers
- E-mail has a built-in external memory
- The external memory can be processed by computer.

E-mail users must often also consider the implemented bandwidth and any file size restrictions of the networks involved between sender and recipient. A major reason the E-mail systems mentioned by Sproull and Kiesler were fast is that they were text-based. Even a user connecting to a network with an old 9600 bits per second modem could send 1200 characters per second with an ASCII (American Standard Code for Information Interchange) based E-mail system, so most text messages in a few seconds could be sent to or received from an E-mail server. As people start to send more alternative media files, that are much more greedy in terms of storage requirements, the issue today is increasingly not if people have access to E-mail, but how confined they are by the speed and file size restrictions involved in that access. File size restrictions and bandwidth are two reasons why people have adapted their messaging behavior to use FTP (File Transfer Protocol) programs (that don't normally impose file size limits) and the Web (which now increasingly provides streaming options, lowering the time between starting file transfer and file viewing when video or audio is involved.

Today's E-mail systems are more sophisticated, but the majority of messages still only have text as their content. This may be sufficient to convey the message the sender wishes the recipient to receive, but sometimes asynchronous communications may be usefully enriched with additional formats and doing so should not return the user to a low-level of abstraction from the details of the machine. For most E-mail systems that is the case, as the user has to use separate programs to create disjoint portions of the message, such as audio or video, and then navigate through the computer's file system to locate and attach them to the E-mail message as separate files.

One way text based E-mail messages are used differently from their regular mail counterparts is the extent to which a sender's text is often reused by the recipient in creating a response. This is such a recognized practice that E-mail programs try to explicitly support the respondent intermixing, but keeping distinct, responses to particular portions of the text from the original message. In some senses the reply a person gets back is an annotated version of the original message. When the user includes images or audio with a message, as separate files, annotating a response in a similar fashion is not normally possible.

Neuwirth et. al. (1998) studied the effect of the external representation in a problem solving task involving E-mail exchanges. They first conducted an observational study where the task given to participants was to act as a system administrator and try to track down E-mail "spoofers". Participants needed to communicate with others acting as system administrators for other systems that the spoofers might be sending messages from. The participants needed to keep track of the information in a number of messages over time and some started to use paper-based representations of the state of their progress as they searched for culprits. In an experiment that followed this study participants were asked to look at the current state of a system administrator's representation of the problem-solving task – half when the representation was a number of E-mail messages and half where the E-mail messages were supplemented by an electronic representation similar to those previously created on paper. The electronic representation was created using a program that could build a table of data from filters placed on incoming and outgoing messages as well as user-entered data. They found that those with the additional task specific representation could more quickly answer questions about the current state of the problem-solving task. This research demonstrates that E-mail systems should not be studied or designed in isolation from context., because these representations were intrinsically tied to the task.

Multimodal Asynchronous Messaging and Annotation

Messages and Annotations

Annotation: "A critical or explanatory note."

Comment: "A note in explanation, expansion, or criticism of a passage of a book, article, or the like; an annotation."

(Webster's Encyclopedic Unabridged Dictionary of the English Language)

An annotation or comment is a communication regarding something that already exists, which is intended to add in some way to what is referenced. It can be created for oneself or for others to see. Messages often contain "annotations or comments" because they reference both what exists outside the message itself, the contents of previous messages, and the contents within the current message.

Asynchronous Multimodal Systems

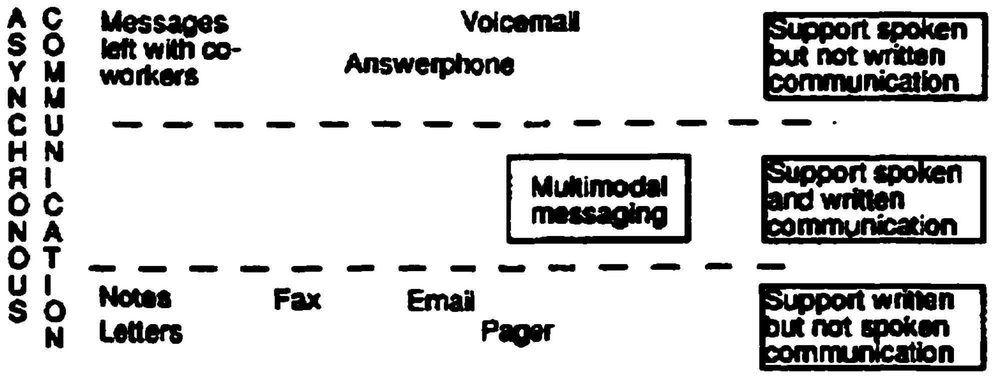


Figure 3.1 Asynchronous communication methods in order of development (Daly-Jones et al., 1997)

When both human auditory and visual modalities are involved, systems are said to be 'multimodal' (Daly-Jones et al., 1997). Figure 3.1 shows Daly-Jones et al.'s breakdown of popular asynchronous communications methods in terms of which of these two modalities they supported in 1997, and the fact that none of the methods at that time supported multimodal messaging. However, written text is not the only form of visual information, and the representation of information can be significant at both the perceptual and cognitive levels.

Voice, Text and Graphics

One basic dimension, which might usefully supplement the summary in Figure 3.1 is whether or not the communication method supports the transmission of graphical images as well as just text or audio.

Table 3.1 is an adaptation of Figure 3.1, with this added dimension. None of the basic asynchronous communication methods in Figure 3.1 that support audio also support graphics, but most that support text also support graphics (although the mixing of the two may require using a separate application for E-mail depending on the E-mail program).

	Speech	Text	Graphics
Verbal messages left with co-workers	✔		
Answerphone	✔		
Voicemail	✔		
Notes, Letters		✔	✔
Fax		✔	✔
E-mail		✔	✔
Pager		✔	

Table 3.1 Basic asynchronous communications methods support for speech, text and graphics

The dual coding theory of Paivio (1986), shown in Figure 3.2, proposes that that there are fundamentally different types of information stored in working memory; he calls them *imagens* and *logogens*. Imagens denote the mental representations of visual information, while logogens denote the mental representations of language information.

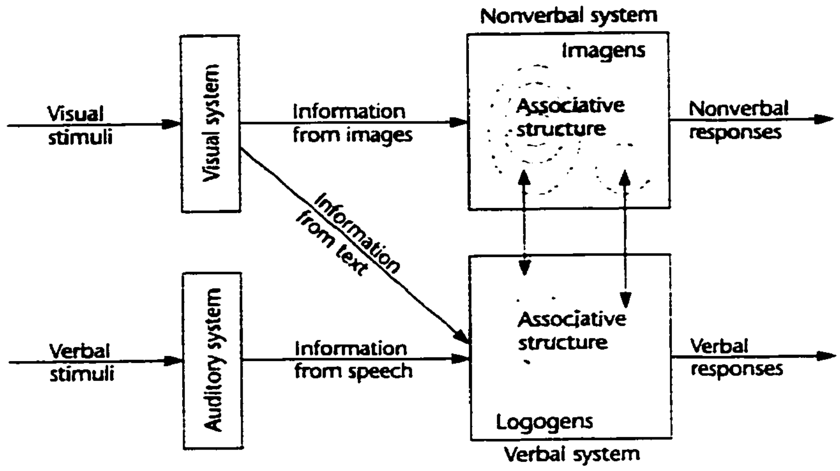


Figure 3.2 The architecture of Paivio's dual-coding theory (Ware, 2000)

The division of real-world visual information into just two categories: text and graphics is also certainly a gross oversimplification. Complex information can be presented in a myriad of forms.

"To envision information – and what bright and splendid visions can result – is to work at the intersection of image, word, number, art. The instruments are those of writing and typography of managing large data sets and statistical analysis, of line and layout and color."

Tufte's Introduction (1990)

Semiotics is the study of signs and symbols. Three basic forms of representation identified by those working in this area are prepositional reference for linguistic or digital forms; iconic reference for objects that resemble that which they represent; and analogical where the representation captures the structure and behavior of that which is represented (e.g. a map).

Norman (1988) makes the point that the same image can represent different things to people of different cultures (e.g. "arrival time" normally means the time the wheels are first on the ground as a plane lands to FAA employees, but the same term mean the time in at the gate to people working for the airlines) and also that meaning is derived from experience with interfaces.

The representation effect (Kotovsky, Hayes and Simon 1985; Zhang & Norman, 1994) of a particular visual image also refers to more than just the effect of a graphical image versus one composed of text:

The *representation effect* refers to the phenomenon that different isomorphic representations of a common formal structure can cause dramatically different cognitive behaviors. One obvious example is the presentation of numbers (for cognitive analyses, see Nickerson, 1988; Norman, 1993; Zhang 1992; Zhang & Norman, 1993). We are all aware that Arabic numerals are more efficient than Roman numerals for multiplication (e.g. 73x27 is easier than LXXIII x XXVII), even though both types of numerals represent the same entities - numbers. (Zhang & Norman, 1994).

Wojahn et. al. (1998), looked for effects from the location of comments in a collaborative writing task. They compared three conditions: *Split-Screen Interface*, where comments were placed in a horizontal frame below the main text; *Interlinear Interface*: where the comments were placed between text in the main window of the document itself; and *Aligned Interface*: where comments were placed in a vertical frame to the right of the main text and aligned horizontally. They found that subjects communicated about more problems in the Interlinear and Aligned conditions, without a significant difference in time on task, than subjects in the Split-Screen condition.

A fundamental characteristic of speech compared to more visual forms of communication, such as text or graphics images) is that the listener is freer to use other modalities, such as vision, while processing the speech input (Streeter, 1988). Most research comparing spoken with written communication has been concerned with synchronous communication (Daly-Jones et al., 1997). Perhaps the classic study being conducted by Chapanis (1975) who found that speech based communications during problem solving involved many more words per minute than text and that the tasks were solved faster when speech was used. Neuwirth, et al. (1994), however did conduct a study of spoken versus written asynchronous communications. They compared the nature and quantity of voice and written comments produced in each mode, when reviewers gave feedback to writers. They found:

1. Reviewers used more words in voice than text mode during the same time period, but that the same number of annotations was made on average. The additional words were attributed in part to providing more reasons why the reviewers thought something was a problem and for polite language that mitigated the problem.
2. Evaluations of reviewers were less positive when reviewers produced written annotations than spoken.
3. Comments about low-level mechanics (e.g. spelling or grammar) were preferred in text.

Overall, the findings support the utility of voice modality for supporting collaborative writing activities – although it should be noted that while people can generally speak faster than they type, people also generally process typed text faster than voice recordings (Streeter, 1988).

In eye tracking and recall testing studies, Faraday and Sutcliffe (1997, 1998) investigated attention and comprehension by users interacting with multimedia presentations. In one study (1997) research students observed a commercially produced CD-ROM, 'The Etiology of Cancer' while wearing eye-tracking devices, then had their domain knowledge recall measured. The presentation showed DNA repair by photoreactivation, during which objects, labels and arrows would be revealed from a previously hidden state and some objects would move across the screen. From this study, a set of guidelines for controlling attention in multimedia presentations was produced:

- *Use object motion to control attention and viewing order;*

  (Participants' attention was drawn to motion and fixations tracked the moving objects path)
- *Use animation with care;*

(Multiple simultaneous animations from moving objects or revealed objects and labels, or too rapid motion, sometimes caused attention to unintended areas)

- *Gradually reveal labels, symbols and objects, to control viewing order;*

  (Revealing hidden objects, labels or arrows, when focus on them was desired, was effective in drawing attention)

- *Reveal related elements in a sequence;*

  (Simultaneous animation sometimes caused attention to objects or labels in an undesired order)

- *Reveal important information to emphasise it;*

  (Static objects and labels received less attention than those revealed or in motion)

- *Ensure that an object and its label appear together to improve identification;*

  (Fixation moved back and forth between an object and its label)

- *Use speech to reinforce information presentation, reveal objects and labels when cued in the speech track;*

  (Participants fixated on verbally referenced objects and labels)

- *Allow reading time after cueing a label;*
- *Use symbols to direct attention to specific objects and locations;*

  (The arrow symbol shifted fixations to that which the arrow pointed to)

- *Speech information should reinforce image;*

  (Propositions given only in the image or animation without speech cueing were poorly recalled)

- *Captions or labels may be useful in re-inforcing the speech track;*

  (Propositions given in speech which were reinforced by labels were well recalled)

- *If the speech information is complex or important then present it concurrently in a caption;*

  (Propositions given only in the speech track were generally poorly recalled)

- *Cue animations with speech;*

(Animated objects, which were cued by the speech track, were well recalled)

- *Show the effect of actions.*

  (Complex actions shown in animations, without showing the resulting effect, were poorly recalled)

In another study (1998) they investigated how people fixate back and forth between text and that which it refers to in an image. In contrast to pointing, which generally precedes related speech (Oviatt, 1997), Faraday and Sutcliffe reported that people would read a sentence, and then look for the reference in an accompanying diagram. At times they found people not able to move smoothly to that referenced, so they developed a system where users can click on a button after the associated text to cause that referred to in the image to be highlighted or animated. One of their examples is shown in

Figure 3.3. This helped control the users' attention as intended. They also recommended placing any label for an object as close to the object referenced as possible, which is consistent with Gestalt principles (Ware, 2000).

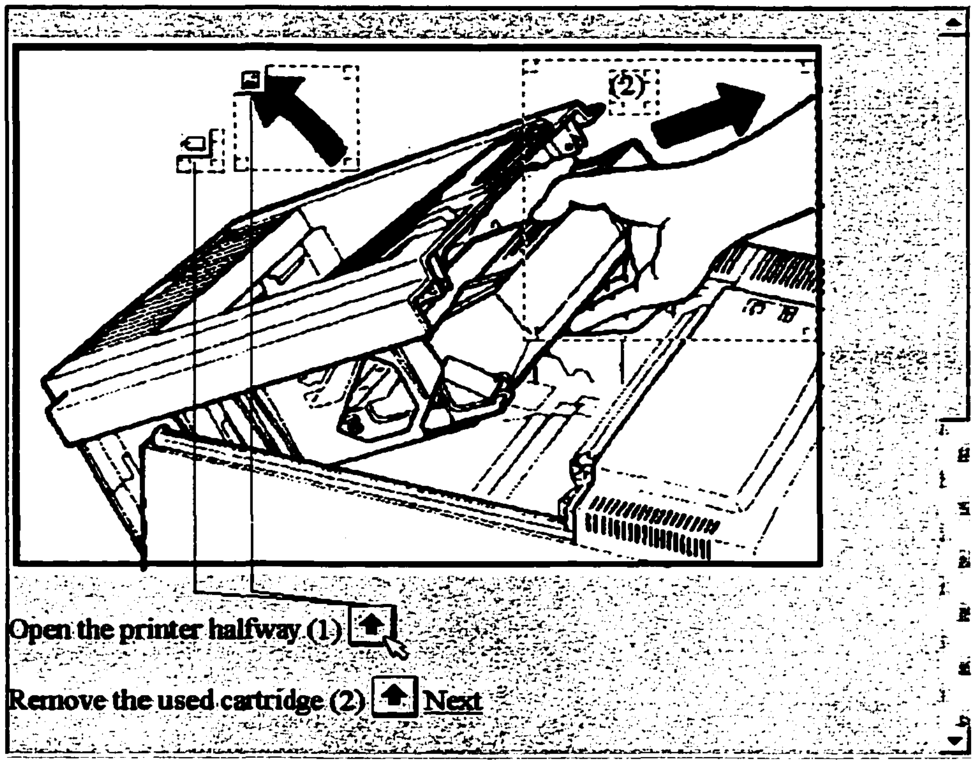


Figure 3.3 Designing connections between text and annotations (Faraday & Sutcliffe, 1998)

The Microsoft Research Annotation System (MRAS) supports streaming video on the web and personalized annotations by those who view it. MRAS allows a video to be paused for note taking, with a contextual link to the current position in the video when that is done. Figure 3.4 demonstrates that viewers can create audio annotations in addition to text and share those annotations with others. Bargeron et al (1999) conducted two studies of its use. In the first they studied personal note taking of users watching a video using MRAS and using traditional pen and paper methods. All participants used both methods - half using MRAS first and half paper. They found when users used the MRAS system they took longer, pausing or rewinding the video. They also found that MRAS-first participants took paper notes differently from paper-first participants suggesting the MRAS system caused a shift from the traditional way of taking notes during a presentation. The MRAS system was preferred to paper notes and the point was made that its value would increase over time as the video would be more difficult to remember and a quick review of noteworthy parts would be useful.

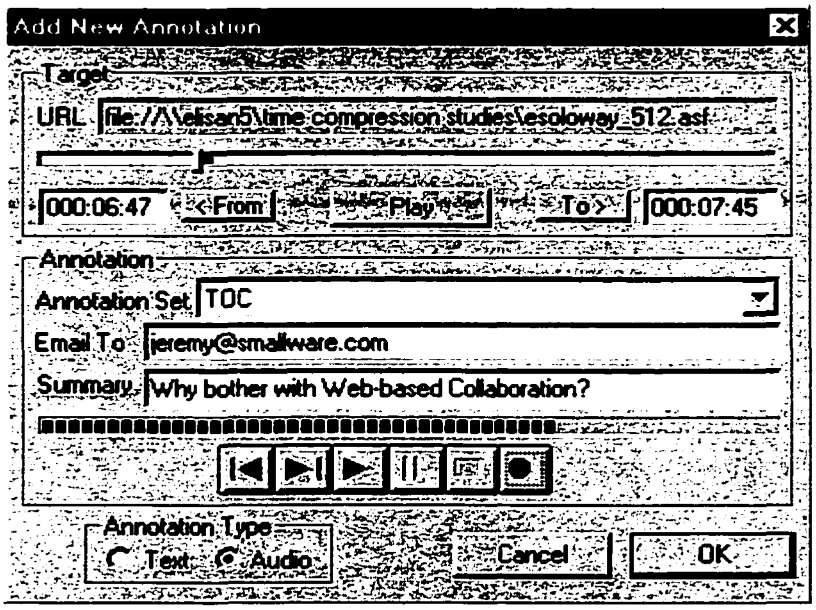


Figure 3.4 MRAS "Add New Annotation" dialog box (Bargeron, Gupta, Grudin & Sanocki, 1999).

In a second study participants added their notes to a shared folder. Each participant worked in one of three annotating conditions: Text-only, Audio-only or Text-and-audio. When replies were made in the text-and-audio condition participants were as likely to use text to reply to audio annotations, as they were to use audio. Participants generally felt it took more effort to listen to audio than to read text. One participant in the text-and-audio condition was frustrated with the speed of audio annotations, saying that "I read much faster than I or others talk. I wanted to expedite a few of the slow talkers." Another participant pointed out that "it was easy to read the text [in the preview pane] as the video was running. By the time I stopped to listen to the audio (annotations) I lost the flow of information from the video." This research is an example where audio annotations did not work as well as text, in contrast to some situations mentioned in the research cited earlier. In summary, it would appear that it is more difficult to listen to an audio annotation while also watching a related video with its own sound than it is to listen to audio annotation while looking at a related still image. This does not seem counter intuitive.

Deictic Gesturing

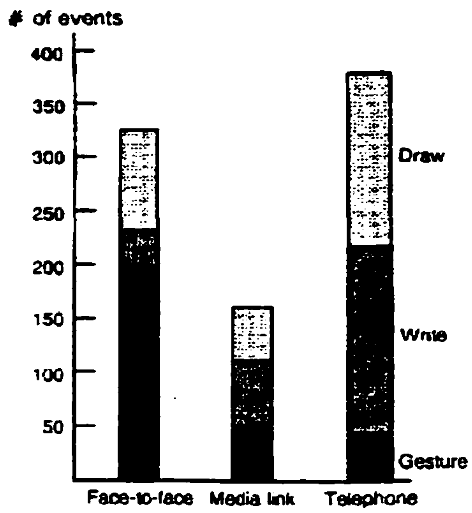
Tang conducted an ethnographic study of eight short small-team design sessions (Tang 1989; Tang 1991; Tang & Leifer 1988), where each team was given problems to solve and large sheets of paper as a shared work surface. Tang built a descriptive framework to help organize the study of work surface activity, where every user activity was categorized according to what action and function it accomplished, as listed below (Tang 1989):

- *Listing:* produces alpha-numeric notes that are spatially independent of the drawing;
- *Drawing:* produces graphical objects, typically a 2-dimensional sketch with textual annotations that are attached to the graphic;
- *Gesturing:* is a purposeful body movement that communicates specific information e.g. pointing to an existing drawing.

Gesturing played a prominent role in all work surface actions (~35% of all actions). Gestures were used to enact ideas, signal turn-taking and to focus the attention of the group (~58% of the gestures were to focus attention).

Bly (1988) studied two-person design sessions in three different settings: face-to-face, geographically separated with an audio/video link, and a telephone only connection. The study tasks themselves involved no new graphic design, but rather extensions of existing user interface mechanisms. Three action types were identified: a draw action was a graphic mark on paper; a write action was a text or alphanumeric mark on the paper; and a gesture was a motion specifically related to an existing mark on the paper. According to Bly, "Gestures allowed the designers to act out a sequence of user actions illustrating a mechanism and to point to a drawing cluster as reference or emphasis to objects and ideas." The division of actions into these three categories is shown in Figure 3.5. There was a higher percentage of gestures in this study than

Tang's for the Face-to-Face condition, and the decline from the Face-to-Face session to the Media Link session may have been partly because the visual information reportedly lagged behind the audio therefore making it difficult to send the image of a gesture synchronized with verbal comments.



	Face-to-Face		Media Link		Telephone	
Draw	93	29%	50	31%	164	43%
Write	35	11%	61	38%	173	46%
Gesture	197	61%	50	31%	43	11%
Total:	325		161		380	

Figure 3.5 Actions for each session (Bly, 1988)

"In human communication theory, a gesture that links the subject of a spoken sentence with a visual reference is known as a *deictic gesture*, or simply *deixis*." (p. 324, Ware, 2000). This type of gesture was found to occur frequently in Tang's and Bly's studies and in others involving human-human communications (Francik 1996; Daly-Jones et al., 1997). It is a natural form of communication and one that makes referencing objects, locations, and sequences of locations and objects, more efficient and less ambiguous.

Tang and Bly call for research to investigate how to develop tools to support gestured activity. Software supporting gesturing with a pointer on a two-dimensional image has fewer degrees of freedom than a real hand in 3 dimensional spaces, but it does nonetheless support deictic gestures to that image.

Faraday and Sutcliffe's research on users' interaction with multimedia involving animated objects seems relevant here as supporting gestures through a pointer results in an animated object, although the reference is to that pointed to and not the moving object itself. Four of there observations seem particular relevant:

1. Participants' attention was drawn to motion and fixations tracked the moving objects path;
2. Static objects received less attention than those in motion;
3. The arrow symbol shifted fixations to that which the arrow pointed to.
4. Propositions given only in the image or animation without speech cueing were poorly recalled, but animated objects, which were cued by the speech track, were well recalled.

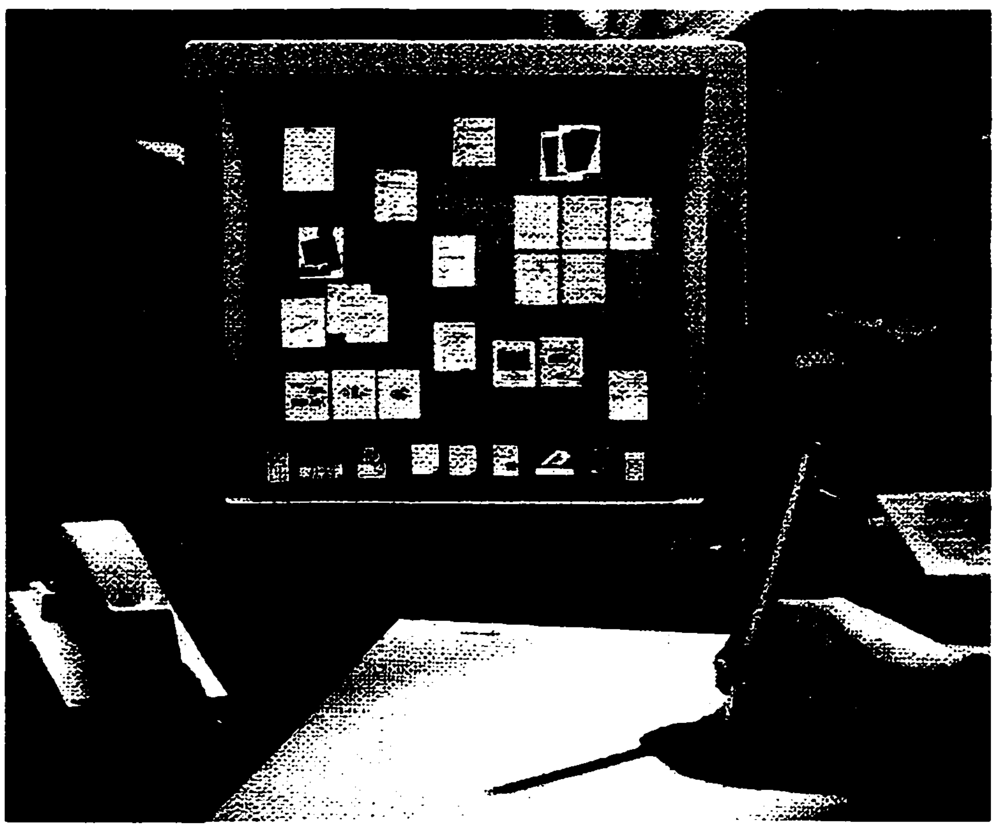


Figure 3.6 Freestyle image desktop; handwriting and voice-annotation tool (Francik, 1996)

Freestyle (Francik and Akagi, 1989; Francik et al., 1991; Francik 1996), was developed by Wang Laboratories in 1988, but it never became widely used and is now no longer available (Francik, 1996). It was an ambitious attempt at a particularly natural virtual working desktop with:

- Thumbnails of actual file contents to represent files on the desktop, rather than a categorical icon and a filename;
- A stapler object to group collections of files together;
- A stylus (see Figure 3.6) specifically engineered to be suited for writing and drawing, rather than CAD applications (which was what styluses were used for at that time). This pen also had a physical eraser operated like the eraser on the top of a pencil.
- A recorder that captured synchronized handwriting, or other stylus cursor movement.

The extensive use of metaphors lead to the marketing slogan, "You already know how to use it". It was intended to be a very paper-like environment[2], implemented on the then widely available 286 PC, but using an operating environment separate from Microsoft Windows. Combined with image capture, scanners, fax interface cards, electronic mail, and high-resolution graphics, it was also a multimedia communications system that drew a lot of attention from the computer- human interaction academics when it was made public:

> When I read that Wang was demoing a product called Freestyle, I have to admit that I was somewhat underwhelmed. I mean, who needs to see yet another drawing program. Word of mouth during the conference had it, however, that Freestyle was a hot design worth seeing, so during a boring lecture I decided to give it a try. It turned out that Wang Freestyle did indeed represent interesting interface innovations and that it was not related to the popular graphics program Freehand with which I had probably confused it subconsciously. (http://www.useit.com/papers/tripreports/chi89.html)

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[2] The development team's view of mice was reflected in its name, the Computer Annotation Technologies or CAT group (Francik, 1996).

The Freestyle system was intended to support spontaneous communication rather than structured workflows – as the name implied. The most frequently used addresses or distribution lists could be turned into "mail slot" icons residing directly on the desktop, so that after creating a message, sending it was a simple task.

Although its users liked it, it took time before they were able to envision how to use the technology to meet real organizational needs. It tended to be first used for very structured processes, for signature processes and electronic distribution of scanned-in paper documents - although the designers considered it best suited for problem solving, planning, and design. There was also the tendency for small workgroups to be setup with the system in organizations, to keep the cost down, making it difficult to achieve a critical mass of users. The cost of the system was reduced by supporting mouse controlled annotation and display on lower-resolution monitors, however, the new desktop interface may have just appeared at a difficult time and with insufficient resources: 'The last thing the world needs is another user interface', said Stewart Alsop 2d, editor of the PC Letter newsletter, referring to Wang's attempt to enter a field recently stirred up by OS/2 Presentation Manager, NextStep, NewWave, Metaphor, Windows, Deskmate, The Mac Desktop [sic], mice, and other technologies designed to make it easier to use computers" (Lewis, 1988). "As impressive as Freestyle is, the system that finally brings its wonders to the masses will probably be Freestyle-inspired rather than Freestyle itself. Wang's sorry financial condition may preclude it from devoting the resources necessary to establish Freestyle's new technology in the PC marketplace" (Bonner, 1990). Francik, herself adds, "In casual conversation, more than one person has dubbed Freestyle 'the Xerox Star of pen-based computing.' There is both flattery and irony in that comparison." (Francik, 1996).

In a more recent attempt at a particularly natural environment involving both multimedia and multimodal messaging, Ricoh Innovations Inc, has developed a touch screen based pointing system called TouchVerse. In a presentation given at Stanford University[3], Greg Wolff highlighted the disembodiment of attachments that occurs with E-mail messages when a person replies to a message, and the fact the voice-mail has no visual context. TouchVerse allows the users to drag documents onto a blank message and then create audio messages on the same screen that have a scroll bar with automatically generated lines from the scroll bar (positioned based on time) to any referenced document, if the person refers to that while speaking.

Lotus Screencam[4] is a software application, developed by Lotus Development Corporation, which records the user's computer screen image (including any visible pointer) and any audio produced by the user at the same time to form a single "video" that can be used as an asynchronous communication. Although it can be used to capture the dynamics of many different annotation modes (such as audio, text and pen based), it quickly produces very large files and provides a very basic file management environment. This is perhaps an application most suited for demonstrating how to use a software application, where the underlying image changes often, and the visual dynamics are particularly valuable.

In a study involving the use of Lotus Screencam (Daly-Jones et al., 1997), 'manager-secretary' pairs were asked to complete an asynchronous appointment-scheduling task and an equipment-booking task in three independent conditions. *Fax-only* involved using Microsoft

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[3] The presentation "In support of multimedia conversations" presented 2/11/2000 is available via streaming video at: http://murl.microsoft.com/videos/stanford/CS547b/000211_OnDemand_100_100K_320x240.htm

[4] There are two versions of Lotus Screencam - a Windows 95 release and a Windows NT4x release. The Windows 95 version does not record on all systems running Windows 98 and there are no plans to create a version for Windows 2000 (http://www.lotus.com/products/screencam.nsf)

Paintbrush; *Voicefax* involved using Lotus Screencam with a Paintbrush image; and *Voice-only* involved just audio. They found that for both sending and receiving users rated voicefax the most useful, then fax-only, then voice-only. In each condition 30 minutes was allocated to complete the task. Users took the same amount of time to complete the tasks in each condition, but fewer messages were sent with voicefax.

There are also currently a number of multimodal human-computer interactive systems being developed that support potentially highly expressive input such as hand gestures, eye gaze, and head and body movements, and annotations (Oviatt, 1999, Oviatt et. al. 1997; Hardock, et. al. 1993; Koons & Sparrell, 1994; Kullberg, 1995). This research is related to multimodal computer supported asynchronous collaboration between humans, but there are important differences. Multimodal human computer interaction is often concerned with machine learning of human commands – including complex gesturing (McNeill, 1992) synchronized with speech (Bourguet & Ando 1998). The ultimate goal is to make computer agents understand fully embodied human communications as well as humans do. In computer supported asynchronous communications however, it is another human who will interpret the message sent. The goal is to provide a representation of the communication that is sufficiently rich for the foreseen collaborative tasks. Thus, many of the issues in human-computer multimodal research are not relevant here, but general observations such as the fact that in one study 95% to 100% of users preferred to interact multimodally when they were free to use either speech or pen input in a spatial domain, but that users typically intermix unimodal and multimodal expressions (Oviatt, 1999[5]), are interesting assuming they translate to computer supported multimodal human to human communication.

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[5] A corresponding presentation at StandfordUniversity is available via streaming video at: http://murl.microsoft.com/videos/stanford/CS547/990226_OnDemand_100_100K_320x240.ht m

The research presented here does not consider annotations in 3-dimensional space, however, there has been research in that area, including the development of a voice-based annotations system for annotations in immersive environments (Harman et al., 1996).

Drawing Tools

In addition to highlighting the significance of gesturing, Bly (1988) also noted (1) participants expressed frustration when not sharing the same writing/drawing space and (2) the frequent rapid switching between annotation marks when drawing and writing (stating that few, if any, existing computer supported sketching tools allow such rapid transitions). Greenberg et al., (1992) developed a multi-user sketchpad (called Sketchpad), that is a synchronous communications system, but the issues raised are also relevant for asynchronous communications systems. Following the guidance of Tang and Bly, Sketchpad was developed with the intention of supporting tele-presence (Egido 1988) and to make switching between annotation modes as effortless as possible. Thus, their design criteria include the following:

- Since gestures must be seen in order to convey information, all cursors within a work surface are always visible to all participants. Cursors are also made prominent on the display by their larger than normal size.
- Cursors are unique, each identifying the person it belongs to by labeling it with the user's name. In addition (and more subtly) each cursor is orientated at different angles.
- Cursor movements appear with no apparent delay on all displays, which means that they remain synchronized with verbal communication.
- The simplicity of GroupSketch allows it to have a nearly modeless interface. When no mouse buttons are depressed, the cursor is in the pointing gestural state. Drawing occurs as long as the left button is depressed, which also turns the cursor into a pen. Typing immediately inserts text at the current cursor location. The cursor image changes to the

pen, and automatically reverts back to the hand-shaped cursor after a reasonable pause in typing is detected.

In asynchronous communications a clear voice and deictic gesturing would seem to have the potential to provide a degree of tele-presence too; user specific pointers could still be useful when saving the recordings of multiple users; and the ease of changing annotation modes is also relevant. Both situations need to support WYHIWIS (What you hear is what I said) , and while asynchronous communications may not be a WYSIWIS (What you see is what I see) situation[6], they can perhaps still be WYSIWID (What you see is what I did) if dynamic activities such as gesturing are captured.

Popular Software with Features for Annotation

Some asynchronous systems support richer interaction by allowing the integration of original content and annotations in a variety of forms such as graphics, text, audio and video, so that, for instance, an image can be seen with comments about it without having to consciously work with multiple files and programs. In some cases these systems involve programs originally intended for other purposes, but where the user has adaptively created a messaging system. In other cases, they are systems specifically designed to create this type of environment.

Microsoft Office 2000

Microsoft Office is a popular package of commonly used applications – the most recent version of the package being Microsoft Office 2000. Three of its applications that can be used to create content for a message, which can be annotated by sender and recipient to create a message richer than text, are Powerpoint, Word and Excel.

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[6] Unless WYSIWIS can also be interpreted as what you see is what I *saw*.

Microsoft Powerpoint

Powerpoint is most often used as a presentation program rather than as part of a messaging system. However, if a person wishes to receive a response to information placed on a series of slides the slide show can be transmitted as an E-mail attachment and the recipient asked for feedback in the form of annotations on the slides. The original content can include text, images, graphical annotations, audio and video. Thus, for instance, an image could be a map with arrows drawing the recipient's attention to particular points on the map, text providing additional information about what is at those points, and an audio voice over providing a personalized greeting, additional information, and questions about the information shown on the image supplemented by knowledge from the sender. However, Powerpoint was not designed for messaging, so users using it that way to a large extent have to create their own grammar for ordering and showing who created what annotations. Microsoft Office 2000 does allow the user to place a "comment" on a slide resembling a "sticky note" and associate a person with that comment, but otherwise there is little support for tracking annotations about the contents of a slide and the slide show in general[7]. The slide show structure itself is, however, simple and the inherent decomposition provides a means for attaching context to particular annotations on a slide.

Microsoft Word

Word is normally used for creating largely text-based documents, but with figures sometimes included. Although classified as a word processor it actually has many of the features

[7] Microsoft Powerpoint does contain a built-in link to the program Microsoft Netmeeting for synchronous discussion about a slide show. There is apparently also support for asynchronous discussion, in what the documentation describes as resembling the structure of a newsgroup, if a group of collaborators are all connected to a server with Microsoft Office Server Extensions.

that were once only associated with desktop publishing programs. The built in annotation features are clearly designed for people collaborating to produce a Word document as the end product of their work. Of course, not all communications are concerned with producing an increasingly refined artifact that is part of the communication.

Figure 3.7 shows how a comment can be created in a separate window from the main text. A comment can be in the form of text or audio. What is created is really a "hypercomment" so that pointing at text which has a comment linked to it causes that comment to appear in a popup window[8]. Figure 3.8 shows support for navigating through a series of comments, and controlling changes to the document.

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[8] Wojahn et al's (1998) *Split-Screen Interface* is essentially the same as in Microsoft Word except the comment did not popup when the mouse pointer was passed over the text that had a comment attached to it.

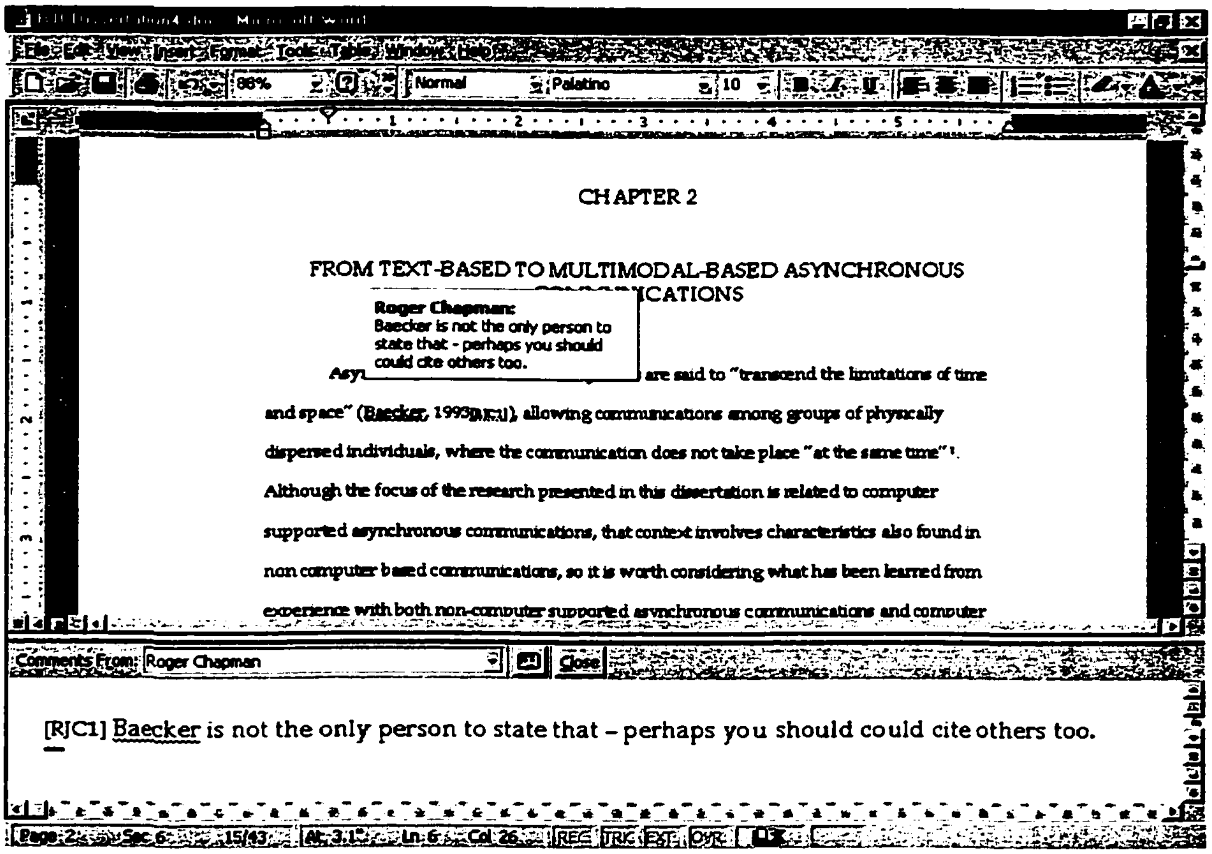

Figure 3.7 A comment in Microsoft Word

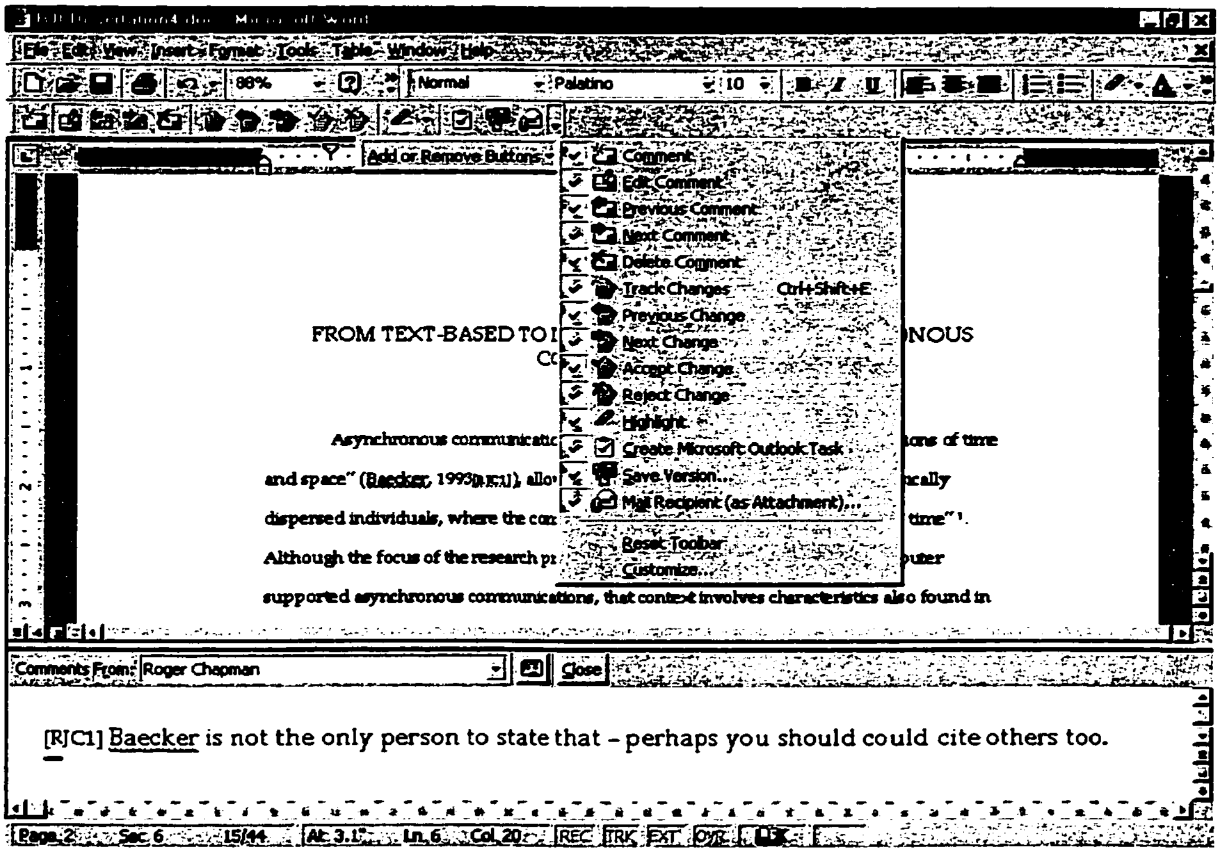

Figure 3.8 Comment management in Microsoft Word

While Word is quite sophisticated in placing annotations within and between text and handling issues of control between users, it does not support very well placing an annotation at an x, y position on an image or notational pen marks over that image suggesting possible changes to the image or the world it represents. Figure 3.9 demonstrates that an arrow can be placed pointing to part of an image, but controlling the placement of text or pen marks overlaid on an image is a difficult formatting process. Figure 3.9 actually not only involves a marking on the image, but between the text and the image, making for very little momentum loss as the reader moves between the two.

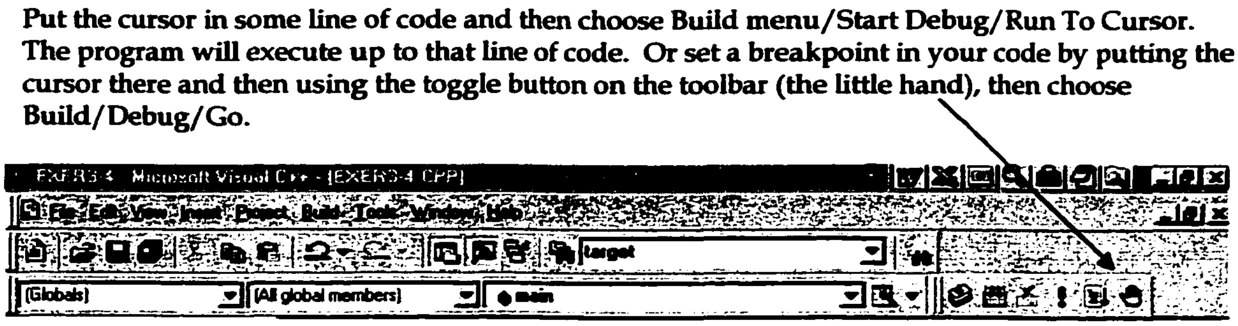

Figure 3.9 A reference to an object in Microsoft Word made explicit

Microsoft Excel

Excel also supports hypercomments, but they are attached to cells rather than chunks of text. Figure 3.10 shows a comment attached to a column header. Again Excel supports navigating through the sequence of comments created, but it does not directly support audio based comments[9].

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[9] Audio files may be attached to a cell as an "object", as may other file types.

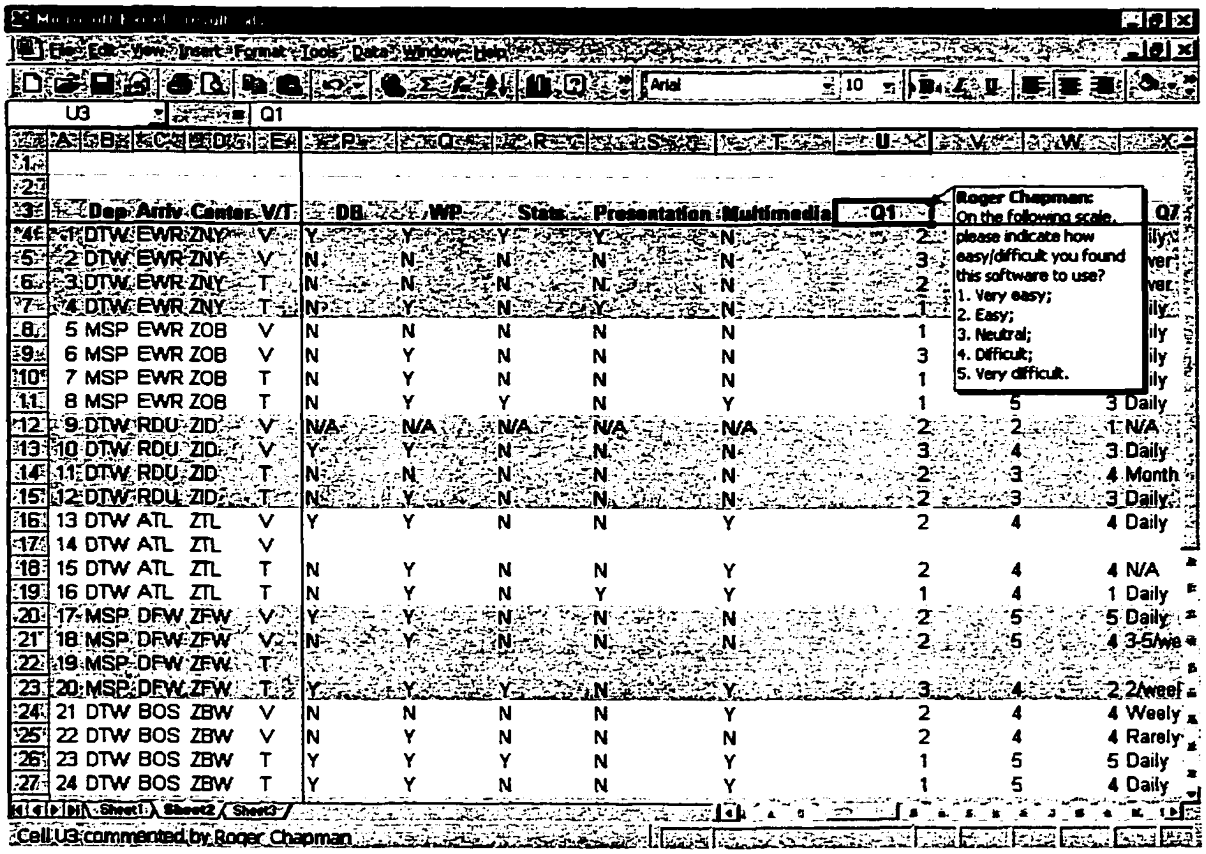

Figure 3.10 A comment in Microsoft Excel

Microsoft Paint

There are a large number of graphics programs that allow annotation of a single image. If providing an annotated "picture" significantly enhances the context of a message these programs can be useful to create a more fully descriptive message. They are not multimodal, but they provide a means to create external memory annotations that can be referred to with audio and text communications. Microsoft Paint is a program that has a modest number of annotation options. The fact that this type of program is considered fundamental is demonstrated by its inclusion in the Microsoft Windows operating system.

E-mail systems with html formatted content

The Hypertext Markup Language (HTML) is the basic language used to create web pages, but a number of E-mail programs now provide it as an option to format the content of a message. E-mail messages in this case have the same potential for formatting as web pages. They may then, for instance, include text and images in the content of a message, as shown in Figure 3.11. Additionally, an audio or video recording could be part of the message with hypertext/"hyperimage" links to those recordings. They don't support annotations tools such as a freehand pen or arrows.

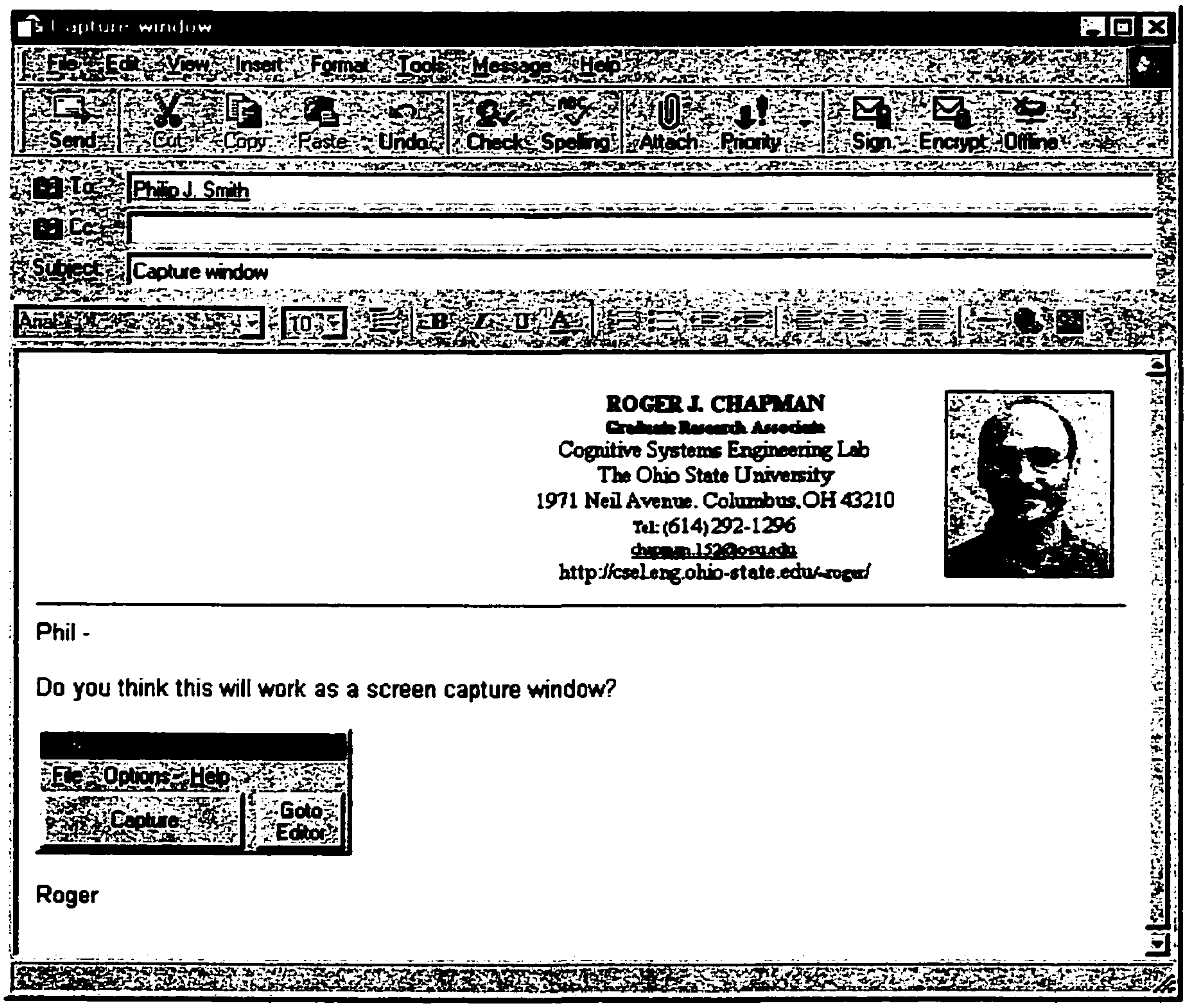

Figure 3.11 An html formatted E-mail message

RealNetwork's RealSlideshow

RealSlideshow is another application centered on the idea of creating a presentation as a series of slides. It is however different from Microsoft Powerpoint in several ways:

1. It focuses much more on synchronizing voice and a series of images.
2. Figure 3.12 shows the main window where the user can place a series of images and voice-overs within the very visual temporal frame of reference.
3. As shown in Figure 3.13 it assumes the images are already created although it does allow captions to be assigned to each image, rather like subtitles can be used in a movie.
4. Saving the slide show creates a streaming media slide show, which is particularly useful if the recipient(s) can not access the Internet with a fast connection.

It is unfortunate that only a preview of the image is seen as a voice-over is created for it. Adapting RealSlideshow for use as a messaging system is possible, but it is particularly difficult to try to reuse the content of a sender's message.

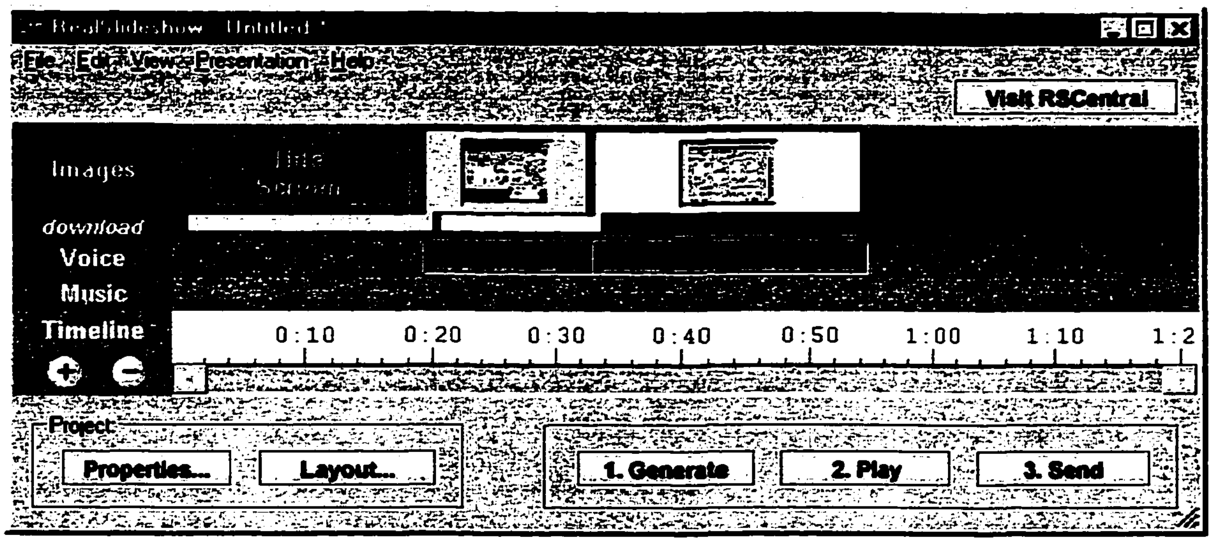

Figure 3.12 A RealSlideshow slide show

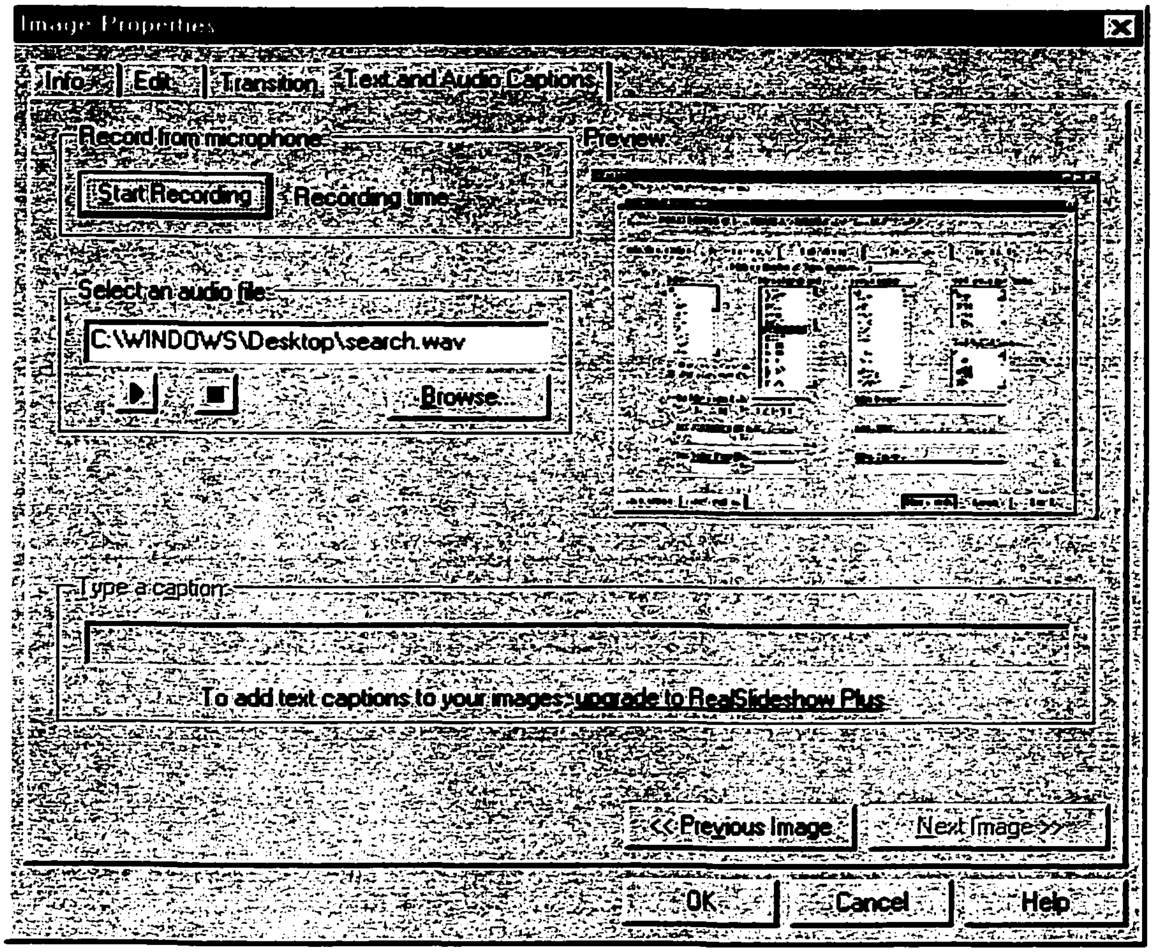

Figure 3.13 An audio caption in RealSlideshow

CHAPTER 4

COLLABORATIVE ANALYSIS OF NATIONAL AIRSPACE SYSTEM POST OPERATIONS DATA AS A TEST BED

Introduction

Decker (1987) describes a taxonomy of problems for distributed systems that has four dimensions: (1) the level of decomposition (granularity); (2) the distribution of expertise; (3) the methods for achieving distributed control; and (4) the process of communication. In this chapter the NAS is overviewed with particular attention to the nature and significance of communications in the system, and its relationship to the other key factors that Decker describes. The Post Operations Evaluation Tool is also described in this chapter, with particular attention given to the information it contains that can be shared between the airlines and FAA; its representation; and the impact of that representation on multimodal systems that might be used for communications. The type of information not contained in POET that might also predictably be discussed is also described.

The National Airspace System

The NAS is certainly a large, complex system. One dimension of this is the amount of traffic that is actually involved. There are from 4,000 to 6,000 aircraft operating in the NAS during peak periods, which equates to approximately 50,000 aircraft operations per day (http://www.fly.faa.gov/Information/information.html). Figure 4.1 shows approximately 5,000 aircraft operating in the system at one time, although the aircraft are obviously not drawn to scale

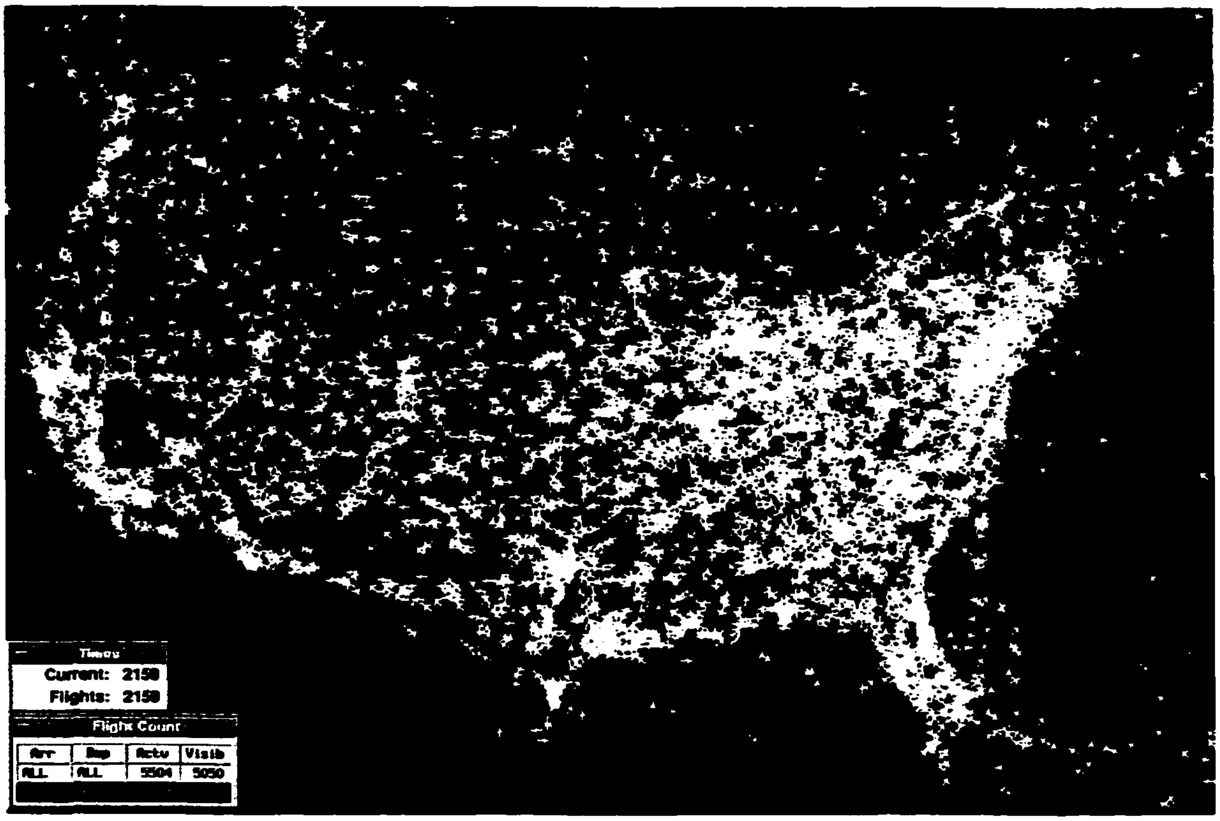

Figure 4.1 5,050 aircraft simultaneously operating in the NAS (http://www.fly.faa.gov/Information/information.html)

Agents

The FAA defines the NAS as "The common network of U.S. airspace; air navigation facilities, equipment and services, airports or landing areas" (www.fly.faa.gov/ Glossary_of_Terms/acronyms.html). While the components mentioned are part of the NAS, the definition is misleading in that it doesn't mention the people or their organization that are a critical part of the system. The tasks they perform are essential and the design of these tasks and the environment in which they are to be performed is a critical design within the system.

The FAA and the major airlines both have a major impact on how the NAS is used. Some of their key strategic and tactical decision makers concerned with traffic operations and management are as follows:

Airline personnel

1. Pilots and other flight crew members, responsible for individual flights;
2. Dispatchers, within the Airline Operation Centers (AOCs), who are jointly responsible with flight crews for flight safety;
3. Air Traffic Control Coordinators (ATCCs) who are responsible for air traffic control liaison on a daily operational level.

FAA personnel

1. Air Traffic Control System Command Center (ATCSCC) personnel, who have primary responsibility for ensuring a safe and efficient flow of air traffic through the system. They have primary responsibility for national strategic air traffic management;
2. Traffic Management Unit (TMU) personnel at enroute Air Route Traffic Control Centers (ARTCCs) and TRACONS;
3. Air Traffic Controllers (ATCs) in these enroute Centers and in Terminal Area Traffic Control and Airport Control facilities. These people are responsible for tactical air traffic control.

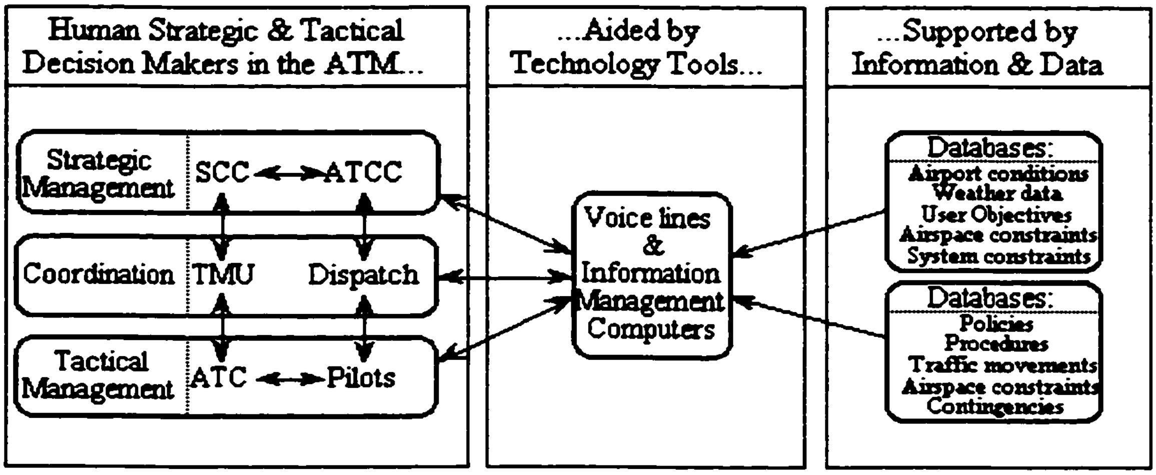

Figure 4.2 A concept of the traditional air traffic management operational process (Smith, et al., 1999)

Figure 4.2 shows what Smith et al., (1999) refer to as the traditional air traffic management operational process, because of the hierarchical nature of the control and communication channels between strategic and tactical decision makers. As will be discussed, the actual channels can vary depending on the task.

Information Technology

As a cognitive system, the NAS can be considered to involve both human and machine cognitive agents, and the interactions that occur between all agents are often critical. There is also diversity in the purpose for which technology exists in the NAS (Billings 1996), but here the focus will primarily be on technologies intended to provide information and support communications related to flight management. As Figure 4.2 shows, these information systems can serve a number of purposes and their autonomy can vary too - some passively providing situation awareness data for human decision makers to use; some assisting in planning and scheduling by maintaining constraints; some more actively implementing decision making procedures; and some providing computer mediated communications.

Goals

The NAS is complex in part because of the number of individual agents and objects in the system, but there is also diversity in the tasks being performed and the goals in performing those tasks. At an organizational level there are some differences because of the different goals of the respective organizations. The FAA is interested in the efficient use of the airspace, and part of that philosophy is captured by the fact it refers to the airlines as "the customers". At the same time it must also act as both a policing organization and a refereeing organization, as it is concerned with both safety and fair competition between its customers. The airlines are also interested in efficient use of the airspace, but so they can provide a profit making, competitive, quality service to the customers they carry on their flights. Both the FAA and airlines are also of course concerned with safety.

Matching Data with Control

As shown in Table 4.1, historically, traffic flow management has been a function under the control of the FAA, with traffic managers at various facilities making decisions about what routes could be flown by flights scheduled by the airlines. The first major change arose in 1992, with a shift from "management by direction" to "management by permission" (Smith, et al., 2000). This allowed the airlines to request non-preferred routes (routes for flights that differed from the FAA-assigned preferred routes). An airline could send a message via teletype to the ATCSCC requesting an alternative route for a particular flight. A specialist would then evaluate this request, checking with traffic managers at the involved regional ARTCCs, and approve or disapprove it.

1. Management by Direction:	
FAA traffic managers simply inform an airline regarding the route that can be used by a particular flight	
2. Management by Permission (1992-1995):	
A default flight plan is assigned by the FAA, which can be revised if the Airline Operations Center requests an alternative and receives permission from FAA traffic management staff	
Benefit from change	*Cost from change*
• Increased understanding by users of provider and system constraints from one-on-one interactions between TMUs and AOCs • Increased understanding by providers of user economic and operational needs	• Increases in the time, and therefore personnel, required to accomplish these interactions concerning requests for exceptions to the preferred route structures; • The increased flexibility afforded to airspace users, while considerable, was still felt to be inadequate by air carriers.
3. Management by Exception (1995-present):	
An Airline Operations Center can simply file the flight plan that it desires, subject to some basic constraints, for a given flight	
Benefit from change	*Cost from change*
• Greater flexibility for users to accommodate economic and other business objectives • Potentially, an ATM system that is more directly responsive to user requirements and needs, as the users now have a way to express their preferences for routes very clearly (by actually filing those routes)	• Significant additional information must be considered by dispatchers if AOCs are going to plan effectively around known or predicted ATC constraints • Less information and knowledge exchange occurs between TMUs and AOCs, because users do not have to interact with traffic managers prior to executing their plans.

Table 4.1 Changes in the distribution of control and data for traffic flow management in the NAS (adapted from Smith, et al., 2000)

Management by permission gave the airlines a means to try to improve their efficiency as a routine mechanism by which they could request more economical flight plans for their aircraft. It also caused routine interactions to occur between airline ATC Coordinators, ATCSCC traffic specialists and TMU staff, giving each group a broader understanding of the factors considered by the other group, resulting in more effective and efficient interactions. The primary weakness of this paradigm was that it was manpower-intensive and was thought by the airlines to be excessively conservative at times in the approval of requests for alternative routes.

Although the management by permission architecture was viewed as a significant improvement, in 1995, its perceived limitations were sufficient to motivate a revised program based on "management by exception". This new program, known as the expanded National Route Program (NRP), allowed the airlines, subject to certain constraints, to file the routes that they preferred for each flight. FAA traffic managers would then monitor conditions, watching for situations (such as severe weather) when the program had to be canceled temporarily in particular portions of the country. This architectural change significantly altered the allocation of control, requiring dispatchers to consider factors (such as the prediction of air traffic bottlenecks) that in the past had been handled largely by FAA traffic managers, if the dispatchers wanted to file effective routes.

As these approaches demonstrate, there are some standard questions that can be asked when considering the distribution of control and data:

1. Does the person or group in control of a situation have the data or knowledge to support an effective decision?
2. Does the person or group with the data or knowledge have control to make a decision?
3. Are there interactions when the data and control don't reside with the same person or group?

Communications

Communications in the NAS have evolved to produce diversity. For instance, the ATCSCC provides a regular Strategic Planning Team (SPT) teleconference to allow the Command Center, ARTCCs, airport tower and airline representatives to interact in real-time and discuss plans to respond appropriately to forecast weather and other events that will impact traffic. Increasingly the ATCSCC is using the Web to broadcast procedures as well as to provide real-time data such as traffic advisories (Federal Aviation Administration, 2001). The Collaborative Convective Forecast Product (Aviation Weather Center, 2001) is used to issue 6 forecasts a day after chat discussions between the FAA and airline's weather experts. ACARS is used to transmit text-based messages to and from flight crews. Email is used to transmit messages and documents within organizational networks and on the Internet. The impact of the communications method on a particular task in a particular context is important.

Two general questions that can be asked with regards to communications are:

1. Does the system reliably and efficiently support the transfer of relevant and meaningful data?
2. Is the information and data exchange synchronized with the collaborators' tasks?

The Post Operations Evaluation Tool

Introduction

The FAA's Collaborative Decision Making (CDM) program (Metron, Inc., 2001) has been developing a collection of tools that help groups in the NAS collaborate to reduce congestion and improve NAS efficiency. One such tool is the Post Operations Evaluation Tool (POET). It allows users to review an individual flight or collections of flights and display flight details and performance metrics including departure, en route, and arrival delays and filed versus actually flown flight tracks. The evaluation tool's server is installed at the Air Traffic Control System Command Center (ATCSCC) with access to archived FAA Enhanced Traffic Management System (ETMS) data that is updated on a daily basis. The Post Operations Evaluation Tool has the capability to integrate FAA data with airline provided flight data (such as the predicted vs. actual fuel consumption, or taxi in and out times) to give a more complete picture of what is happening in the NAS. Thus, because its information comes from data obtained from both the FAA and the airlines, it can provide information to both groups, and because it allows flights to be aggregated it can also be used to reveal patterns that might otherwise not be detected.

Conducting a Search

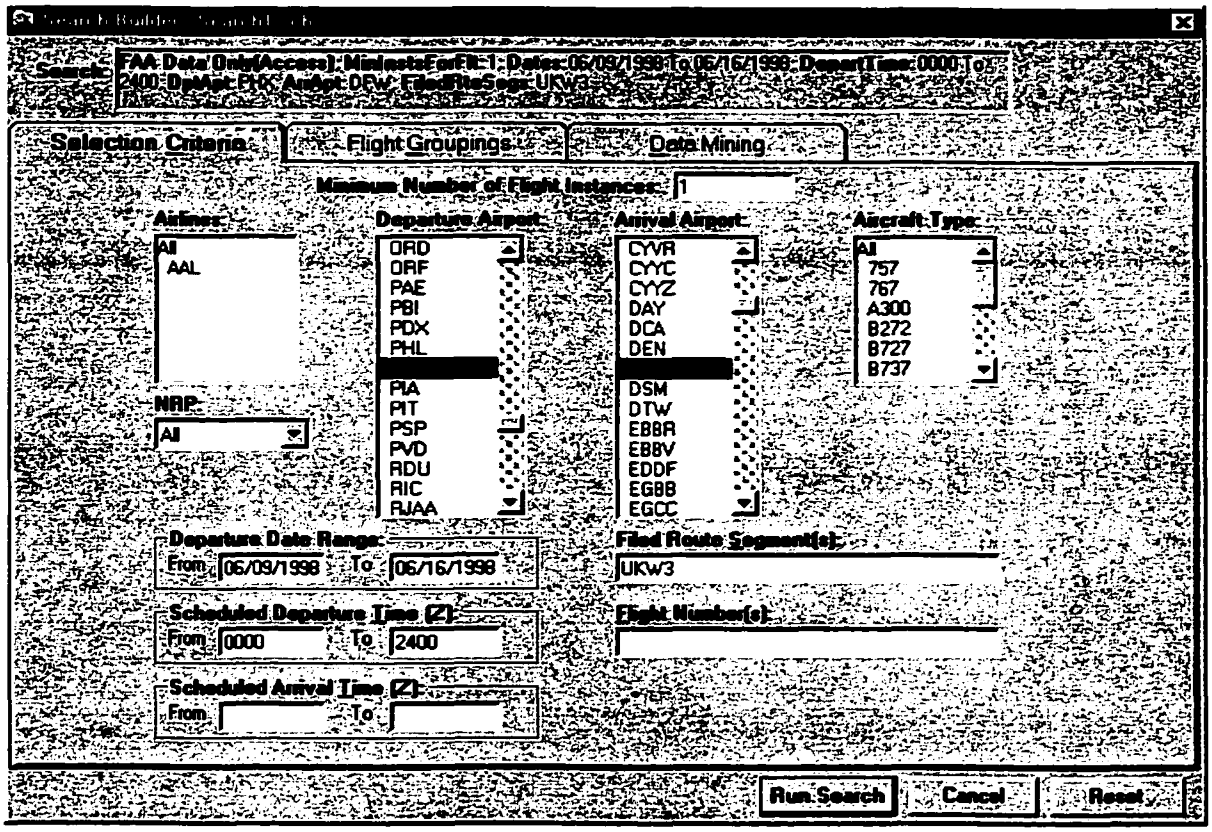

Figure 4.3 The search builder window

Figure 4.3 shows the Search Builder window, which is used to create the initial query of the database. The **Search Builder** window is automatically opened when POET is started. Building a search involves selecting or entering items in the fields under the **Selection Criteria, Flight Grouping**, or **Data Mining** tabs. The **Run Search** button at the bottom of the Search Builder window is for carrying-out the search. At any time the **Cancel** button may be used to cancel the search building and return to the previous screen. Clicking the **Reset** button returns all Search Builder fields to their default states. A search summary representing the current state of the Search Builder tabs appears at the top of the Search Builder window. As entries in the different fields are changed the search summary is also changed automatically.

The same search summary is displayed on many other POET screens to identify the current search. The **Selection Criteria** tab allows a search to be focused by restricting the flights returned to those that have a particular set of characteristics. In the example shown in figure x, the flights returned are restricted to those flying from PHX to DFW, departing between 6/9/98 and 6/16/98 that were filed through UKW3, the northwest cornerpost for DFW. More specifically, each criterion is defined as follows:

- The **Minimum Number of Flight Instances** field specifies how many instances of a flight must match the conditions specified in the Search Builder window for that flight to be included in the results. The default number is 1, but this default may be changed by selecting File from the Menu Bar, then selecting Poet Properties..., then selecting General Options, and finally typing the new number in the **Default Minimum Number of Flight Instances** field. (In POET a flight is defined as a collection of flight instances that occur day after day, such as a month of flights from PHX to DFW scheduled to depart at 1437Z.)
- The **Airlines** field is used to specify the airlines to be included in the search. More than one can be selected.
- The **Departure and Arrival Airport** fields are used to specify the departure and arrival airports to be included in the search, respectively.
- The **Aircraft Type** field is used to specify the aircraft types to be included in the search. More than one type can be selected.
- The **NRP** field is used to specify whether flights that were filed under the North American Route Program are to be included in the search or not. The value for this field can be All, NRP Only, or non-NRP Only.
- The **Departure Date Range** fields are used to specify a block of consecutive departure days to be used in the search. A matching flight instance must have departed on or after the **From** date and before or on the **To** date. The form for both the From and the To field is mm/dd/yy (e.g. 4/1/98, 04/01/98).

- The **Scheduled Departure Time(Z)** fields are used to restrict matching flight instances to those that have a scheduled departure time on or after the **From** time and before or on the **To** time. In both cases Zulu times are used.
- The **Scheduled Arrival Time(Z)** fields are used to restrict matching flight instances to those that have a scheduled arrival time on or after the **From** time and before or on the **To** time. In both cases Zulu times are used.

  The **Filed Route Segment(s)** field defines a comma separated list of route segments that must match the route filed. Examples:

TXO	TXO included in route
TXO.UKW3	TXO.UKW3 included in route
JEN, UKW3	JEN or UKW3 included in route

- The **Flight Number(s)** field defines a comma separated list of flight numbers. A matching flight instance's flight number must be one of these.

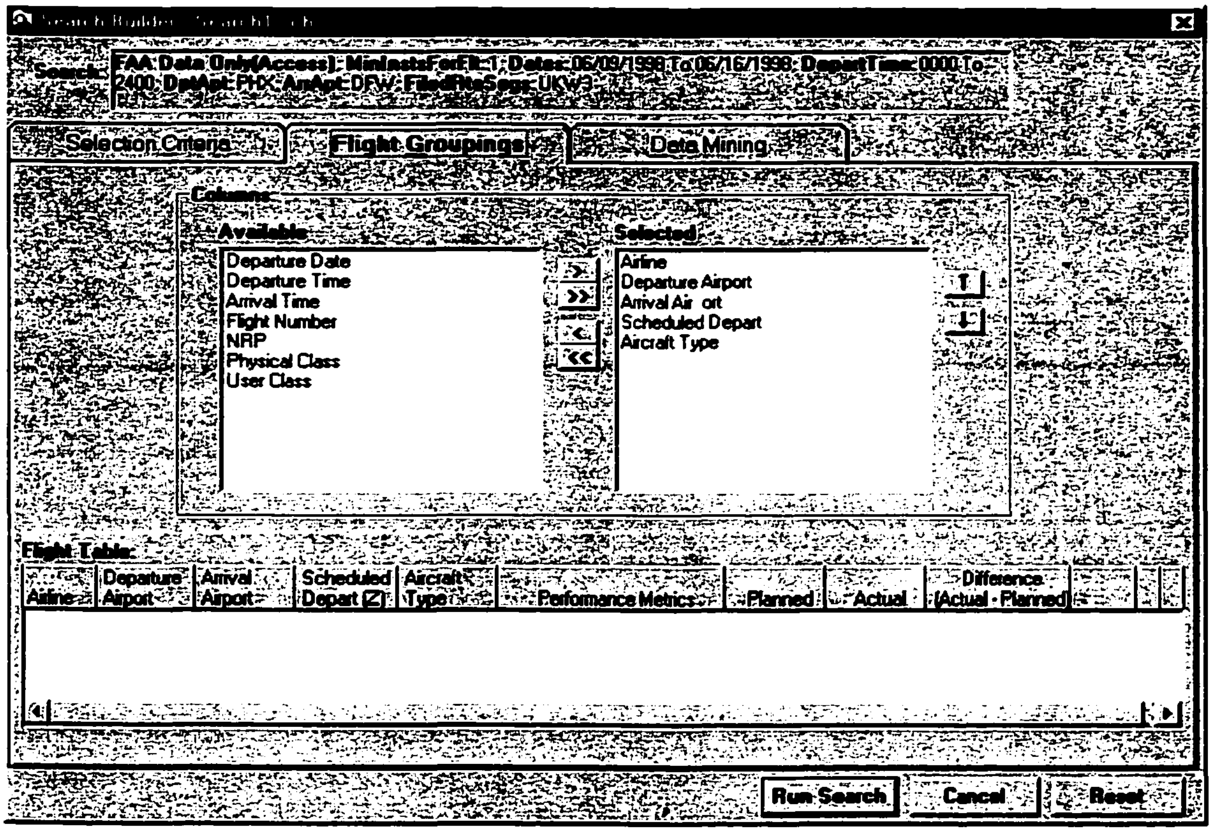

Figure 4.4 The flight-grouping tab

The **Flight Grouping** tab shown in Figure 4.4 is used to decide how flight instances found by the search will be grouped in the Flight Table. With the default columns (Airline, Departure Airport, Arrival Airport, Departure Time, and Aircraft Type) selected, groups are produced that each have a unique combination of values for these criteria, and where there is at least one flight instance for the group found by the search. If one of these criteria is removed as a column in the table, flight instances will no longer be grouped separately by that criterion.

The **Columns** frame is used to make changes to the list of selected columns and the **Flight Table** below it shows how the Flight Table will appear with the current settings. Double clicking on a field in either the **Available** or the **Selected** list will move that field to the other list. Alternatively, after clicking once on a field in the Available or Selected list the right arrow or left arrow button, respectively, may be used to move that field to the other list. To move all fields at once the double right arrow or double left arrow button can be used. The down arrow and up arrow buttons may be used to change the order of the selected fields by highlighting a field and using the appropriate arrow. Note: the last four columns shown in the Flight Table above, (Performance Data, Actual, Planned, and Difference), are actually fixed as these fields are always used in flight tables.

Data Mining

Additionally, there is built-in a collection of data mining tools to assist the user in recognizing patterns and trends within the data. Some of the patterns currently recognized include *circular airborne holding*[10], arrival fix swaps, and flown routes that differ significantly from the routes filed.

Clicking on the **Explore Data Mining** button in the Flight Table window produces the Data Mining environment for the flight instances included in the selected row of the Flight Table when the button is used.

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[10] The holding pattern is actually more "race track"shaped.

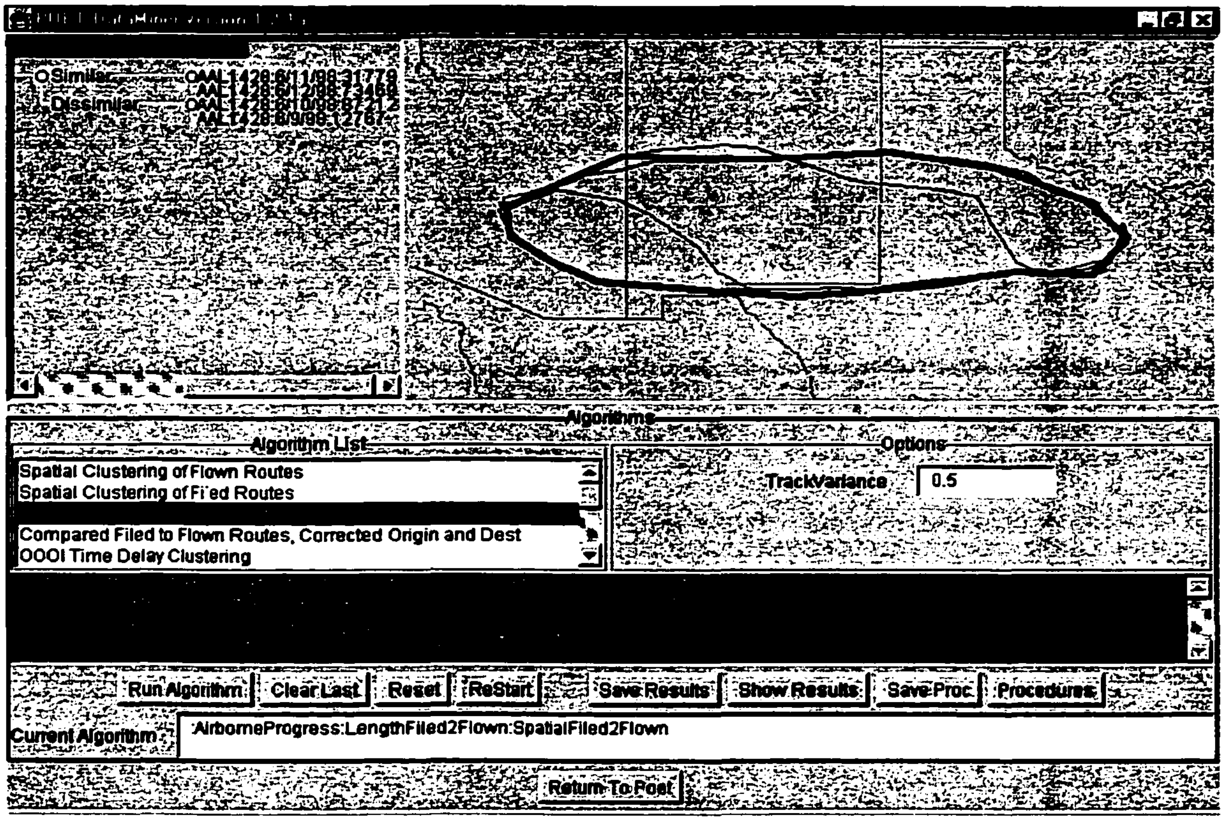


Figure 4.5 The data mining environment

The data mining environment includes a **Flight Display Panel** and a **Algorithms Selection Panel**, as shown in Figure 4.5. The display panel shows the tree structure of Flight IDs (FIDs) and a 2-D map view of flight routes. The **Algorithm List** shows all the algorithms available. A algorithm is selected by clicking on it. The **Options** panel displays the available options associated with the current algorithm. Below the Algorithm List and Options panel a brief description of the algorithm is displayed in the **Description Text Box**. Below this are a number of buttons for running the algorithms and managing the results. Below this the **Current Algorithm** field displays the algorithm or algorithms that have been run and for which results are displayed in the Flight Display Panel.

Algorithms may be run sequentially. When this is done, the Data Miner continuously clusters the results of prior algorithms. The Current Algorithm displays the sequence of algorithms that have been run, separating each with a colon (:).

Data Mining Algorithms

Spatial Clustering of Filed Routes
Groups routes based on the similarity of their filed flight plans. Similarity is determined using the Spatial Similarity Algorithm (SSA). Filed flight plan information is contained in the RT message portion of the POET database.
Options: Track Variance

Spatial Clustering of Flown Routes
Groups routes based on the similarity of their flown flight paths. Similarity is determined using the SSA. Flown flight path information is contained in the TZ message portion of the POET database.
Options: Track Variance

Compared Filed to Flown Routes
Compares a flown flight path to a filed flight path and flags the flown path as either similar or dissimilar. The SSA is used to generate a variance, which is compared to the user specified threshold, and perform the grouping.
Options: Track Variance

Compared Filed to Flown Routes, Corrected Origin and Dest
Since TZ messages are generated while the aircraft is actually in the air, the origin and destination point may not be contained in the flown flight path. This may lead to erroneous results when comparing the flown and filed flights. This algorithm is virtually identical to Compared Filed to Flown Routes with the exception that the origin and destination points are inserted at the beginning and end if not found in the TZ message.
Options: Track Variance

OOOI Time Delay Clustering
OOOI is an acronym for Out of Gate, Off the ground, On the ground, Into the gate. In each instance the algorithm calculates the difference or delay, in minutes, between the filed plan and the actual event. A single parameter (Delta Time) is specified as a threshold. Routes are then identified as falling under the threshold delay or equal to/greater than the threshold delay. The OOOI options are mutually exclusive choices which can be chained together by running them sequentially.
Options: Out Time On Time Off Time In Time Delta Time

Compare Cruise Route
Analyzes amendment messages for chosen routes to determine whether any changes occurred in the aircraft's flight plan. It compares the FZ flight plan message against the AF messages and returns as soon as one of the following determinations is made: (a) the flight was changed on the ground, (b) the flight was changed in air, (c) the flight was diverted, or (d) the flight was not changed. This analysis occurs outside the SID and STAR portions of flight, i.e. for the cruise portion only.
No Options

Length Comparison of Filed to Flown
This is a straightforward algorithm that compares the sum of segment lengths of the filed route and the flown route. It creates three groups: Longer, Equivalent and Shorter. A route is Longer if its filed length is (1 + Longer%) percent longer than the Flown route length. A route is Shorter if its Filed route length is (Shorter%) percent shorter than the Flown route length. Otherwise, the route is marked Equivalent.
Options: Longer % Shorter %

Efficiency Determination Based on Delay and Fuel Burn
One measure of efficiency as applied to aircraft routing is airborne delay and fuel burned. A simple measure of efficiency using airborne delay and fuel burned is to define a straight line function with percent more fuel burned and delay in minutes. The vertical axis (fuel delta) is the difference between actual and planned fuel burn, while the horizontal axis (airborne delay) is the difference between actual and planned flight time. The line connecting the threshold fuel burn (Fuel Burned %) and delay (Delay (mins)) values marks the boundary between inefficient and efficient flights. All points that fall above the line are deemed inefficient while all points below are deemed efficient.
Options: Delay (mins) Fuel Burned %

Airborne Holding

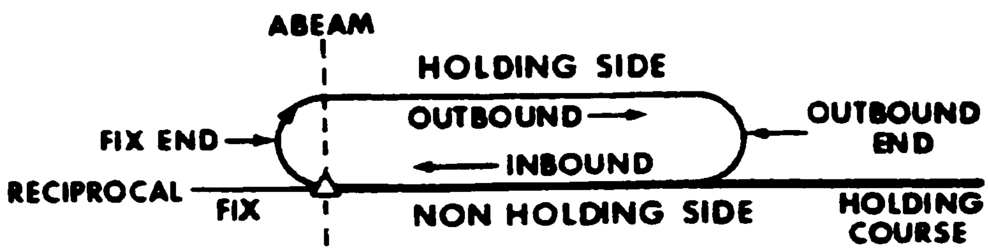


Figure 4.6 Portions of a holding pattern (Stern, J. M. 1998)

Airborne holding occurs when a flight is put into a temporary race-track shaped flight pattern, as shown in Figure 4.6, in order to achieve better spacing, wait for weather conditions to improve, or absorb a delayed approach into an airport. Holding normally occurs relative to previously established holding fixes that appear on aviation charts. Because instances of holding are not normally captured as such elsewhere in the NAS, an algorithm needed to be developed for POET to automatically detect holding based on the flight path actually flown. The algorithm applied to each individual flight uses a time ordered sequence of x-y coordinate position values, time value, and Center value. The algorithm is essentially as follows:

1. Approximate the path flown between individual "radar hits" with straight lines and consider one line crossing another as potential evidence of a flown holding pattern, with the intersection close to the holding fix.
2. In order to avoid false alarms the following was also required to consider holding to have occurred:
    a. The intersection is ruled out if it occurs within 30 miles of the origin and 10 miles of the destination, as a flight path may cross itself during arrival or departure.
    b. The time of radar hits are specified in minutes. Because the merging of data from radar in different Centers' regions was found to generate false alarms close to the point where a flight path leaves one Center region and enters another, some points were removed as a simple method for "cleaning" the input stream of flight path portions and speeds that would be very unlikely or impossible. Specifically, if the time sorted list of points produces a point from one Center, then from another, and then from the first Center again, the second Center's point is filtered out. When both the next points are from a different Center than the current one, the next point is only accepted if it is at least 3 minutes later than the current one.
    c. The area created within the "loop" detected by the algorithm has to be at least 10 square miles.

Because this is a data-mining algorithm (i.e. applied to a very large number of records in a database), efficiency of the algorithm is important to reduce run-time. Thus, in the future there might be some benefit in developing a list of holding fixes for each city pair to simplify the search algorithm. This might also improve the accuracy of the algorithm, as it is currently conservative in detecting holding. At present a short hold can easily be missed if the sampling of points does not happen to generate an intersection when those points are connected. A "spike" in the flight path close to a known holding fix might be sufficient to accurately detect holding.

POET Results

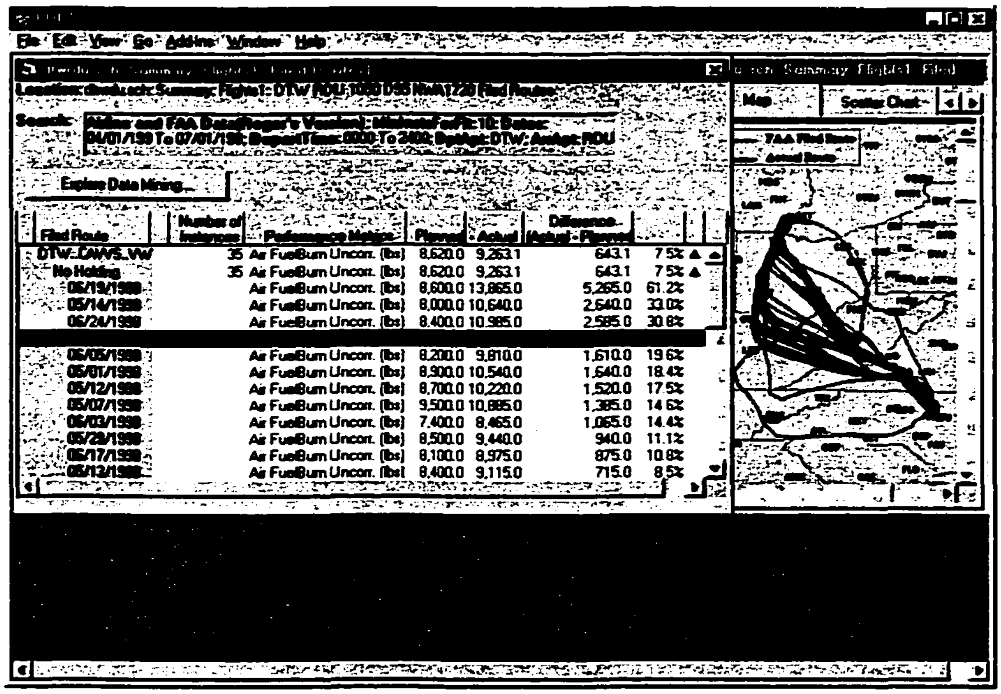


Figure 4.7 Repeated pattern across flight instances

The ability to see multiple instances of flights with a common set of attributes over an extended period of time is useful for finding what is systematically happening to those flights. Figure 4.7, for instance, shows quite clearly a pattern of deviations to the south from the planned route for a particular flight over a three-month period. The ability to plot performance metrics over time can reveal clusters of flights in a particular time period, and also indicate how an average performance value is found in a representation much more meaningful to the average user than, for instance, an indication of mean and standard deviation. The tabular data can also be sorted by performance metric values to allow the more extreme flights groups to be investigated first as a simple searching heuristic.

Figure 4.8 The performance summary table

When a successful search is complete a performance **Summary Table** appears, such as shown in Figure 4.8. The search summary in the **Search** field is the same as the corresponding Search Builder window. The **Total Flights** field contains the number of flights that were returned by the search. The **Total Instances** field is the number of instances of these flights.

The **Air Time** is the time between the takeoff and landing. The **Off Time** is the takeoff time. The **On Time** is the landing time. The **Minimum Average Difference** is the minimum average difference between the actual and predicted performance parameter values of the flights found. The **Maximum**

Average Difference is similar to the Minimum Average Difference, except that it is the maximum value rather than the minimum that is shown. Thus, if there were two flights found in a search and one had an average air time difference for its flight instances of 3.1 mins and the other 5.7 mins, the Minimum Average Difference on the Air Time row would display 3.1 and the Maximum Average Difference 5.7. (Note for the air time the difference between the actual and planned is shown as a percentage of the planned.)

Double clicking on a row in the table produces a more detailed table focusing on the respective performance data parameter and automatically opens the **Displays** window with the **Scatter Chart** and **Bar Chart**. In general, in POET, double clicking on any flight table row will produce more detail on the information shown in that row.

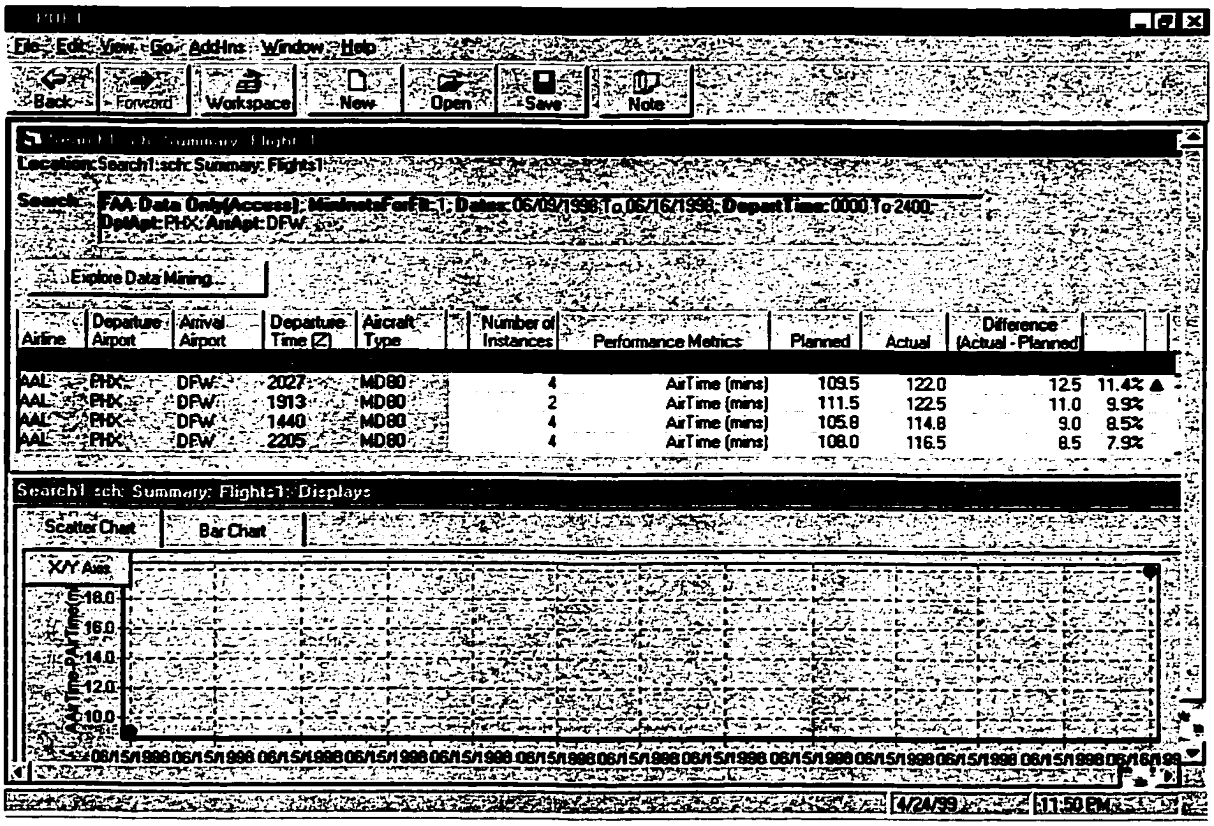


Figure 4.9 Flight level details

After double clicking on a row in the Summary Table, a **Flight Table** focusing on the respective performance data parameter is produced. In the example shown in Figure 4.9 Air Time (mins) was selected from the Summary Table, thus the **Planned** and **Actual** fields represent average planned and actual air times. Each row in this table is a flight and the number of instances of each flight are shown in its **Number of Instances** column. By default, the rows are sorted in descending order by the **Difference** field. The **Airline, Departure Airport, Arrival Airport, Departure Time,** and **Aircraft Type** fields appearing in the table are the default fields that may be changed by using the Flight Grouping tab in the Search Builder window.

At the end of a row there will sometimes be one of three special symbols. A ▲ means that there is at least one filed route for the flight that has a statistically significant high average difference (actual - planned) for the instances of that filed route. Similarly, a ▼ means there is at least one filed route that has a low average difference. A ⧗ means there is at least one flight route that has a significantly high average difference and at least one flight route that has a significantly low average difference. The Filed Route Table reveals specifically, which filed routes where statistically significant. Double clicking on a row in the Flight Table produces the Filed Route Table for that rows flight.

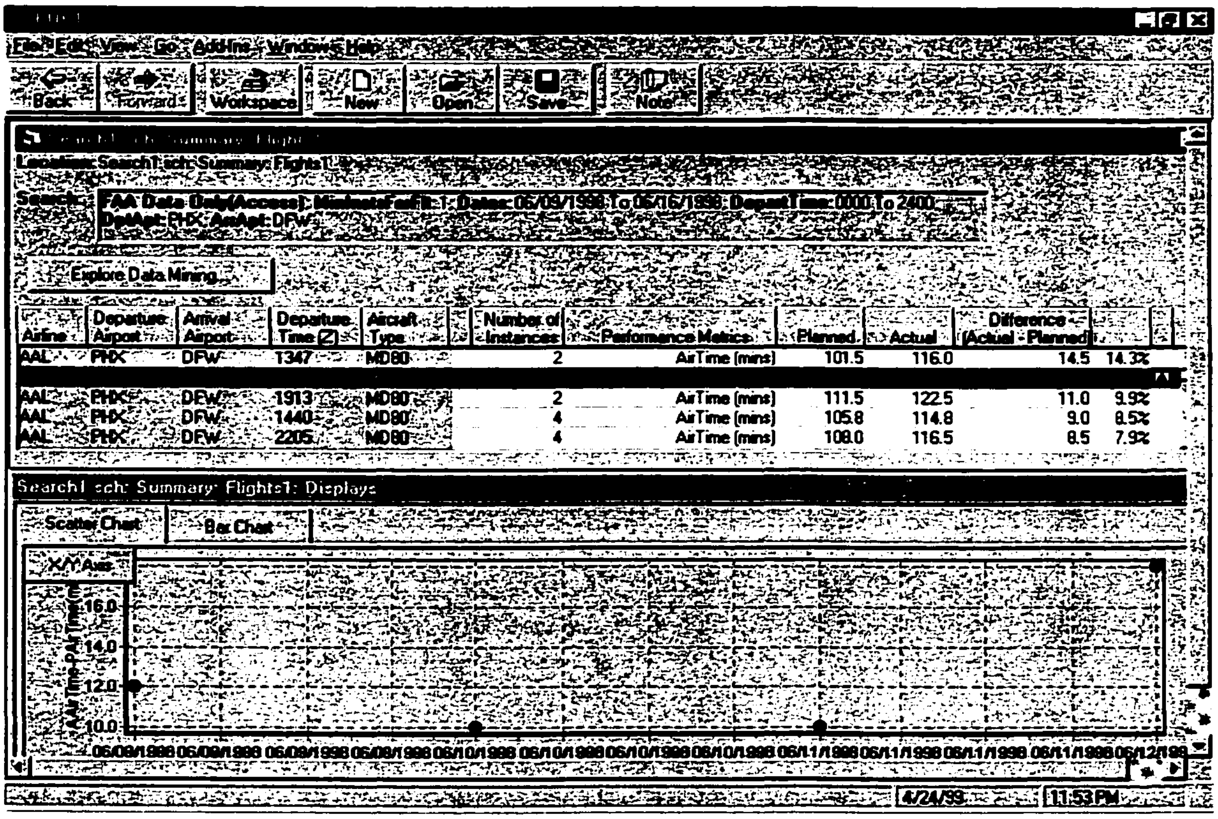


Figure 4.10 The scatter chart window

A **Scatter Chart**, such as shown in Figure 4.10, appears automatically with the Flight Table when a performance parameter is selected from the Summary Table. The Scatter Chart presents the performance parameter data for each flight in a graphical form that helps in the detection and visualization of relationships between parameters and unusual values. As a different row is highlighted in the table the Scatter Chart is changed to reflect the new flight's data. Each dot in the Scatter Chart represents one flight instance. If that dot is double clicked, the Flight Instance Window for that flight instance appears.

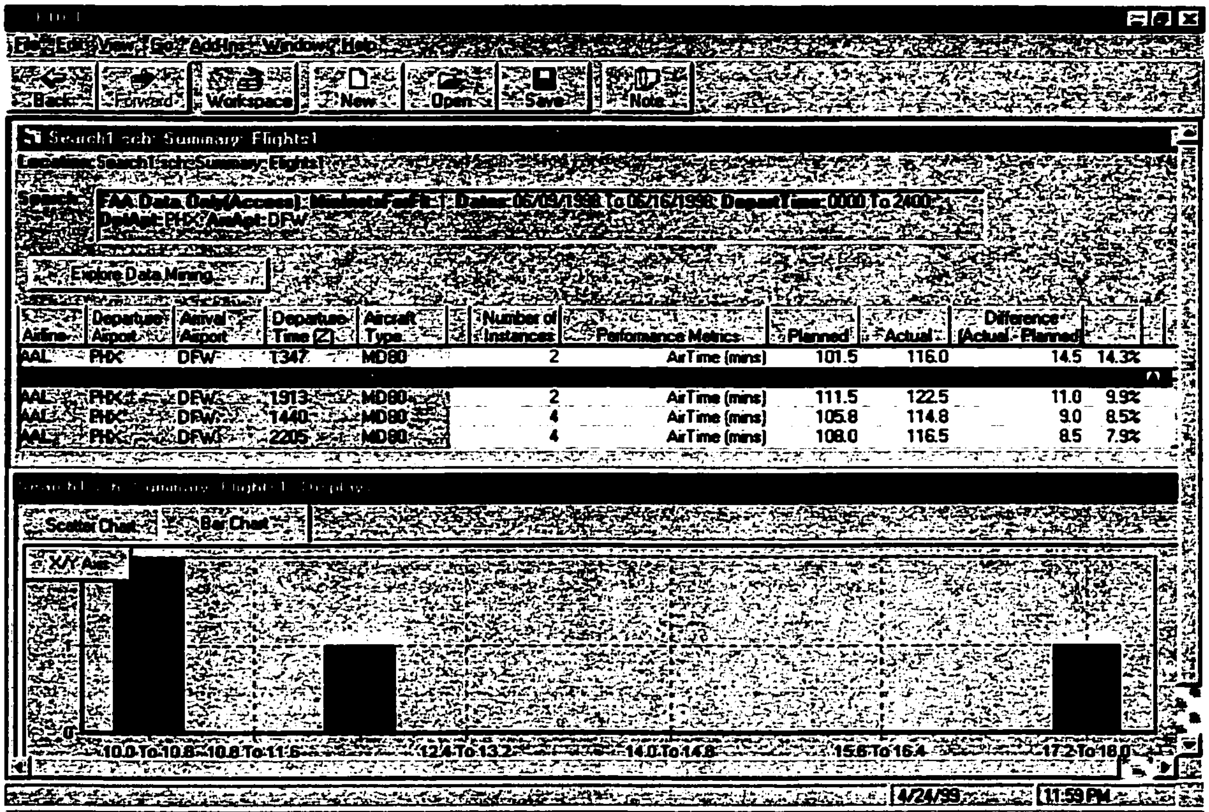


Figure 4.11 The bar chart

A **Bar Chart**, such as shown in Figure 4.11, describing the instances of a flight can be produced by clicking on the "Bar Chart" label at the top of the Bar Chart tab. The Bar Chart's y-axis is always the number of occurrences in the performance parameter of the values shown on the x-axis. Thus in the example shown in figure x, for instance, there were two instances of the flight departing at 2027 that took between 10 and 10.8 minutes longer than planned to fly from PHX to DFW.

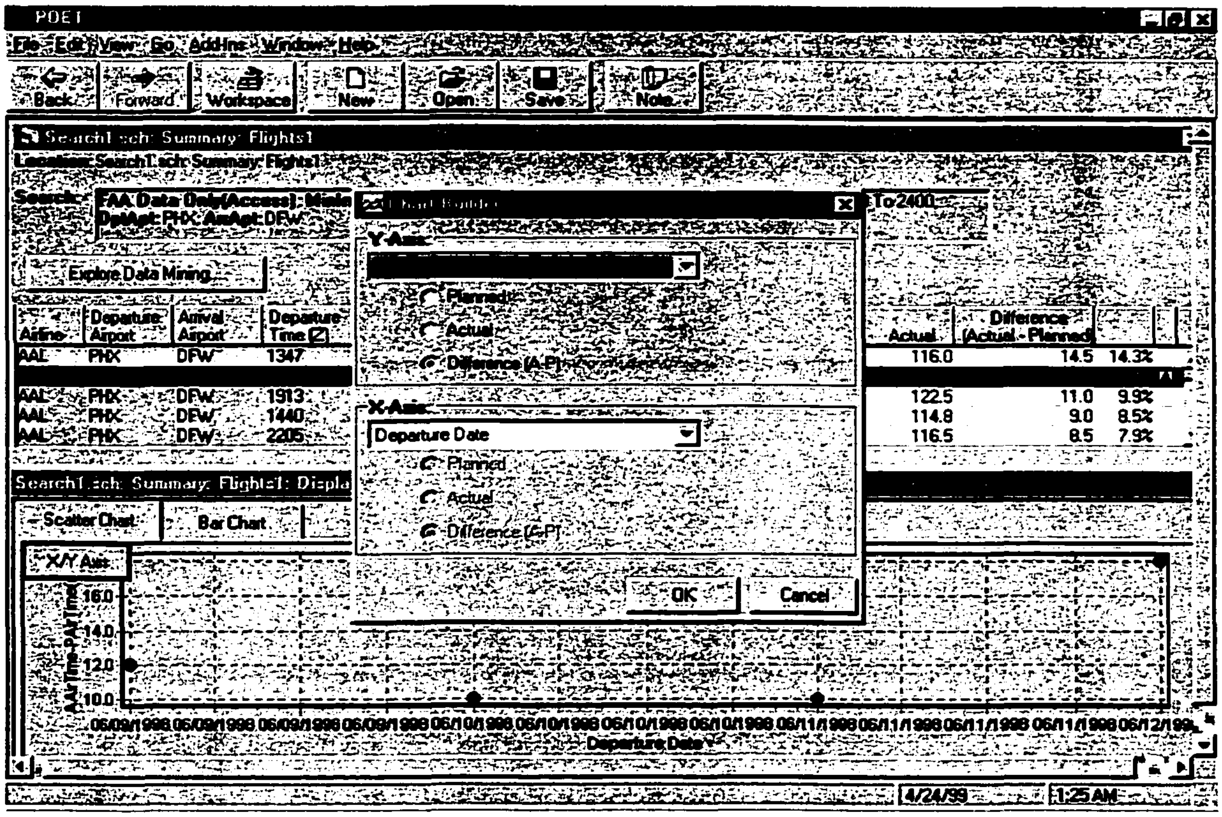


Figure 4.12 The chart builder window

Clicking the **X/Y Axis** button on either the Scatter or Bar Chart produces the **Chart Builder** window shown in Figure 4.12. This can be used to change the parameters used on the x and y-axis for the Scatter Chart and the y-axis for the Bar Chart. In both cases the y-axis is the **Planned**, **Actual** or **Difference** (Actual - Planned) for a performance parameter. The same options are available for the x-axis of the Scatter Chart, plus the **Date** option. For the Bar Chart the x-axis is always the number of occurrences.

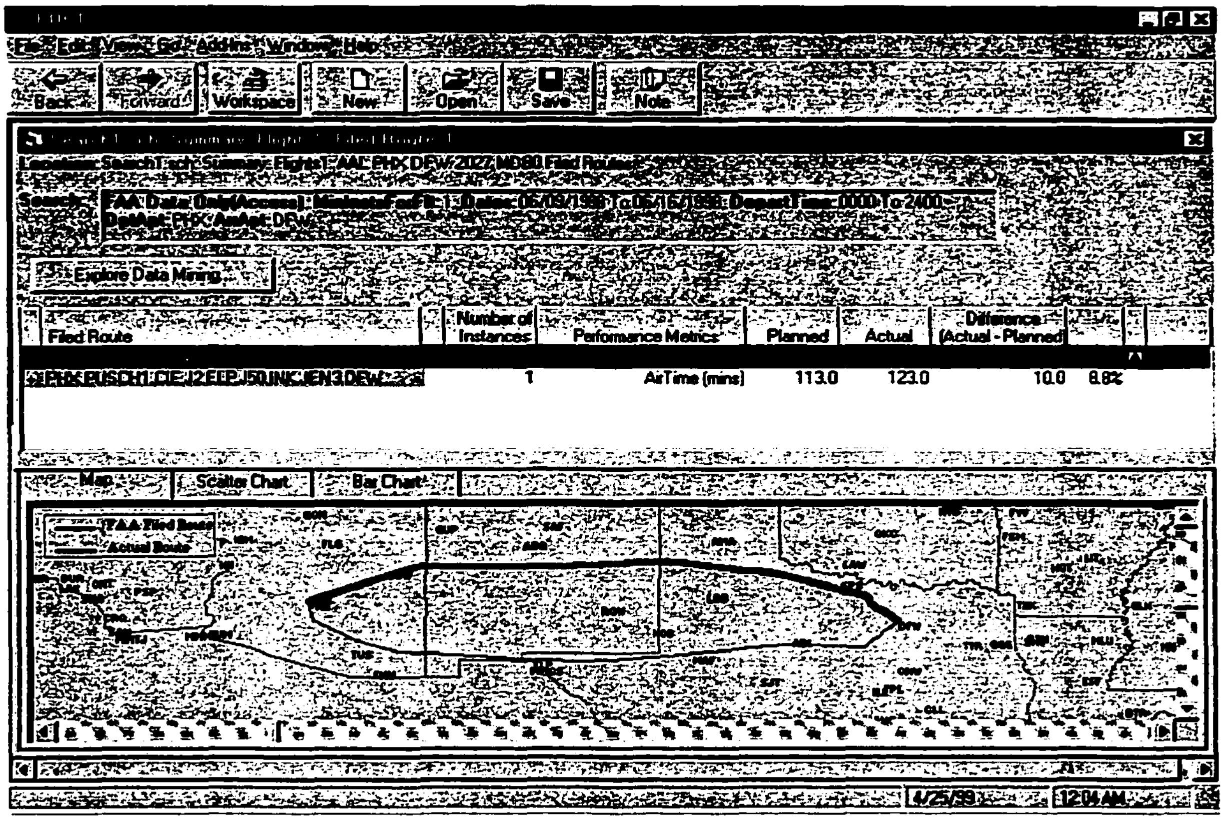


Figure 4.13 The filed route table and the flight route map

The **Filed Route Table,** shown in Figure 4.13, is produced when a particular flight is selected from the Flight Table. Each row represents a different filed route. The route itself appears in the first column and the number of flight instances with that filed route for this flight is shown in the **Number of Instances** column. The performance columns are the same as in the Flight Table. The routes actually flown for a filed route can be produced by double-clicking on a row in the Filed Route Table. The **Flight Route Map,** also shown in Figure 4.13, is displayed automatically with the Filed Route Table when a flight is selected from the Flight Table. At that point, only the filed routes will be displayed on the map. The one currently highlighted in the Filed Route Table will be drawn as a series of connected lines that are a thicker green than the other filed routes.

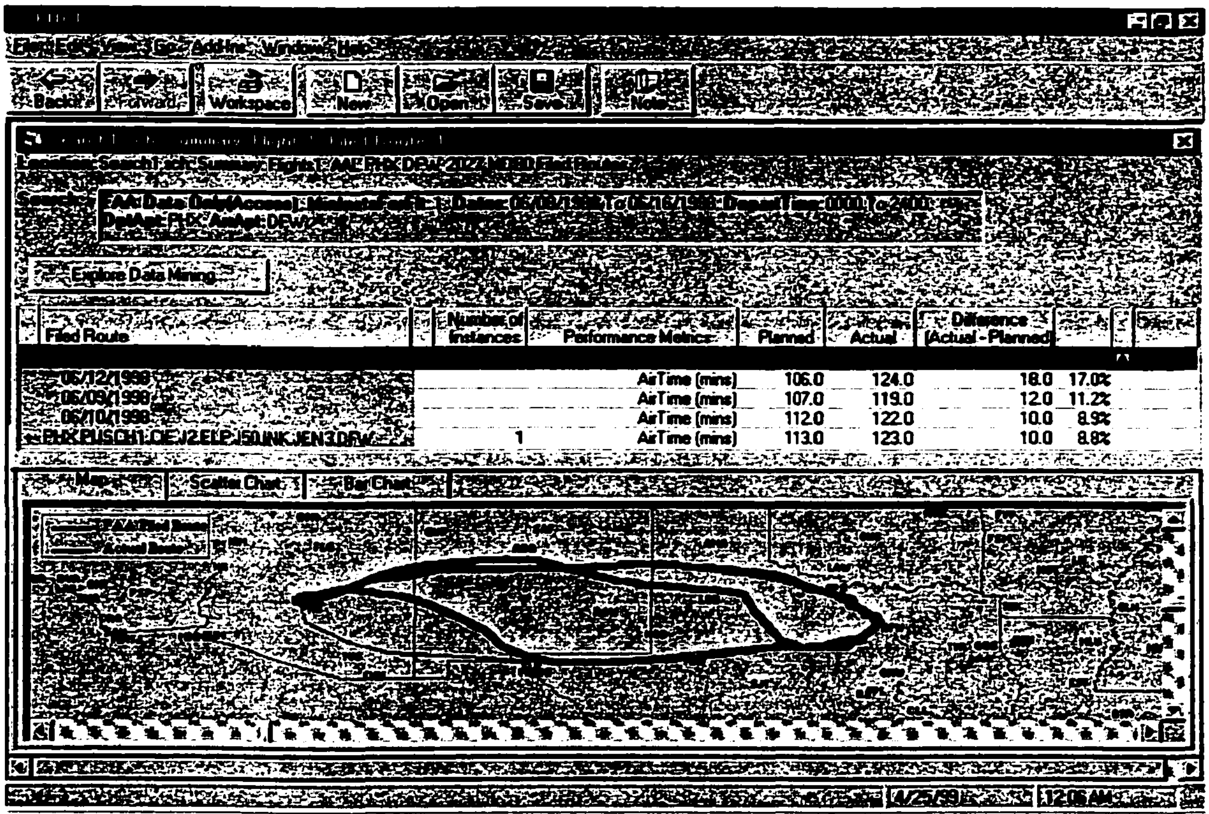


Figure 4.14 The expanded filed route table

If a flight route is double-clicked in the Filed Route Table the individual flight instances for that particular flight also appear to produce an expanded Filed Route Table, as demonstrated in Figure 4.14. More than one flight route can be expanded in this way and instances can be hidden again by simple double-clicking on the instances' filed route. The **Actual Route** flown for each instance displayed in the Filed Route Table is shown with black lines in the Flight Route Map. These lines are thicker if they are for the route currently highlighted in the Filed Route Table.

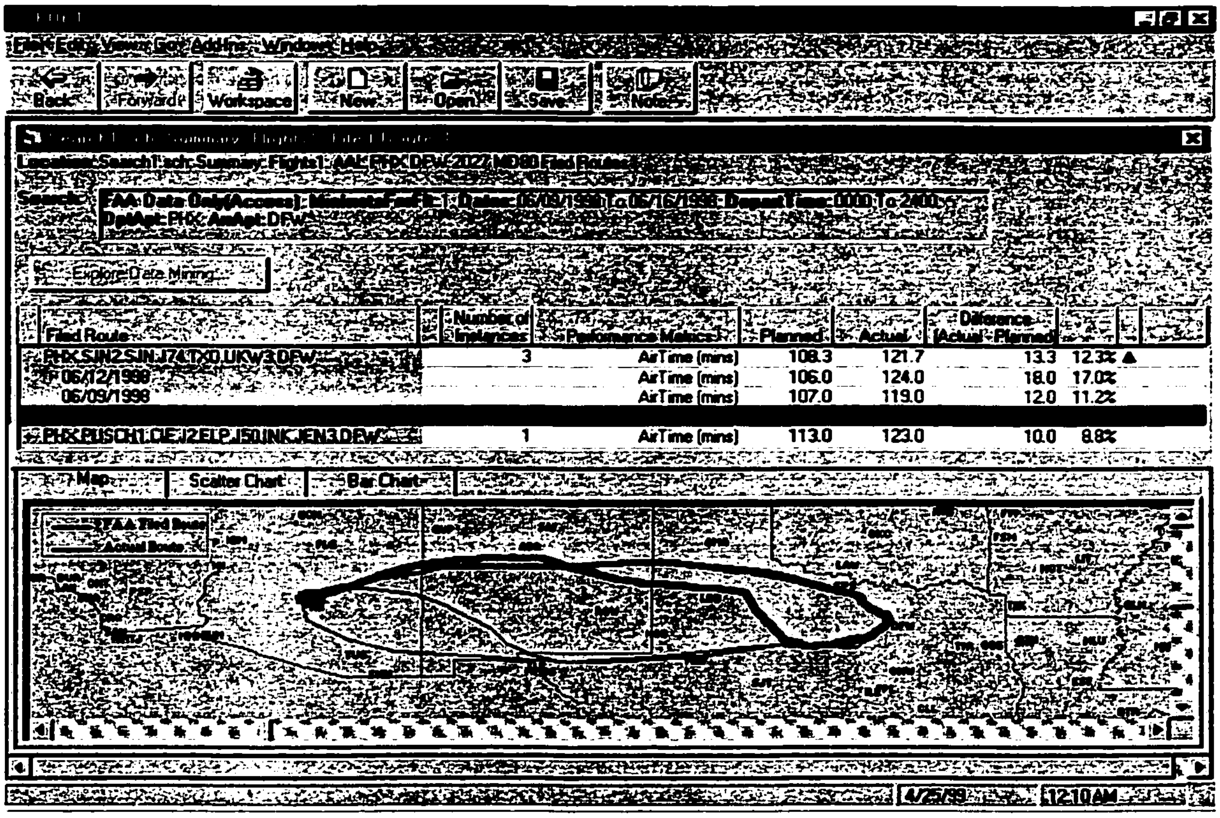


Figure 4.15 A single flight instance is highlighted

If an individual flight instance is highlighted in the Flight Route Table the respective route flown in the Flight Route Map is redrawn with a blue line and all other routes flown are shown with thin black lines. If a route flown is clicked on in the Flight Route Map the corresponding instance in the Flight Route Table becomes highlighted, as shown in Figure 4.15. More than one instance can be selected in either the Flight Route Table or Flight Route Map by holding the Ctrl-key and clicking on multiple instances. Double clicking on a flight instance in the Flight Route Table produces the Flight Instance Window for that flight.

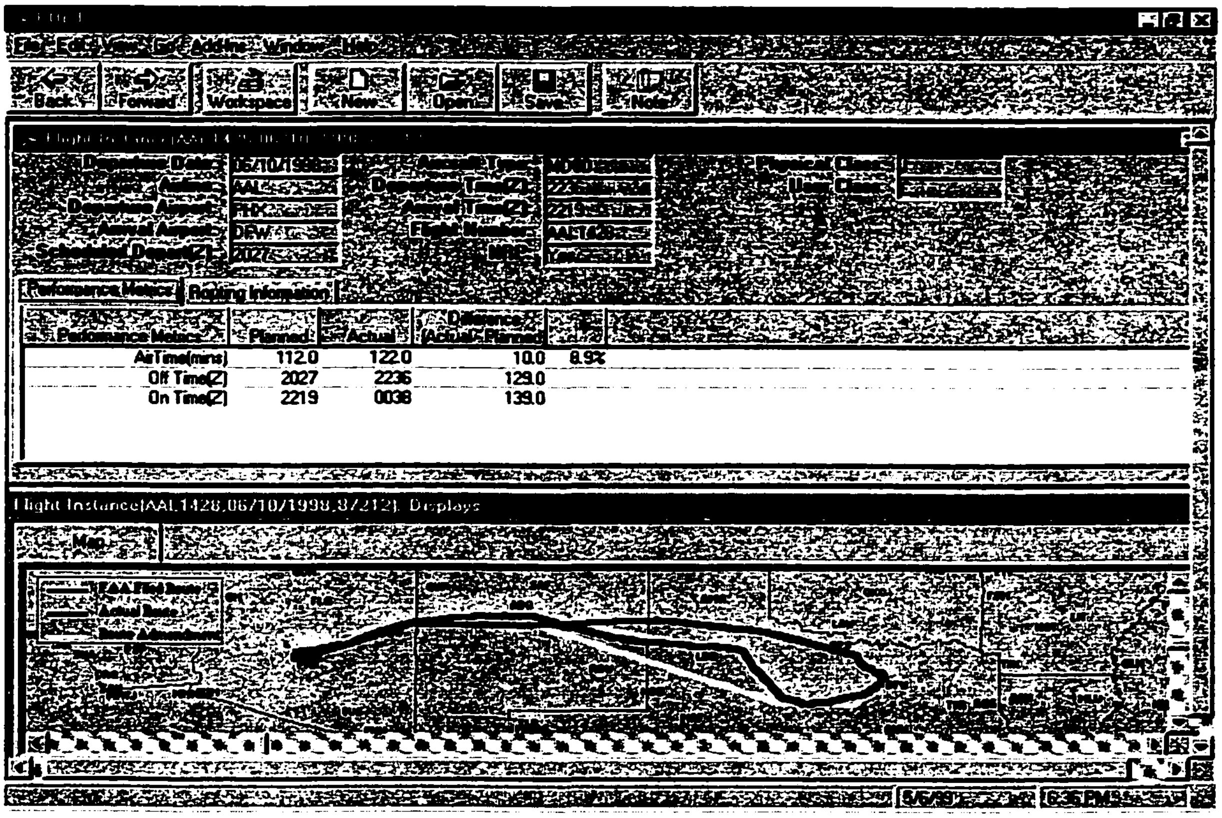


Figure 4.16 The flight instance window

The Flight Instance Window, shown in Figure 4.16, focuses the search results on a single flight instance. All the available data for this flight instance is displayed as demonstrated. The Flight Instance Window is produced by either clicking on a flight instance entry in an expanded Filed Route Table or by clicking on a flight instance's dot in a Scatter Chart.

Using POET Results

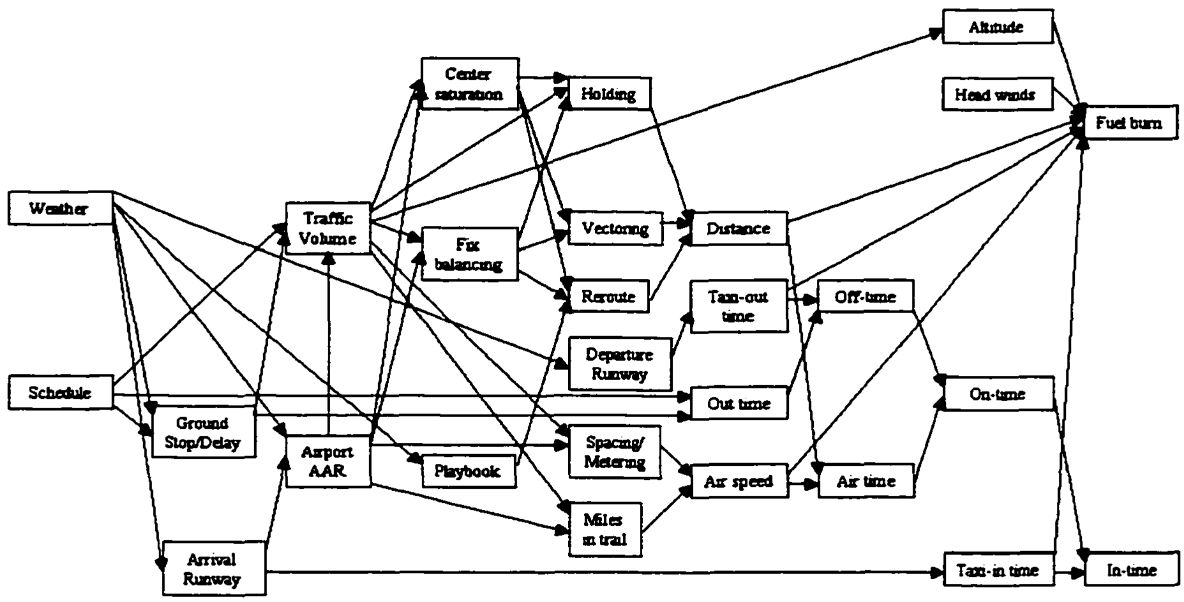


Figure 4.17 Influence diagram for POET performance metrics

The Post Operations Evaluation Tool provides individuals with more data and useful representations for aggregated data, but this system reveals *what* happened to flights and the *why* must be inferred from the data. The influence diagram in Figure 4.17 demonstrates some of the factors that can influence a flight and thus the performance metrics shown in POET. A person analyzing a set of performance metrics may apply backward or forward chaining reasoning to determine what could have produced the results he or she is concerned with, but one reason the process shown is an oversimplification is because it doesn't represent the decision making process that the Centers use and the interactions between traffic flows.

The knowledge necessary to determine actions to improve performance for the flights POET helps identify is sometimes distributed. Communications may therefore be necessary among FAA traffic managers at the ATCSCC and enroute centers, and personnel at AOCs (Airline Operations Centers) to learn what actions might actually be viable. The graphical and tabular nature of much of the information presented in the Post Operations Evaluation Tool means that discussion of its results must support discussion of data formatted that way. In addition, when proposing actions to improve the performance of flights identified with this tool an environment is necessary that accommodates expression of those actions.

Common forms of communication between these organizations are E-mail, facsimile messages, voice-mail, and regular mail for asynchronous communication, and telephone (including multi-party telecom) for synchronous communications. While there are clearly some advantages to real-time communications, these interactions often need to be asynchronous in order to be practical. The efficiency and effectiveness of available asynchronous communication methods is therefore important for post operations analysis.

In their analysis of cooperative problem solving for flight planning of commercial aircraft, Smith, et. al. (1995) point out the benefits of the knowledge sharing that takes place between the AOCs, enroute centers, and the ATCSCC by telephone and teletype. They also state that three goals could potentially improve cooperation even further:

1. Cooperative technology should help facilitate information exchange between individuals at very diverse locations and with diverse skills, goals and backgrounds.
2. Cooperative technology should use intelligence in ways which aid human decision makers without sacrificing their goals and needs.
3. Cooperative technology should have the capacity to help individuals build interpersonal relationships with the people that they will work and coordinate with.

In addressing the first goal the value of potentially sharing displays is discussed, including the following quote from a participant in their study: "A phone call's time consuming. A picture is worth a thousand words." Given that different organizations will often have different information or the same information represented differently, the ability to reference the same displays while their significance is discussed is useful in trying to form shared mental models.

The second goal is consistent with the approach taken with the Post Operations Evaluation Tool. This tool reduces problem solving search processes by number crunching to sort and aggregate large amounts of data within flexible categories determined by the user, and the user selectively applying heuristic data mining algorithms to further avoid what might otherwise be a relatively blind search.

In discussing the third goal, it was suggested that telephone conversations would be better for building interpersonal relationships than typed messages.

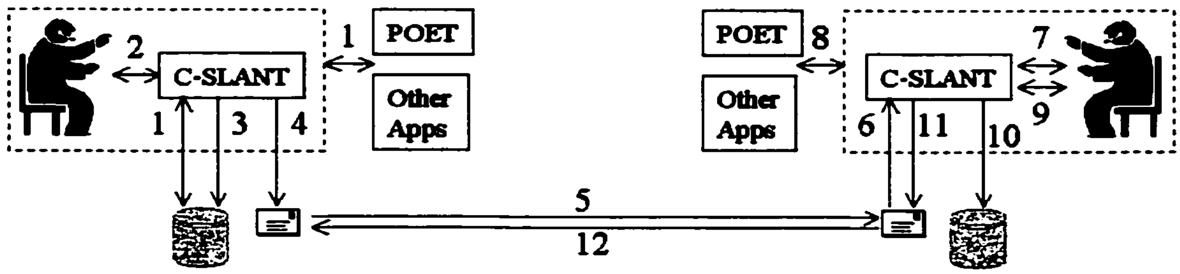
CHAPTER 5

THE DESIGN OF THE COLLABORATIVE SLIDE ANOTATION TOOL (C-SLANT)

Introduction

The Post Operations Evaluation Tool supports post operations analysis, but has no built-in mechanism for communicating about the results produced. Creating such a mechanism was considered because it would allow queries, data structures, and other context specific information from POET itself to be transmitted, and thus allow the recipient (or the recipient's software) to use that information to interact further with POET. However, this (1) would have complicated the development of POET; and (2) would have removed the ability to create messages on computers not running POET. A separate program called the Collaborative SLide ANnotation Tool (C-SLANT) was therefore developed to provide enhanced collaborative analysis considering the working environment of those who need to look at the results of an analysis and to use their knowledge to provide input. C-SLANT was developed to support asynchronous discussion of Post Operations Evaluation Tool results, supplemented by related data such as weather, after currently available asynchronous communications methods (normally E-mail and facsimile) were ruled out because they were not considered sufficiently efficient and effective.

Figure 5.1 shows a typical sequence of events to create a C-SLANT message and for a recipient to respond to that message. Alternatively, a C-SLANT message can be posted on a website and viewed on demand, by anyone with access to the site and a copy of C-SLANT.



Event	Description
1	Using C-SLANT the context of a message is formed by taking a series of computer screen snapshots and/or by loading previously created graphics files
2	The images are annotated with synchronized voice and pointing; pen marks; text-based notes, and arrow markers
3	The slideshow is saved
4	The annotated message is added to an E-mail message as an attachment
5	The message is sent through the user's E-mail system
6	The annotated message is loaded into C-SLANT via the recipient's E-mail system
7	The recipient views and listens to the message
8	The recipient possibly interacts with other software to gather screen captures to be part of the response
9	The recipient creates an annotated response
10	The recipient saves the message with both sets of annotations
11	The annotated message is added to an E-mail message as an attachment
12	The message is sent through the recipient's E-mail system

Figure 5.1 A typical C-SLANT event sequence

Two constraints imposed by C-SLANT are that a message must be built on top of one or more images and annotated via the C-SLANT annotation tools (or by visual annotations placed on the image through another application before it is captured or imported). Otherwise, the message is relatively unstructured in that there are not any "fields" that must be completed by the user.

Requirements

The following requirements were placed on the design of C-SLANT, given the context of the intended use, described in the previous chapter:

- *To not be over intrusive;*

  Both the FAA and airlines' personnel experience fluctuations in workload as weather severity varies, traffic density varies, and other events occur causing spontaneous problem solving to be required. Sometimes individuals have sufficient information about the procedures employed and the current conditions to estimate when not to initiate a synchronous communication (for instance, by telephone) but this can not always be the case. In addition, because the traffic manager will normally be in control of the situation, the dispatcher (or more likely ATC Coordinator) has added incentive to request an action at a time when the workload of the traffic manager is relatively low. In real-time dynamic situations the potential benefit will override the cost of communicating at a bad time for the traffic manager, but when the topics for discussion are relatively strategic, rather than tactical, the temporal flexibility means this is not necessary.

- *To support annotation of Post Operations Evaluation Tool screens and related data from other applications that may not be available to all parties communicating;*

  It was anticipated that the Post Operations Evaluation Tool would be made available to each of the enroute centers as well as the command center, and that possibly the major airlines would have access to it, but this was not certain. The Post Operations Evaluation Tool does not have weather data, which would be very valuable when evaluating what happened on individual days, so that information might be one example of what could be combined with POET data. If an analysis was focused on a particular airport, then additional information about that airport might likewise come from another source (such as a CTAS display). It general, because these are separate organizations, they have different information and information represented differently in their respective software applications. Thus, the ability to easily take a snapshot from any software application was highly desirable.

- *To be easy to learn and use;*

  Although computer systems are widely used within the FAA and the airlines, it could not be assumed that users would be highly computer literate in general. In addition, the frequency with which it could be used was not clear, so it would need to be as intuitive to use as possible.

- *To support a core set of common annotation techniques;*

  Programs with features for annotating vary in exactly what options they provide, but they normally include the ability to type and draw, underline or highlight. They also normally do so in more than one color. Supporting these features would allow transfer of knowledge from other applications and also support basic annotation methods.

- *To support synchronized voice and pointing annotations;*

  Assuming a person is not intimidated by having his or her voice recorded, the ability to quickly create an annotated message over computer screen snapshots seemed much more efficient and effective than trying to use traditional software with annotation features or fax machines. Because employees of the FAA and airlines often have their voices recorded it was assumed this group would be comfortable having their voices recorded.

- *To only require inexpensive and easily obtainable technology.*

  In order to support installation of the system with minimal equipment and labor requirements, and to allow a critical mass of users to develop quickly, it was necessary to keep the equipment needs to a minimum. In general, it was also highly desirable to require no special equipment, so that there would not be any unpredicted side effects to current FAA and airline applications if C-SLANT hardware was added to those systems.

Requirements	Comments
To not be over intrusive	Asynchronous messages that can be sent as an E-mail attachment or posted on a website.
To support annotation of Post Operations Evaluation Tool screens and related data from other applications that may not be available to all parties communicating	• A set of screen images may be captured to allow the information in the Post Operation Evaluation Tool's graphical and tabulated data displays (or other software's displays) to be the context of a message. • Visual annotation options were designed to contrast with these display backgrounds
To be easy to learn and use	• A slide show structure was used to organize these images, as the concept was considered to be simple and ubiquitous, even if the user is not familiar with the most commonly used software implementation of it – namely, Microsoft PowerPoint. • No attempt was made to provide extensive slide formatting functionality as in Microsoft PowerPoint. While it could be used to create one-way communications, C-SLANT was not designed to be a rich presentation system, but instead a simple, but effective messaging system. • A small set of interface options, that are predicted to serve the novice-users requirements are visible at all times, and more advanced and less frequently used configuration options are available through pull-down menus.
To support a core set of common annotation techniques	• Pen marks support common annotations such as underlining, highlighting, circling, drawing an object, or a path • The arrow marker has been shown to shift fixations to what the arrow points to (Faraday & Sutcliffe, 1998) and this complements the pen, whose markings could be confused with routes if used on the route maps. • Text boxes allow short comments or extended narratives as the text box window will scroll automatically when necessary
To support synchronized voice and pointing annotations	• A recorder is included that has the same functionality as an audio-only recorder, except it will also record the current x-y position of a special pointer for deictic gestures as that audio is recorded • A subject can be saved for each recording to label that recording

(Continued)

Table 5.1 Requirements for C-SLANT

Table 5.1 (Continued)

To only require inexpensive and easily obtainable technology	• Support for a very authentic virtual reality environment was not considered because of the goal of an inexpensive system involving easily obtainable technology and because it was not clear such a high level of virtual "presence" in a 3 dimensional environment is necessary for these tasks. One might also question the social practicality of wearing, for instance, a head mounted display and data glove in this context. • C-SLANT is a Microsoft Windows application requiring a sound card and microphone, but no other specialized hardware.

Interface Design Features

Figure 5.2 shows a background image from a Post Operations Evaluation Tool screen capture; the Slide/Annotation Manager window, which contains the majority of the interface options in C-SLANT; the deictic gesturing pointer which is always visible when the point is above the captured image; the voice and pointer recorder with a 7 second recording playing; a single text box window; and an arrow marker.

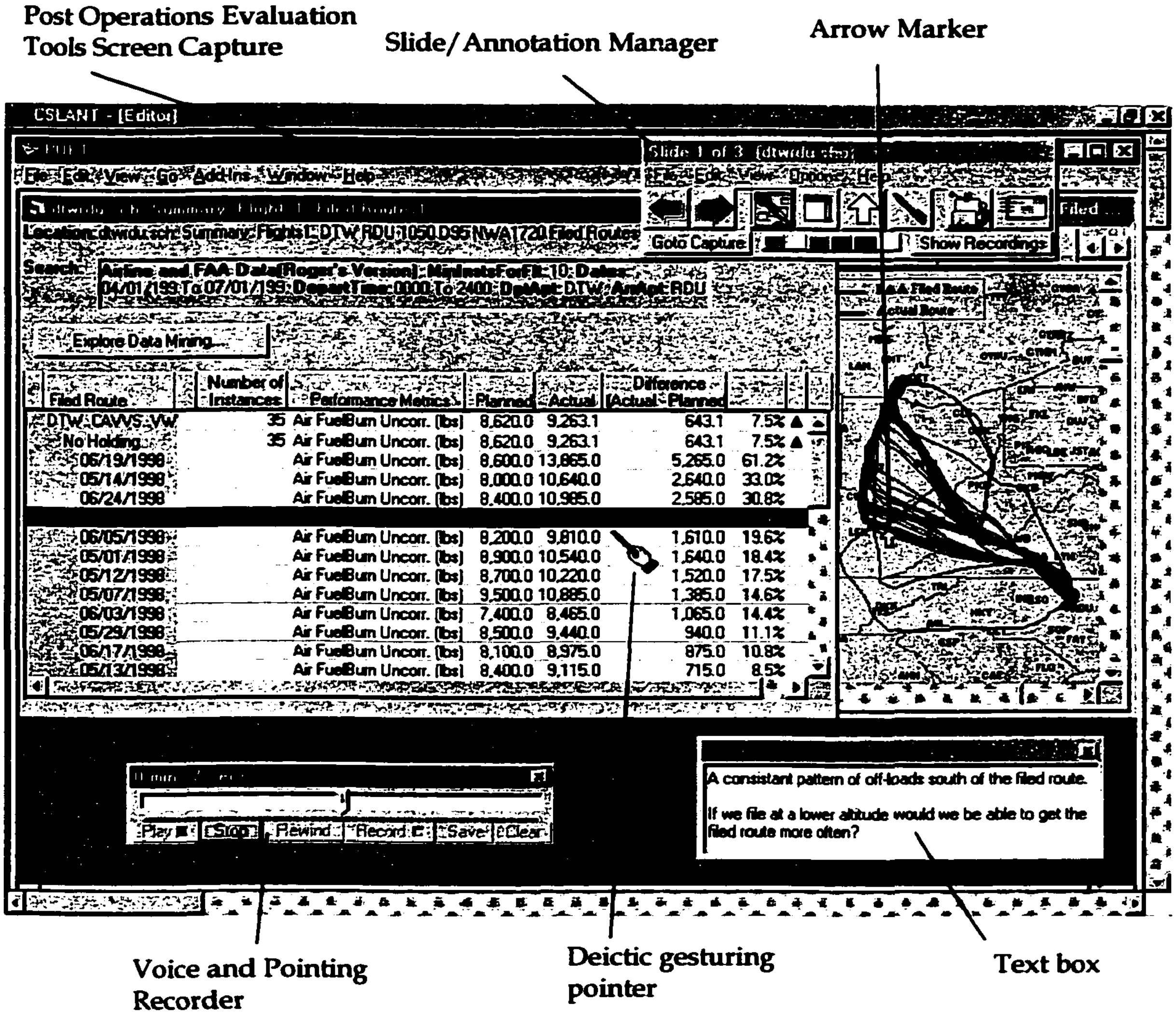


Figure 5.2 C-SLANT's slide editing mode

The Slide/Annotation Manager Window

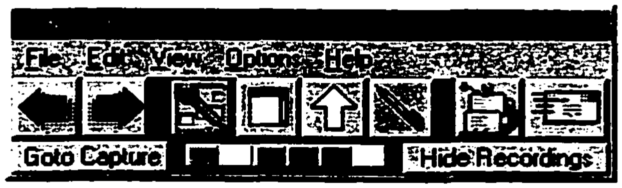


Figure 5.3 The slide / annotation manager window

The slide / annotation manager window shown in Figure 5.3 can be moved anywhere on the screen and its location is saved when a slide is saved, allowing it to be positioned so as to cover the least important data or an unused part of the screen.

	Move to the previous slide
	Move to the next slide
	The recorder allows the user to make an voice annotation and also have any pointing saved and synchronized with the audio so that when playing back the recording the mouse pointer movements are seen as they were made during the recording
	The text box allows a text comment to be placed above a slide
	The arrow marker allows arrows to be placed on a slide to mark particular points on the slide
	The pen allows freehand markings to be placed on a slide
	This button opens the slide sorter to allow the order of the slides to be changed
	This button opens the user's default E-mail program with the current slideshow as an attachment
	This button switches C-SLANT to the screen capture mode
	A color palette is provided in C-SLANT to allow the user to change the active pen color, arrow color, or text color
	This button allows the recordings window to be displayed or hidden

Table 5.2 Slide / annotation manager window buttons

Screen capturing

Figure 5.2 shows C-SLANT in its slide-editing mode. Clicking the *Goto Capture* button switches C-SLANT to its screen capture mode, where the small moveable window shown in Figure 5.4 appears above the user's desktop or open application(s). Entire screens or individual windows can be captured using the *Capture* button to produce a new slide. The *Goto Editor* button puts C-SLANT back in the slide editor mode.

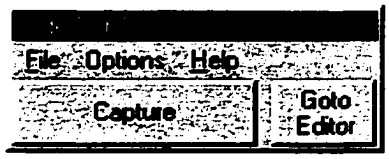


Figure 5.4 Screen capture window

The same effect can actually be achieved by (1) using the PrintScrn key to take a screen capture (or the Alt-PrintScrn to capture the current window) and copy it to the clipboard, followed by (2) issuing the Paste command in C-SLANT. More experience PC users would know this "trick", but it could not be assumed for less experienced users.

Annotation Tools

Synchronized speech and pointing

After selecting the recorder button in the Slide/Annotation Management window the window shown in Figure 5.5 appears. After clicking on the record button, C-SLANT records any audio input while simultaneously recording any movement of the pointer relative to the underlying image. Because the only visible dynamic to be saved is the pointer's position, little additional storage beyond the size of the image itself is required to capture this effect. Very long audio recordings however can still cause a file size problem for low bandwidth communications when the message is sent as an E-mail attachment.

Figure 5.5 C-SLANT's Recorder

A pointer for deictic gestures

Mode errors are possible when annotating over screen images that appear to have interactive components such as buttons, but actually are just portions of the picture. A pointer consisting of a hand holding a "stick" (shown in Figure 5.2) was therefore used. It affords (Norman, 1988) pointing more than button pushing, so it provides mode feedback. The metaphor of a person using a stick to point at a chalkboard also is appropriate. It appears when pointing over the background image, and changes to the normal Window's pointer when moved over an interactive object, such as a button. When the user selects a pen or an arrow marker, the pointer changes to a pen or arrow pointer. When the user moves the pointer into a text box the pointer changes to a standard text-editing pointer.

Providing a temporal-positional frame of reference for deictic gestures

A slider is provided as part of the recorder in C-SLANT so that during playback the user can see the current position in the recording and move forward or back in the recording by sliding the position indicator. A side-effect of synchronizing the pointing with speech is that the pointer's positions are retraced during sliding, so that the user has a frame of reference in the image and not just the normal temporal frame of reference provided by audio only recorders.

The player window

When the user saves a recording on a slide a player window, such as shown in Figure 5.6, is created that can optionally be given a subject (as a visual static description for the dynamics of the audio and pointing) and moved to a position close to that the recording references and/or where it covers the least or no information in the background image[11].

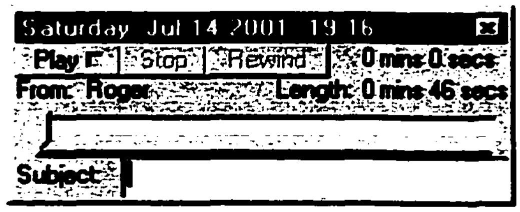


Figure 5.6 The C-SLANT player window

Message chunking

C-SLANT supports the creation of message chunks in the sense that it supports attaching annotation to context framing individual background images. Multiple speech and pointing recordings can be created for a single image where further sub-chunking is required, shown in Figure 5.7, as can multiple text boxes, line drawings, and arrow markers.

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[11] The player window has been replaced by a multiple recordings composite window (described in chapter 7) in the current version of C-SLANT, but separate player windows for each recording were used in the experiment described in chapter 6.

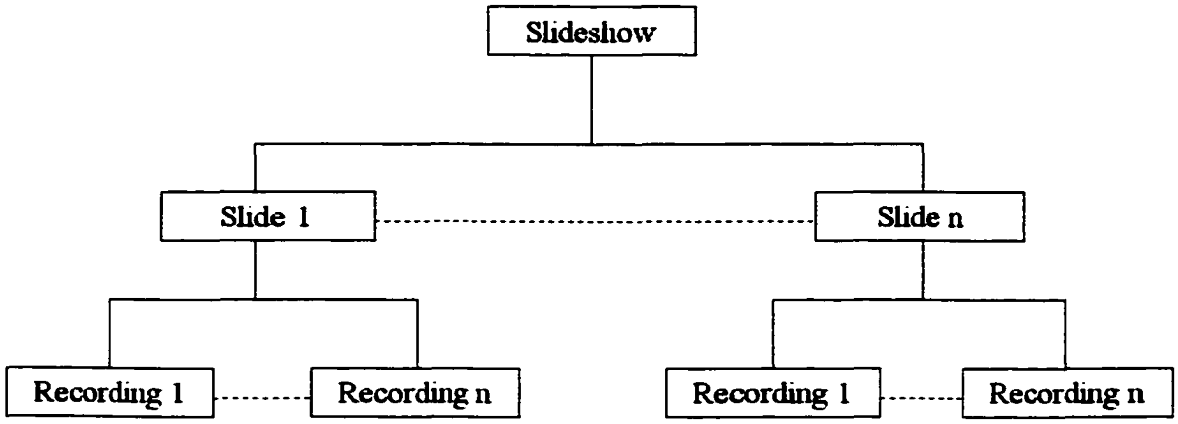

Figure 5.7 Verbal/deictic referencing abstraction hierarchy grounding asynchronous communications

In Clark and Brennan's (1991) discussion of grounding in communication, they point out how two people working together at the same place and time benefit from the ability of the speaker to check that the person they are talking to seems to understand what is said very shortly after it is said, "They [speakers] can present a difficult utterance in installments and check for understanding after each installment". This is clearly not fully replicated here, because the speaker would likely not proceed to the next installment if the last one did not appear to be understood. However, at least the potential to package and save a "collection of installments" that can be separately responded to allow the speaker to get feedback directly tied to a particular installment if that was something the respondent didn't understand. The analogy to a speaker accepting questions during a presentation versus taking comments and questions at the end of a presentation seems appropriate here. Clark and Brennan also state that the most basic form of positive evidence a speaker gets that they are being understood comes from what appears to be continued attention from the other participants in the communication. In the environment provided by C-SLANT the speaker works in a quasi-joint activity (Clark, 1996) proceeding "as if coordinating actions with another agent". If the speaker is more confident that the recipient's attention will be correctly focused the speaker is perhaps less concerned about not receiving immediate evidence of continued attention.

Text boxes

Text boxes support visible sentences on a slide, which can be quickly scanned or read. These also require very little storage compared to their audio equivalent. Used poorly, they may cover important parts of an image and there is the potential for comments to be more ambiguous when referring to an image if there is no direct link from the text to that referenced. However, they do provide an external memory that might, for instance, be used to note key points or data related to a more extensive audio recording. The background color of the text boxes is light yellow so that they resemble "sticky notes". The font color can be changed by the user to provide a basic means of distinguishing selected text, such as who wrote what.

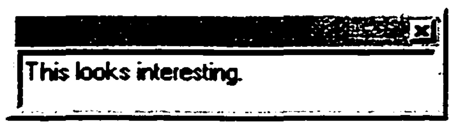

Figure 5.8 Text box with no scroll bar

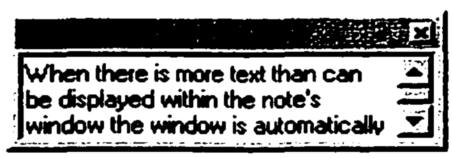

Figure 5.9 Text box with a scroll bar

Figure 5.8 and Figure 5.9 show that the scroll bar is automatically generated when the text is too long to fit into the visible text area.

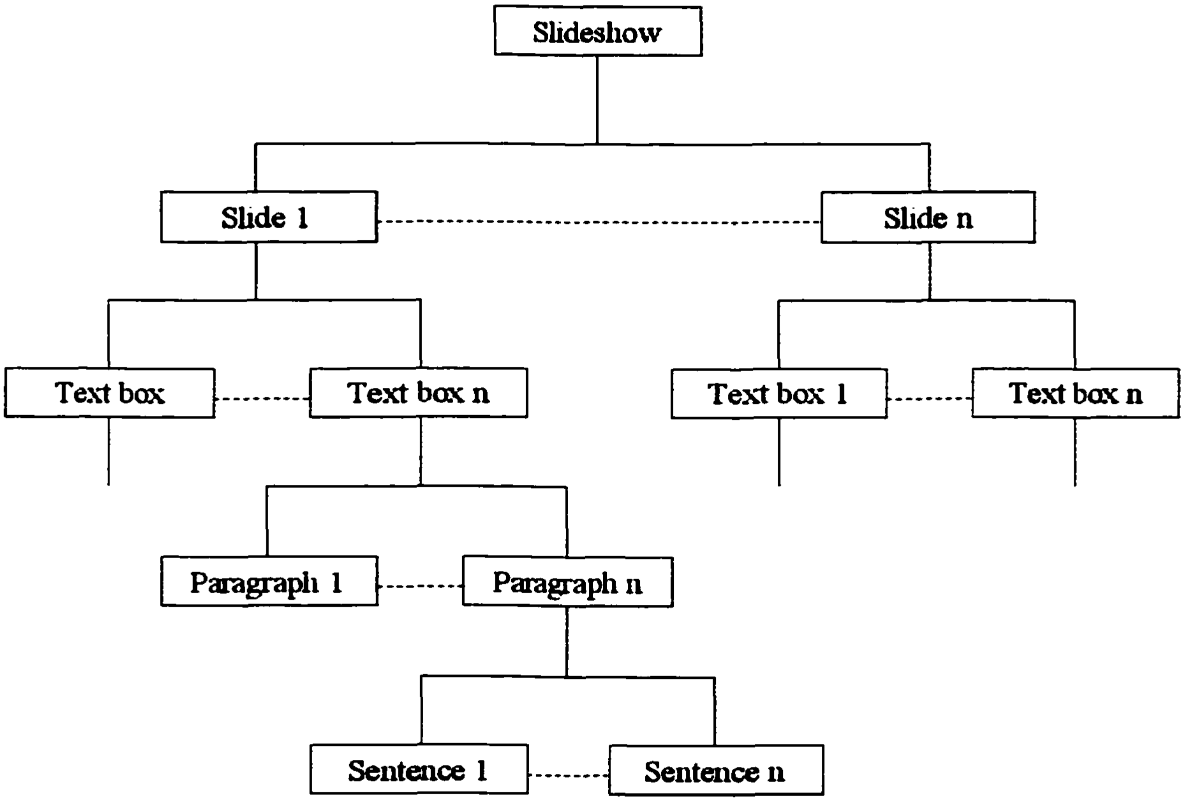

Figure 5.10 Text abstraction hierarchy

Just as multiple recordings can be associated with an individual slide, so too can multiple text boxes. This allows for sub-chunking again, as shown in Figure 5.10, but also for recipients to share a text box and place a response close to the original comment.

Ink and highlighter freehand pens

Annotations on paper are commonly performed with a pen or highlighter so these features are natural for the user. Given the Post Operations Evaluation Tool often has a lot of data packed fairly densely; the highlighter was considered essential to avoid covering data. The pen and highlighter were also specifically expected to be used to propose and highlight routes.

Arrow markers

Particular x, y positions on a screen can be marked by placing arrow markers on them as shown in Figure 5.2, where a particular point on an individual flown route is marked. In general, the arrow marker is a static pointer compared to the dynamic pointing that occurs during synchronized speech and mouse pointer recording. It also differs in that it stays constantly visible above the image unless the user decides to remove it. The arrow marker was thought to be useful in marking locations such as fixes or airports. Both the arrow and the pen were predicted to be used in the scatter charts and tables. The arrows point towards the top-left, as do most mouse pointers.

Abstraction from the file system

C-SLANT has a built-in option to send a slide show using the default E-mail system on a machine so the user is saved from having to explicitly make the slide show an attachment. This is desirable to reduce the number of steps involved in sending a slide show and also to avoid interfacing with the file system, which can be a problem for novice users. When a slide show is received most E-mail programs allow an attachment to be automatically opened by the appropriate program for that file type, so again the user can normally just double click on the slide received and have C-SLANT automatically open the slide show and thus avoid dealing with the file system. Of course, this abstraction from the file system works unless the user wishes to archive slide shows outside their mail system.

Slide Sequencing Window

There are a number of operations that need to be performed at the slideshow level as opposed to the slide level. Saving, loading, and sending are the most basic. Viewing and rearranging are two additional functions.

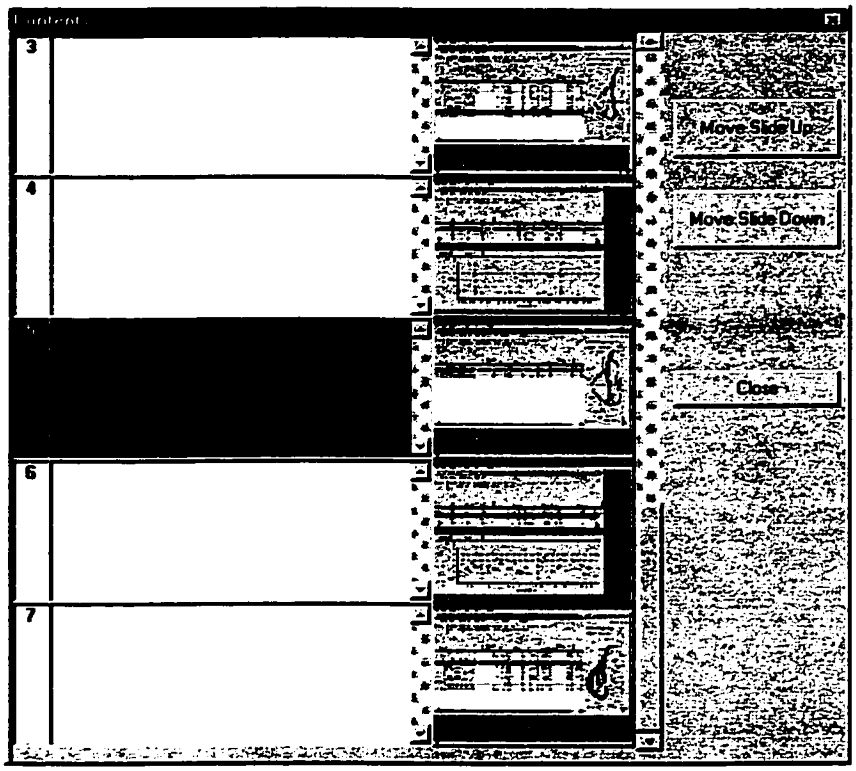

Figure 5.11 Slide sequencing window

This level of abstraction is not as well developed in C-SLANT as the slide level. Users can view a sequential list of thumbnails for each slide, summarize the slide, and move a slide using the up and down arrows, shown in Figure 5.11, but the user can not apply the direct manipulation technique of simply dragging thumbnails, as can be done in Powerpoint.

Architecture

C-SLANT does not contain any code for direct machine-to-machine communication; however, when C-SLANT messages are sent as E-mail attachments, it is operating in the client-server environment of the E-mail system, as shown in Figure 5.12

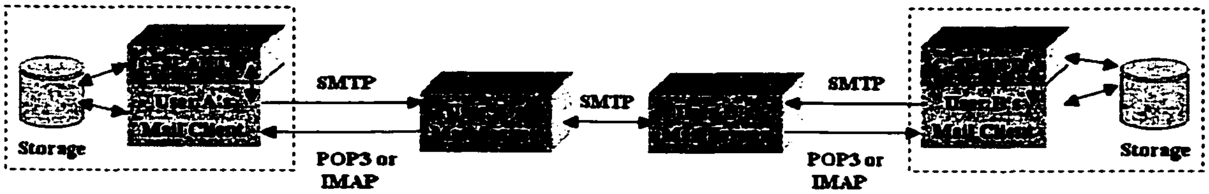

Figure 5.12 C-SLANT asynchronous communications via E-mail

This is the scenario originally intended and C-SLANT is "mail enabled" in that it uses the Messaging Application Program Interface (MAPI) to interact with MAPI compliant E-mail systems, such as Microsoft Exchange, Microsoft Outlook Express, and Eudora. In such an environment the user can simply click on the E-mail button in C-SLANT to have the current slideshow automatically be an attachment to a new E-mail message opened and displayed using the underlying mail system. If the underlying mail system is not MAPI compliant the user must complete this process manually.

Implementation

Software Development Environment

Microsoft Visual Basic 6.0 was used as the implementation language, because it supports rapid prototyping of applications where the interface is more complex than the underlying algorithm through its visual Integrated Development Environment (IDE). The system was decomposed into modules, in order to achieve the benefits of *structured programming* (Kruse, 1994), but there were also some disadvantages in this environment:

1. Visual Basic 6.0 supports the object oriented paradigm, but not particularly well;
2. The compiled code will only run on Windows platforms;

3. It does not have the software engineering tools of more sophisticated environments. For instance, state transition diagrams for the recorder were drawn on paper rather than using a CASE (Computer Aided Software Engineering) tool.

Audio Format

The audio format used in C-SLANT is WAVE PCM (Pulse Code Modulated audio), 11,025 KHz sampling, 8 bit, mono format. These settings require 11,025 bytes for each second, and the compression of C-SLANT can reduce the image sizes significantly, but only reduces the audio size slightly.

Compression

C-SLANT uses the zlib compression-decompression library[12] to compress all files used to represent a single slide into one file (a .sld file) and then combines all slide files to produce one slide show file (a .sho file). This is hidden from the user unless he or she chooses to turn compression off or save or load slides, recordings or images individually. The compression feature was thought critical for asynchronous communication when a network connection is slow, but for fast connections or local machine access it is useful to have the option of turning off compression.

C-SLANT captures screen images using the BMP (BitMaP file) format, but also allows these to be saved as JPG (Joint Photographic Experts Group) files.[13] Screen captures normally

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[12] zlib is library compatible with the gzip format commonly used on Unix systems. It is written by Jean-Loup Gailly and Mark Adler, and is freely available. The home page for zlib is http://www.gzip.org/zlib/

[13] JPG files are created using Intel's free JPEG library of routines. These are described at: http://developer.intel.com/software/products/perflib/ijl/index.htm

look better in this BMP format because BMP files are not compressed. JPG files have color information removed during compression, so that sharp edges tend to blur. However, JPG files capture 24 bits of color information, so are most commonly used for photographs and similar continuous tone bitmap images. With the .zlib compression algorithm used in C-SLANT the file size is reduced to be approximately equivalent to the JPG format, but the edges remain sharp when decompressed.

Summary

Category	Summary
Platform	Microsoft Windows
Communication Method	Asynchronous via application file transfer (e.g. E-mail attachments, FTP transfer, or non-streamed Web access).
Annotation Methods	Unimodal (via text, pen marks and arrows) and multimodal (via voice over images with deictic gesturing)
Message Structure	Linear sequence of annotated images (slides)
Compression	Zlib algorithm
Audio Format	Wave PCM
Graphics Format	JPG or BMP (can import GIF)

Table 5.3 Basic implementation summary of C-SLANT

Table 5.3 shows a summary of the basic implementation level characteristics of C-SLANT.

CHAPTER 6

EXPERIMENTAL PROCEDURE

This research has involved trying to develop a functional tool that could be usefully used in the target domain and context. However, developing this tool also provides a valuable opportunity to use it as a "tool for discovery" and to (1) test certain hypotheses about the effect of particular communication modes for collaborative post operations analysis in this domain; (2) learn more about the information gap that exists between these two organizations; and (3) evaluate the usability and usefulness of C-SLANT used in combination with POET, and as an application in general.

Subjects

36 AOC dispatchers took part in the study. Eight were female; twenty-eight were male. Nine did not provide their age, but of those who did the age range was 33 to 55 with a mean of 45 years old. The number of years working for Northwest Airlines was between 9 and 35 years with a mean of 18 years. 26% indicated the computer they used at work or home had a sound card. Experience with software applications either at work or home was as follows: word processing 81%; spreadsheet 61%; database 35%; presentation software 23%.

36 Traffic Managers took part in the study. Four were female; thirty-two were male. Three did not provide their age, but of those who did the age range was 31 to 57 with a mean of 43 years old. The number of years working for their respective centers was between 3 and 32 years with a mean of 17 years. 34% indicated the computer they used at work or home had a

sound card. Experience with software applications either at work or home was as follows: word processing 88%; spreadsheet 51%; database 48%; presentation software 37%.

None of the dispatchers or traffic managers had any previous experience with POET.

Experimental Design

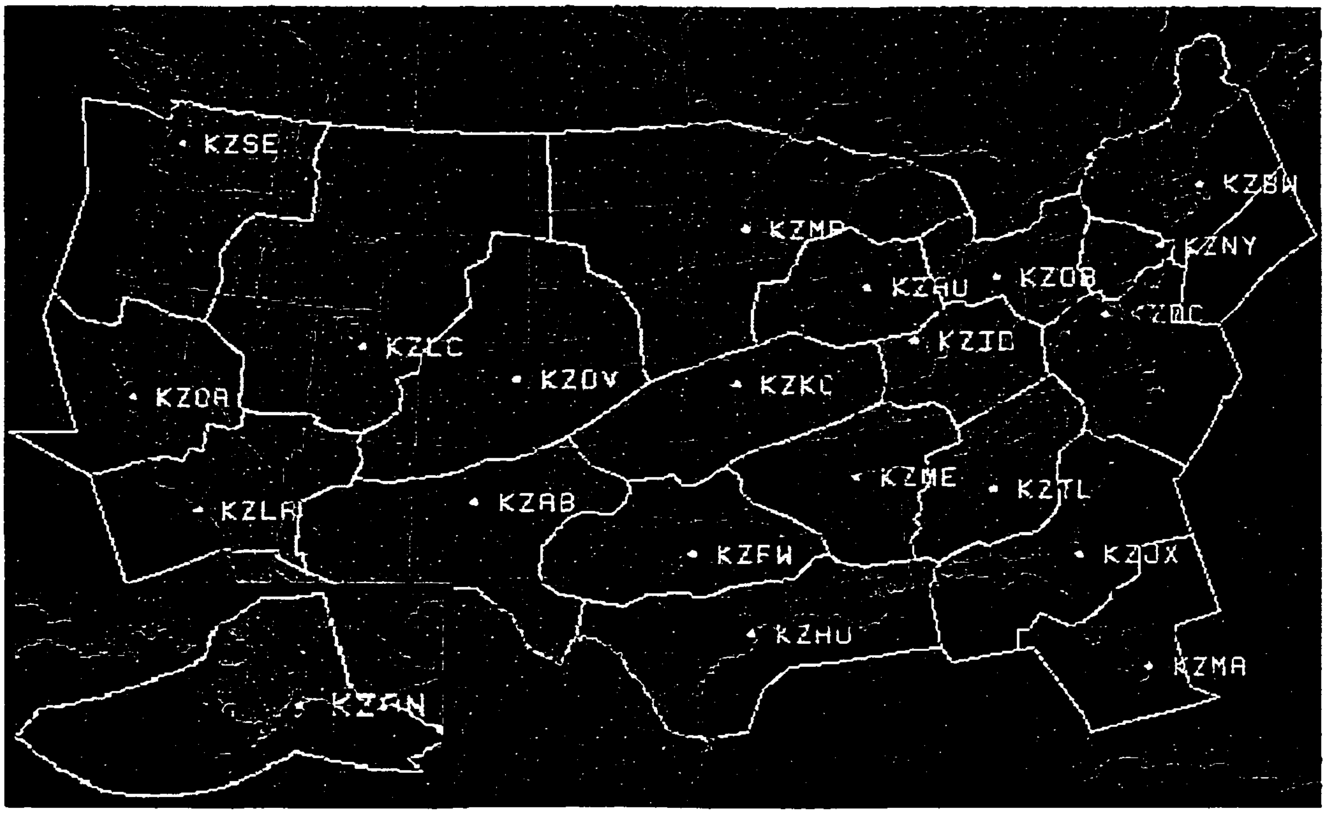

Figure 6.1 Enroute Centers[14]

[14] The 'K' prefix before the Center names represents the United States, but is not normally used, so that convention will be followed in this document.

POET searches were run on Northwest Airlines historic flight data to identify nine collections of flight instances (each collection involving direct flights in one direction between a city pair combination) where it was predicted there would be sufficient concern about the undesirable performance of those flights to cause a dispatcher to welcome the opportunity to discuss with a traffic manager at a relevant center what might be contributing towards those results and what might be viable actions to improve performance. The collections of flight instances each involved a different city pair combination and 8 different centers were identified as particularly relevant. The Minneapolis center was involved twice, but given the hub for Northwest Airlines is located in Minneapolis this did not seem inappropriate.

Figure 6.1 shows the location of the FAA Enroute Centers (except the center based in Honolulu). Those included in the study were: ZMP, ZOB, ZBW, ZNY, ZID, ZDC, ZTL, and ZFW. This involves no centers on the west coast because, for Northwest Airlines, the flights with the worst performance results, where POET appeared to reveal a systematic pattern, involved the other centers more. Nine slide show scenarios (see Appendix A.) involving POET screen captures for the nine respective flight collections were created and four dispatchers were selected at random for each of the nine scenarios and asked to create one message using their assigned slide show scenarios as the context for the message. For each scenario, two used C-SLANT with the textbox button hidden and two used it with the voice and pointing button hidden. For each of the nine scenarios, four traffic managers were selected at random from the relevant center and each used the same configuration of C-SLANT that the dispatcher used to create a response. This experimental design is summarized in Table 6.1.

	Voice+Pointing 1	Voice+Pointing 2	Text 1	Text 2
Scenario 1	1	2	3	4
Scenario 2	5	6	7	8
Scenario 3	9	10	11	12
Scenario 4	13	14	15	16
Scenario 5	17	18	19	20
Scenario 6	21	22	23	24
Scenario 7	25	26	27	28
Scenario 8	29	30	31	32
Scenario 9	33	34	35	36

Table 6.1 Experimental design (72 participants: 36 airline-FAA participant pairs each assigned to one of 9 scenarios and either the voice and pointing mode or the textbox mode)

In addition to selecting flights that involved poor performance results, flights were picked where the POET results showed some kind pattern in what was happening to those flights, e.g. most being rerouted from the filed route in a particular direction or a significant number being put into holding. Thus, because of the information provided by POET the discussion was predicted to not only involve communicating what the performance results was, but also at least in part why they were occurring. It was anticipated that the message would additionally involve discussing further causes not supported directly by information on the slides, and solutions to the problems identified, because of the knowledge in the minds of the dispatchers and traffic managers. For both the additional causes and the solutions it was anticipated the images would be used when they would help (e.g. spatial information could be used) in the communication.

It was hypothesized *a priori* that:

1. The two modes of communication would interact differently with the collaborative problem solving and discussion. (E.g. the task time; the number of questions asked; the number of dispatcher ideas responded to by the traffic manager; and the number of ideas for improving performance produced by the pair.)

2. The two modes of communication would interact differently with the other annotation tools, namely the pen and the arrow marker.

The first hypothesis would be consistent with related research involving different tasks and participants. If evidence supporting this first hypothesis could be found it might help provide guidance for designers on how to support and integrate these communication modes.

The second hypothesis was based on the believe that the workload and communication differences between making deictic gestures and creating similar semantic references in the text mode would effect the way the pen and arrow is used.

Scenarios used

Scenario	Number of slides	Search summary	Scatter chart	Filed route table or expanded filed route table	Flight route map
ZNY	6	X	X	X	X
ZOB	5		X	X	X
ZID	5	X		X	X
ZTL	7	X	X	X	X
ZFW	2	X		X	X
ZBW	6	X	X	X	X
ZDC	6	X	X	X	X
ZMP1	4	X		X	X
ZMP2	3	X		X	X

Table 6.2 Scenarios summary

Appendix B shows which POET windows were used for each slide of the scenarios and Table 6.2 is a summary of that information. As this table shows, the same number of slides was not used for each scenario. Depending on the particular scenario a different number was deemed to be necessary to show a performance problem and provide supporting information that would seem likely to suggest some potential causes. In every scenario at least one flight route map was provided to show the actual route filed versus flown and to support discussion relative to a 2-

dimensional view of the relevant airspace. The one scenario that did not include the search summary was the ZOB scenario, but the filed route table and scatter chart on the first slide together showed the city pair, departure time, aircraft type, time of year, and the number of flights involved.

Detroit to Newark (DTW-EWR): the ZNY scenario

The DTW to EWR scenario shows flight information for flights with a departure time between 1800 and 2100. This involved 210 flight instances with an average over burn of 946.5lbs, but with 28 burning more than 2,000 lbs above planned. 194 flight instances were filed through Slate Run (an essentially direct route) and 14 of these were held with an average over burn of 2,490 lbs. The slides show this information and that the holding normally took place at the boundary between ZNY and ZOB, on the ZOB side, although holding for one instance closer to DTW is shown. Flights filed on this more direct route are shown to not have a direct approach into EWR (being routed first to the north or the south) and there are also two instances of rerouting to the south enroute. Vectoring is shown to sometimes occur in the ZNY airspace. It is also shown that when the remaining flights were filed on a more northerly route through ZBW they were not held and often flew a more direct route than filed. Seven slides are used in this slide show including three showing individual flight instances to more clearly show where the holding occurs, and the enroute vectoring.

Minneapolis-St. Paul to Newark (MSP-EWR): the ZOB scenario

The MSP to EWR scenario shows information for a flight with a departure time of 1955 between April and May, and a flight with a departure time of 1945 through June. These essentially represent the same flight, but a change in aircraft type where a 320 was replaced by a 757 and the departure time changed slightly. There were 51 and 19 instances respectively, and a scatter chart on the first slide showing planned versus actual air times shows a similar distribution for both flights, with an average difference of 13.1 and 14.9 minutes beyond planned respectively, but with 7 (10%) 40 minutes above the planned air time. The scenario shows that most instances were filed and flown on close to straight routes between the city pairs, but there were some flight instances filed and flown to the north, and two instances of flights flown on very large deviations to the south. Holding is shown to have occurred 12 times at SLT and to have occurred for the flights with the worst air times. The scenario also shows holding occurring for flights with both close to planned off times and off times significantly later (80, 72 and 29 minutes) than planned. All flight instances flown to the north are shown to involve no holding and air time delays below the overall average.

Detroit to Raleigh-Durham (DTW-RDU): the ZID scenario

The DTW-RDU scenario shows information for 35 instances of a flight that was scheduled to depart at 1050Z and was filed on an essentially straight route passing through central Ohio after departing DTW in a south west direction. The scenario shows the actual route flown on 34 of these occasions was much more to the south west, often on a route as far south as Cincinnati, Ohio or Lexington Kentucky, with two as far south as Tennessee. The 35th instance flew a route to the north of the filed route. In addition to these 35 instances, one instance is shown of a filed route departing DTW in a south east direction passing over Cleveland. The first slide in this scenario shows the overall impact on fuel burn with the nine worst cases burning between 1,065 and 5,265 lbs beyond planned, and a route map showing the filed versus actual routes. The remaining 4 slides show the same information with the four worst performing flight instances, in terms of fuel burn, selected in an expanded filed route table. These corresponded to those deviating from the filed route the most.

Detroit to Atlanta (DTW-ATL): the ZTL scenario

The DTW-ATL scenario shows information for five flights from Detroit to Atlanta. The first slide shows the planned versus actual average fuel burn figures for these flights sorted by average percentage difference. The next six slides focuses on the worst three performing flights, using two slides per flight starting with the worst first. The table on the first slide shows that the flight departing at 1105 was the worst for this performance metric, burning an average of 1,911.4 lbs (13.7%) more fuel than planed. (The fifth flight in the table had a departure time 10 minutes before this one, and burned 1,078.5 lbs (7.9%) more fuel than planned.) The second flight in the table had a departure time of 0035 and the third a time of 1630. The 1105 flight is shown on slides 2 and 3 to nearly always be filed out of DTW over ROD rather than APE, and to approach ATL from the northeast, but the routes flown are such that as many flight instances are rerouted to approach ATL from the northwest as stay on a northeast approach. It is further shown that both approaches cause the flight to be put into holding and that it occurs for 50% of the flights flown. Slides 4 and 5 show the 0035 flight is filed on the same route, but that nearly always that route is flown at that time of day. One instance of a severe reroute and holding is also shown for this flight. Slides 6 and 7 show flight information for the 1630 flight, where the same route is filed for every instance, but one (which is filed to depart DTW over APE) and the majority of flight instances appeared to be rerouted to approach from the northwest with holding again occurring for flight instances rerouted and staying on the original flight path.

Minneapolis-St. Paul to Dallas-Forth Worth (MSP-DFW): the ZFW scenario

The MSP to DFW scenario involves two slides. On the first slide two filed routes from MSP to DFW are shown approaching DFW from the northwest. One via Oklahoma City and the other via Tulsa. In both cases many flights actually flew a route arriving from the northeast (13/14 for MSP.J21.OVR.J21.ICT.J21.IRW.UKW3.DFW and 12/17 for MSP..MKC.J25.TUL.UKW3.FGW). The second slide shows three filed routes

(MSP..RST..ALO.J233.CNOTA..DFW; MSP..MKC.J25.TUL.BYP3.DFW; and MSP..MKC.J25.TUL.BYP2.DFW) with 35 instances shown filed into DFW from the northeast BYP approach, and in most cases the flight instances stayed on the filed routes. All flights shown in the scenario have a departure time between 1400Z and 1500Z.

Detroit to Boston (DTW-BOS): the ZBW scenario

The DTW to BOS scenario shows flight information for 103 flight instances departing between 1800 and 1900Z. It is shown that the average fuel burn is 994.6 lbs beyond planned with 20 of these flight instances burning at least 2,000 lbs more than planned. 14 flights instances are shown to have been held, with this occurring most often close to the BOS airport, but one extreme case of holding is shown north of the airport and one halfway along the filed route. The flown routes are shown to normally be close to the filed route, but on one occasion a flight instance was flown on a route through Canada to approach BOS from the north.

Memphis to Newark (MEM-EWR): the ZDC scenario

The MEM to EWR scenario presents flight information for 30 flight instances departing at 1900 and 29 flight instance departing at 1915. The flights are shown to burn 1,521.0 and 1,601.9lbs more fuel than planned on average; to have air times 15.9 and 17.3 minutes more than planned on average; and to have off times 23.0 and 30.1 minutes later than planned on average, respectively. More detailed information is presented on the 1915 departure, and it is shown that there are filed routes used that take a northern route to approach New York through the Cleveland Center and there are routes that approach New York from the southeast passing through the Washington Center. The slides show that flights filed on a northerly route are sometimes rerouted to pass through the Washington Center, but when a flight instance is filed on a route through Washington it is not rerouted to fly on a route through the Cleveland Center. Flight instances flown on the northern route are shown to have deviated from it significantly before returning to it on two occasions. Flight instances filed to pass through the Washington Center are shown to be held south of Washington where 4 routes used merge. The most northerly of these four routes, passing through the south of Western Virginia, is the one shown to be filed and flown the most.

Midway to Minneapolis-St. Paul (MDW-MSP): the first ZMP scenario

The MDW to MSP scenario involves 10 flight instances filed on the MDW..BAE..EAU4.MSP route and 16 on the MDW..BAE..EAU3.MSP route, with an arrival time between 2200Z and 2400Z in the month of July. The average planned air time was 62.7 and 62.6 minutes respectively, but the actual average air time is shown to have been 89.7 and 80.7 minutes respectively, with an average off-time 22.8 and 21.7 minutes later than planned, combining to create many significantly late on times for such a short flight. 8 flight instance where held, with 4 coming from each of the two filed routes. In addition to 3 POET screen captures showing this information, an Excel spreadsheet screen capture was included at the end of the slide show that uses POET data to show the worst average air-times for flights into MSP from any other city. This table shows the TWINZ arrival fix to produce the worst four air-time delays and for the two worst arrival hour bins to be 0100Z-0200Z and 2300-2400Z. The table also shows MDW-MSP to be third in this table.

Omaha to Minneapolis-St. Paul (OMA-MSP) : the second ZMP2 scenario

The OMA to MSP scenario shows flight information for 24 flights with arrival times between 2200Z to 2400Z in the month of July. All but two of these flight instances were flown on the filed route to approach MSP from the south. The two flight instances that did not approach MSP from the south, approached it from the west. The average planned airtime for this flight was 45.2 minutes, but 7 flights were held and averaged an additional 32.1 minutes. Those that were not held averaged 20.1 minutes additional airtime. The average off time for those held was

12 minutes later than planned (ranging from 7 to 19 minutes late) and the average off time for those not held was 20.9 minutes later than planned (ranging from 7 to 54 minutes late). The combined off time and air time delays produced many significantly delayed flight instances for such a short flight.

Procedure

Phase	Dispatcher at AOC	Traffic Manager at Center
1	Dispatcher signs consent form and is given problem statement	
2	Training with C-SLANT and introduction to POET screens	
3	The dispatcher creates a message	
4	The dispatcher completes the questionnaire	
5		Traffic manager signs consent form and is given problem statement
6		Training with C-SLANT and introduction to POET screens
7		The traffic manager creates a response
8		The traffic manager completes questionnaire

Table 6.3 Experimental procedure for each participant pair

There were eight phases to the experiment for each dispatcher – traffic manager pair, as shown in Table 6.3. The first four phases for each pair took place at the Northwest Airline Operations Center in Minneapolis. The next four phases for each pair took place at the respective center. During phase 1, the experimenter gave a problem statement to the dispatcher. Phase 2 introduced the dispatcher to C-SLANT's interface and POET screens. Phase 3 involved the dispatcher creating a message using C-SLANT. Phase 4 involved the dispatcher completing a questionnaire. Phase 5 involved the experimenter giving a problem statement to the traffic manager. Phase 6 introduced the traffic manager to C-SLANT's interface and POET screens.

Phase 7 involved the traffic manager responding to the message created by the dispatcher he or she was paired with. Phase 8 involved the traffic manager completing a questionnaire.

1. The dispatchers' problem statement

   In Phase 1 dispatchers were asked to sign a consent form and then given the following problem statement:

   "This is part of a study of asynchronous communication technologies for supporting communication between AOC staff and traffic managers. You will be asked to work with a software application that allows screen captures to be taken from a computer to form a slide show, which may then be annotated to create a message. Such a message could be transmitted as an attachment in any email program.

   You will be given an unannotated slide show of screen captures displaying historic data about a particular city pair and asked to annotate it in order to create a message to be sent to a traffic manager at a relevant center. You are asked to use any of the slides given to begin a discussion with the traffic manager of the problems you see with the city pair and possible solutions to the problems. This message will actually be given to a traffic manager and he/she will be asked to create a response".

2. Training with the C-SLANT interface and introduction to POET screens

   Dispatchers were given approximately 25 minutes of training with the C-SLANT interface using a practice slide show (see Appendix C.) that included POET screen captures to demonstrate the basic types of result that POET can produce and how it is presented on computer displays. Questions were allowed at any time during the training. Slide 1 contained a blank slide so that the dispatcher's attention could be focused on the C-SLANT tools window. Determining the number of slides in a slide show, the purpose of the left and right arrows, and the ability to move the tools window around on the screen above any slide was emphasized.

Slide 2 contained no POET data either, but was a screen capture from the Internet that included a standings table in the Big Ten Conference for American Football at the time the screen capture was taken. This slide included a portion of empty screen space on the right hand side that was used by the experimenter to demonstrate the pens and arrows in isolation, and the ability to change the color of either annotation marker using the color palette. After demonstrating the arrow and pen markers, and the color palette the dispatchers were asked to try them on the slide. If the dispatcher was to work with textboxes a green arrow was placed beneath the score for the Penn State – Minnesota game and the following text was typed into a textbox: "As you can see from the score marked with the green arrow, Minnesota were winning at the time this screen was saved. This was a surprise because Penn State was higher in the standings." Then the lines for Penn State and Minnesota in the standings table were highlighted with a yellow pen. A second textbox was produced and moving and resizing of the textboxes was demonstrated. The dispatchers were then asked to try to create a text box, type something in it and move it on the slide. If the dispatcher was to work with the voice and pointing annotation feature a green arrow was again placed beneath the score for the Penn State – Minnesota game and then the same statements were made as before, this time pointing with the mouse pointer at the Penn State - Minnesota game score and the position of Penn State and Minnesota in the standings table as the statements were made. The recording was played back, the other buttons of the interface to the recorder itself were described and then saving the recording demonstrated along with saving a subject ("Surprising Score") for the recording. A second recording was made underlining the lines for Penn State and Minnesota in the standings table with a yellow highlighter pen while recording to demonstrate that the pen marks are actually not dynamically recreated during playback, but are static on the slide. Again the recording was saved (but this time no subject was given). The ability to move the player windows was also demonstrated. The dispatcher was then asked to create a recording, play it back and save it.

The remaining slides all contained practice POET screen captures that were explained verbally. Slide 3 was used to explain that the text in the search window of a POET screen shows the particular search that was conducted - in this case, that the search was for flights from MSP to CMH between 04/01/98 and 07/01/98 at any time of day. The table of sorted flights by average actual - planned fuel burn was explained, as was the scatter chart for the highlighted flight in the table.

Slide 4 provides additional information about the particular flight that was highlighted in Slide 3. It was used to start describing the maps that POET can produce and their relationship to POET tables when both are displayed at once. In particular, the significance of the color and line thickness of routes shown in the map was explained. In Slide 4 the green thick line shows the filed route for the highlighted 57 flight instances and the block of thick black lines are the routes actually flown. The thin green line is the filed route for the single flight instance that filed a different route from the others shown and its actual flown route is shown with a thin black line. In general, thick lines correspond to those flights selected in the table and green lines represent filed routes whereas black lines represent those actually flown.

Slide 5 was used to demonstrate that if an individual flight is selected in a table its actual flown path appears blue in the map. Slide 6 was used to demonstrate the performance metrics that POET can display in addition to the fuel-burn data demonstrated on the previous slides. Slides 7 and 8 were used to demonstrate what information about race-track (called circular in POET) holding looks like in POET. Slide 7 demonstrates that a yellow diamond indicates at least one instance of holding. Slide 8 demonstrated holding shown in a flight path might be difficult at times to see in the version of POET used in the scenario as it did not have a feature to zoom-in and see the flight pattern clearly.

3. The dispatcher creates a message

After the training dispatchers were given their assigned slide show to use as the basis for their message. They were told they could ask questions at anytime if they couldn't remember how to do something in C-SLANT or if they had trouble interpreting the data presented by POET. A time constraint was not directly placed on the dispatchers, although there was an indirect time constraint in that their supervisor told them that the task would take approximately one hour. After the dispatcher indicated the message was complete it was saved for them.

4. The dispatchers' questionnaire

After saving the message the dispatcher was given a questionnaire to get feedback on the perceived value and usability of C-SLANT and being able to use it in the type of context represented by the experiment.

5. The traffic managers' problem statement

In Phase 5 traffic managers were asked to sign a consent form and then given the following problem statement:

"This is part of a study of asynchronous communication technologies for supporting communication between AOC staff and traffic managers. You will be asked to work with a software application that allows screen captures to be taken from a computer to form a slide show, which may then be annotated to create a message. Such a message could be transmitted as an attachment in any email program.

You have been paired with an AOC person (ATC Coordinator/Chief Dispatcher/Dispatcher) from Northwest Airlines who has already used the same software to create a message to you. This message was created after he/she was given an unannotated slide show of screen captures displaying historic data about a particular city pair and asked to annotate it in order to create a message to be sent to you. The AOC person was asked to use any of the slides given to begin a discussion with you of the problems he/she saw with the city pair and possible solutions to these problems. You are now asked to continue the scenario by responding to this message."

6. Training with the C-SLANT interface and introduction to POET screens

   The training given to the traffic managers was the same as given to the dispatchers, except for those given the textbox condition. The text in the textboxes created by the dispatchers was changed from the default text color of black to blue, before the traffic managers saw those messages. This was to allow the traffic manager to use the same text box to create a response by typing their text in black, between groups of sentences if desired – rather like people often do in an E-mail program, or a separate text box could be used for the response. Traffic managers were explicitly told they could respond using whichever method they preferred.

7. The traffic manager creates a response

   After the training traffic managers were given the respective dispatcher's message to respond to. They were told they could ask questions at anytime if they couldn't remember how to do something in C-SLANT or if they had trouble interpreting the data presented by POET. A time constraint was not directly placed on the traffic managers, although there was an indirect time constraint in that their supervisor told them that the task would take approximately one hour. After the traffic manager indicated the message was complete it was saved for them.

8. The traffic managers' questionnaire

   After saving the message the traffic manager was given a questionnaire to get feedback on the perceived value and usability of C-SLANT and being able to use it in the type of context represented by the experiment. They were also asked if there was anything they thought the dispatcher could have done to improve the message they received.

Data collection

A special version of C-SLANT was created where pressing specific function keys hides the buttons for synchronized voice and pointing or creating textboxes. In addition, a function key was assigned to hiding the "Screen Capture" button so the participants could not switch C-SLANT into its screen capture mode. Participants created and responded to slide shows using a Gateway SOLO 9120 laptop computer connected to an external monitor and keyboard. This allowed the screen output to be duplicated on both the laptop display and monitor display so that the participant could work in front of the regular monitor in a typical desktop environment, but the output duplicated on the laptop could be video taped using a SONY Handycam TRV65 Hi8 camera. The modified slide shows themselves were saved to disk after each participant completed his or her message. The arrangement of this equipment for the ZDC scenario is shown in Figure 6.2.

Figure 6.2 Equipment setup

Data Analysis

Three types of analysis were performed: 1) An analysis of the outcome performance; 2) A questionnaire to get reactions to using the system for the task given; and 3) A qualitative analysis of the communications and the information exchanged.

CHAPTER 7

RESULTS AND DISCUSSION

Introduction

In this chapter results from the experiment are discussed, first focusing on discourse and problem solving characteristics and effectiveness for this task in this domain, followed by an analysis of lower-level interface issues. Stated another way, the focus first is on the semantic issues and then the syntactic ones. The questionnaire results are also analyzed. Following these analyses, the impact of promoting collaborative problem solving between these groups is discussed and then possible enhancements to POET and redesign ideas for C-SLANT are presented.

Discourse and Problem Solving Analysis

While it is a subjective assessment, the "tone" of the communications by both dispatchers and traffic managers seemed to be cooperative, constructive and positive in most cases. There were a few who did not seem to adopt the intended collective responsibility mode, and instead appeared to be assigning blame for the performance problems to the other group; however, this attitude is actually consistent with a "culture" toward each other that has occasionally been reported in the news media:

"'As long as airlines continue to overbook runways, especially during peak hours, air traffic delays will continue and passengers will wait,' said Randy Schwitz, executive vice president of the National Air Traffic Controllers. The airlines say flight scheduling amounted to only 7.5 percent of delays." (CNN Report, October 15, 1999).

"One aviation expert said delays will drop only when the airlines and the Federal Aviation Administration accept responsibility for their share of the problem. 'That means airlines have to schedule realistically,' former FAA chief of staff Michael Goldfarb said. 'Air traffic control has to be modernized. Congress has to give the monies to the agency to truly do that. So everybody has something they have to give and right now we have a culture of blame.'" (CNN Report, August 21, 2000)

An example of this attitude and the need for collaboration was demonstrated by the participants working with the ZFW scenario. One dispatcher working in the voice and pointing mode looking at a pattern of reroutes to Tulsa enroute to DFW made the comment, "If we had more prior knowledge of what you guys were doing we could have routed some of these flights straight south [to] Fort Dodge [to] Kansas City, and come in on a Fort Smith routing into Dallas - Fort Worth. That would have saved us a great deal of fuel and a lot of aggravation." However, in the traffic manager's response he pointed out that there would be a problem with heavy traffic from the North West through Fort Smith. The other voice and pointing traffic manager also mentioned the problem with filing through Fort Smith and provided more details on the problem. He added that there would be problems due to the fact that route would cross into Memphis Center airspace and they already sequence over Fort Smith and have miles in trail for traffic that ZFW must merge for a BYP arrival from Little Rock and another route (which the traffic manager doesn't name but traces with the pointer while recording his response). He added that if the Memphis Center is saturated the Kansas Center would reroute the flight over Tulsa anyway. He suggested contacting the Kansas Center each day to "get a heads up" on what ZFW is doing and whether or not arrivals over UKW or BYP are in effect and to then plan accordingly.

In the MDW to MSP, ZMP scenario, another example of blame occurred where the dispatcher for one of the voice and recording pairs commented on the first slide, "Midway to

Minneapolis. Difficult route. We plan it as conservatively as possible. Obviously, from these statistics we can see we are getting extended enroute times." Then on the second slide wrote, "In looking at the routes that were filed on each of these example flights, we can see the flight actually tracked on its filed routing. Still we experienced this kind of delay. Usually we try to file the preferred routings that ATC likes. If this isn't going to work, we need to figure out ways that we aren't going to have this kind of delays on inbounds to Minneapolis, because this is obviously going to cause problems. We will end up with diversions." In response the traffic manager first commented, "I agree with you this is a problem, but it's a Northwest problem. If you change your schedule by a few minutes you would miss the rush." After looking at the slide again he then commented, "Another thought. Most of the time the flights are taking this busy route over TWINZ. If we offloaded the flights and go up to a northern arrival over Branard or Edward Fields, or a south arrival, we could avoid the busy route at this arrival over TWINZ with fix balancing, because the airport is only busy on this side of the airport at that time of day." On the second slide the traffic manager referred to the airline's scheduling by commenting, "These routes at this time of day, and the kind of delays we are seeing here, are a part of marketing – trying to get all the flights here at the same time in a hub and spoke system. If flow control could have more control of these flights, and offload at will, we could probably take care of these delays."

The fact that the majority of the participants however, did seem to assume collective responsibility during the experiment can therefore be viewed as positive.

Dispatcher task times

After each participant was introduced to POET and C-SLANT using the same training scenario the participant's particular scenario was loaded and the participant was asked to create a message. The time each participant took from this point until he or she completed the message was the task time recorded unless the participant asked for assistance interpreting the POET data or performing a C-SLANT operation, or there was some other interruption from their problem solving and message creation time, in which case that time was deducted.

- *Dispatchers took longer to complete the task in the text mode*

Problem	Text Mode	Voice and Pointing Mode
ZNY	1430, 3570	900, 980
ZOB	2010, 2410	2040, 1080
ZID	1040, 1290	320, 740
ZTL	1950, 2025	1480, 2400
ZFW	600, 510	1110, 1020
ZBW	2831, 3411	1320, 1140
ZDC	260, 1200	950, 510
ZMP-1	840, 830	565, 690
ZMP-2	2200, 1830	1680, 540
Average	1680	1081
Std. Dev.	965.71	544.27
Max.	3570	2400
Min.	260	320

Table 7.1 Dispatcher task time (in seconds) summary

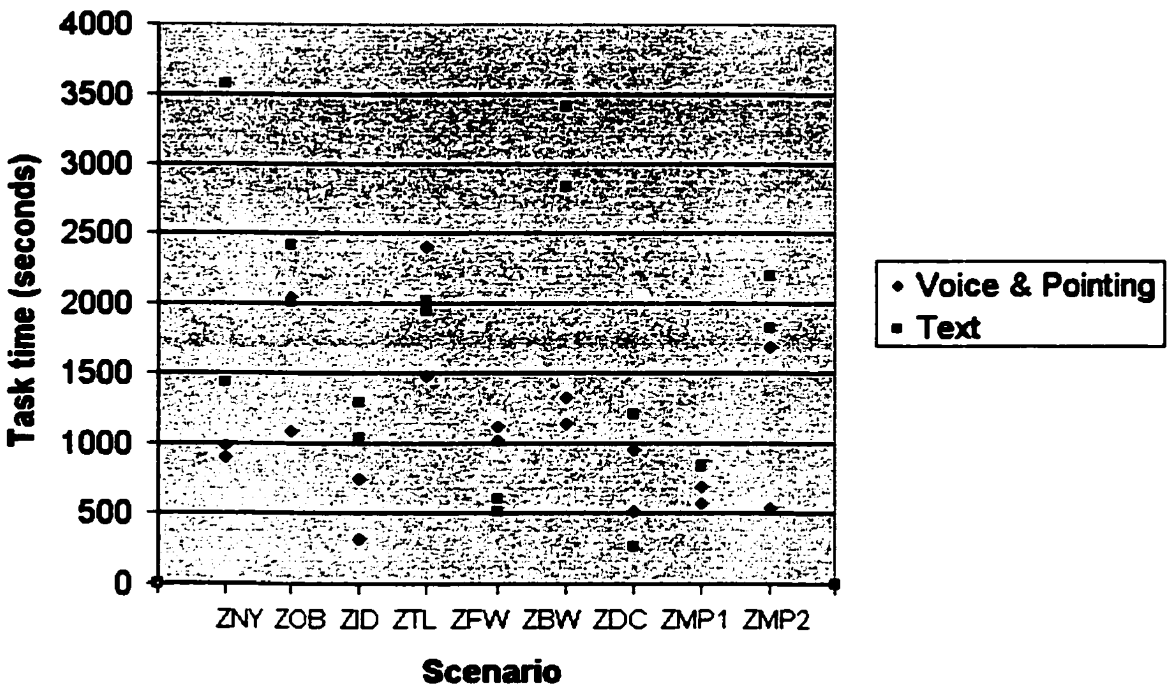

Figure 7.1 Dispatcher task time distribution

As Table 7.1 and Figure 7.1 show, dispatchers took longer to complete the task when working in the text mode compared to the voice and pointing mode. The average task times were 28 minutes (1680 seconds) and 18 minutes 1 second (1081 seconds) respectively, although there was variation between scenarios. 5 of the 6 longest task times were in the text mode, ranging from 36 minutes and 40 seconds to 59 minutes and 30 seconds. The longest task time in the voice and pointing mode was taken by a dispatcher working with the ZTL scenario who took 40 minutes. This scenario involves seven slides, which is more than any of the other scenarios, and the dispatcher made 8 recordings on those 7 slides for a total recording length of 9 minutes and 21 seconds (more than any other dispatcher). The dispatcher also played back several of the recordings and deleted some first attempts. For 5 of the 9 scenarios both text mode dispatchers took longer than either of the voice and pointing mode dispatchers for that scenario, but the ZFW scenario was unusual in that it was the only one were both text mode dispatchers took less time than either of the voice and pointing mode dispatchers. The ZFW scenario involves only two slides, which is less than any of the other scenarios, but it is also the only scenario where both text mode dispatchers created only one text box (which was placed on the first slide in both cases). The ZFW voice and pointing mode dispatchers both commented on each of the two slides, with one of them creating two recordings on each slide. The first text mode dispatcher made no additions and simply wrote on the slide:

it seems more often then not that our flights are geting rerouted from msp to dfw granted some may be for weather but i need to know if we need to file on a denerent route that whld help atc and us for a better trafic flow and to cut down our fuel burns. Thanks

This dispatcher appeared to type more slowly than most text mode participants and also possibly didn't process the problem as thoroughly as the other participants given this scenario, because the slides actually showed that flights filed to approach from the west were being rerouted consistently, but not those from the east. The other traffic manager working with the ZFW scenario in the text mode wrote more:

I am concerned about flights inbound to DFW that are planned to arrive from the west. It seems that from ICT to destination routings are quite often being offloaded to the east resulting in inaccurate fuel burn data. Could I have a response as to why this is? Center transitions? Perhaps if this is happening as often as it should we should work out new routes or file the arrivals via the east fixes daily so we can have more accurate arrival times/burn.

However, both the voice and pointing mode participants discussed the routings filed and flown in more detail and actually proposed specific new routes which they drew. The first voice and pointing mode participant also mentioned a flight instance that appeared to be rerouted for weather and the second discussed the problems that the reroutes caused the airline in terms of fuel burn and planning.

The shortest task time of 4 minutes and 20 seconds was taken by a dispatcher working in the text mode with the ZDC scenario, who placed one text box on the last slide. He simply wrote:

i have some concerns about the route mem ewr and most often if holdiing is done its done over the dca area . ... would it be possible to move some of this traffic more north and and out of the dca area ....also the highlignted flts that took reroutes that used several thousands of lbs of fuel was this really necessary .... expect a reply as soon as practical..

The second shortest task time of 5 minutes and 20 seconds was taken by a dispatcher working in the voice and pointing mode with the ZID scenario who placed one recording of 1 minute and 6 seconds on the first slide. This participant did not create any pen or arrow marks and simply indicated that the largest deviations from the filed route were probably due to thunderstorm activity or heavy traffic. He then added that the heavy traffic flow of the north-east corridor could be a factor, but he said he thought that thunderstorm activity was most likely the main reason for the deviations.

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	1	3223222	3223222	3223222	12.00	0.003
Scenario	8	11317380	11317380	1414673	5.27	0.002
Treatment*Scenario	8	4736422	4736422	592053	2.20	0.078
Error	18	4836475	4836475	268693		
Total	35	24113499				

Table 7.2 ANOVA for dispatcher task times

Table 7.2 shows that using an Analysis of Variance (ANOVA) statistical test on the data in Figure 7.1, the hypothesis that there is no difference between the dispatcher task times in the two respective modes (treatments) can be rejected (p-value < 0.05).

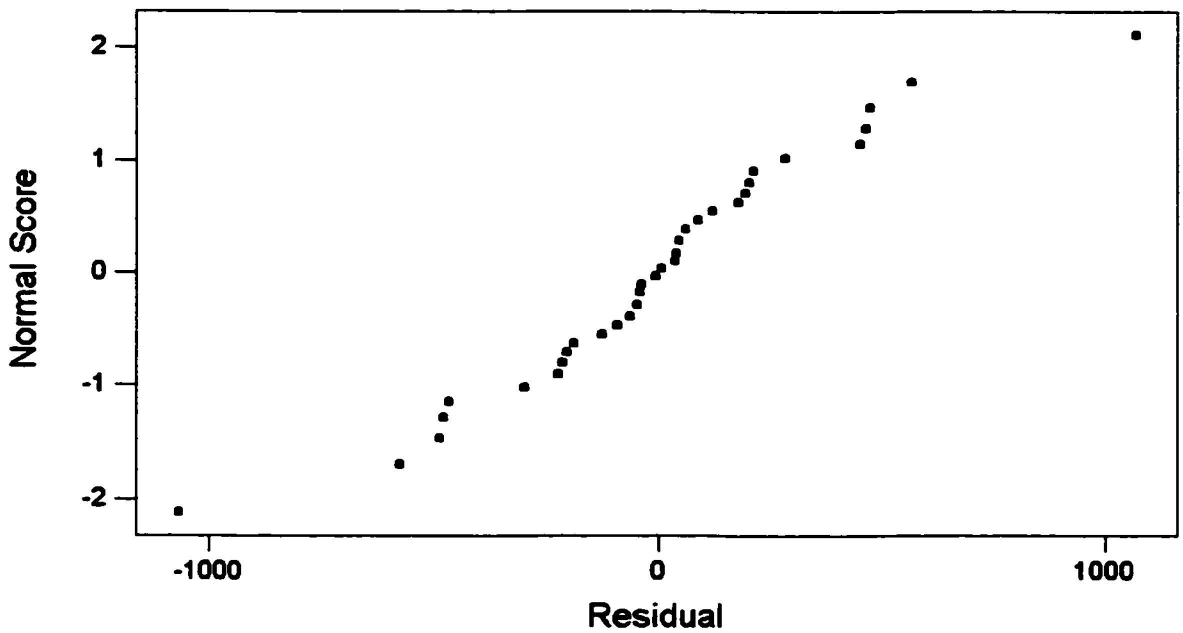

Figure 7.2 Normal probability plot of the residuals for dispatcher task time

As a condition for using the ANOVA test, the residuals should be normally distributed, and therefore the normal probability plot, shown in Figure 7.2, should be close to a straight line. The plot is approximately a straight line, but as shown in Table 7.1 and Figure 7.1 the task times for the ZNY participants differed by 35 minutes and 40 seconds, which produces the two significant differences from the observed values and the fit (which is simply the average of the two observed values). The average time for all dispatchers working in the text mode was 28 minutes. In the ZNY scenario one participant took 23 minutes 50 seconds and the other took 59 minutes and 30 seconds, which was the longest time for all participants working in the text mode. This latter dispatcher working in the text mode created pen or arrow marks on all but the first slide and also wrote more than any other dispatcher, producing 1,836 characters. In general, the number of characters has a linear relationship with the task time for dispatchers (with Pearson's correlation = 0.82; and sufficient evidence at $\alpha < 0.01$ that the correlation is not zero). The writing style of this dispatcher also involved complete detailed sentences, such as the following on slide 6:

The worst case of en route holding is depicted here. The flight was held very shortly after departure from DTW. This usually happens when ZNY stops traffic from ZOB at the center boundary and ZOB has to begin holding traffic further from EWR. In cases like this, would it be possible to offer a reroute to one of the northern alternate routes? This soon after departure from DTW, an alternate route could be easily analyzed and there would be enough fuel to accept such a route in most cases. The added flying on the alternate route would probably consume less fuel than the 2900 lbs this flight burned in holding and vectoring..

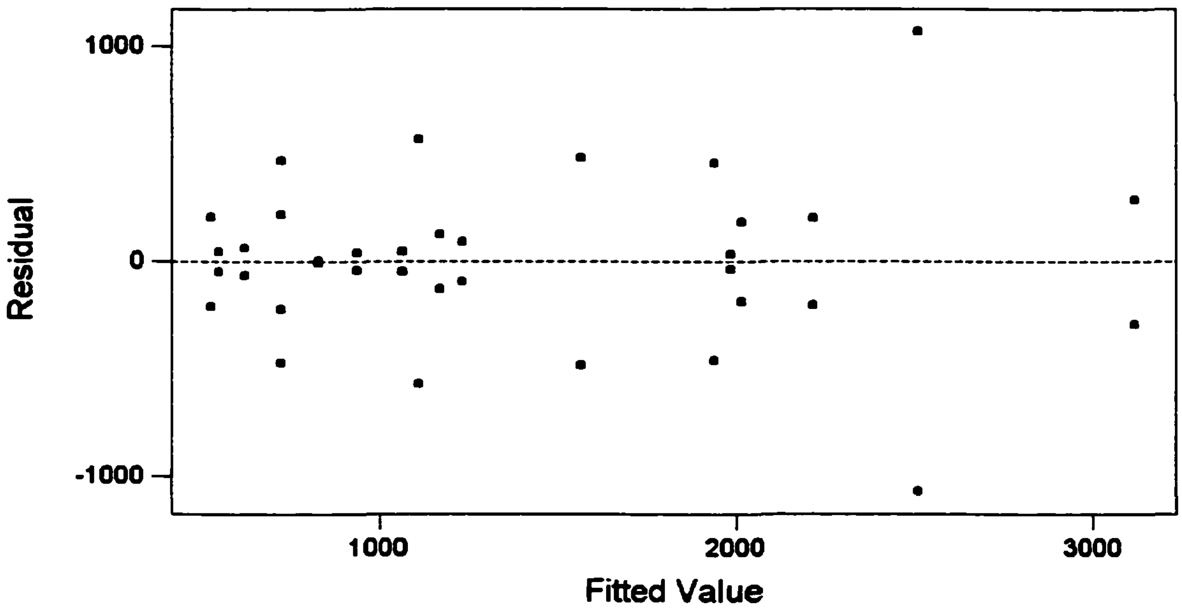

Figure 7.3 Residuals versus the fitted values for dispatcher task times

Figure 7.3 shows that the largest pair of residual values occurred for the second largest average task time for a particular scenario, but it shows there is not a strong relationship between the average task time and the residuals. Although there does not appear to be a compelling reason to remove the ZNY scenario as an outlier, Table 7.3 shows the result of performing an ANOVA with that scenario removed for completeness. The effect is that (1) the hypothesis that there is no difference between the dispatcher task times in the two respective modes (treatments) can still be rejected (p-value < 0.05); (2) the hypothesis that there is no difference between the dispatchers task times across the scenarios can still be rejected (p-value < 0.01); the hypothesis that there is an interaction between the mode (treatment) and the scenario can no longer be rejected (p-value < 0.05).

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	1	1829785	1829785	1829785	11.51	0.004
Scenario	7	10799048	10799048	1542721	9.70	0.000
Treatment*Scenario	7	3696259	3696259	528037	3.32	0.022
Error	16	2543475	2543475	158967		
Total	31	18868567				

Table 7.3 ANOVA for dispatcher task times (with ZNY data removed)

Figure 7.4 shows the main effects of the mode (treatment) and the scenario. The average task time for the text mode participants was 28 minutes 0 seconds and the average task time for the voice and pointing mode participants was 18 minutes 1 second, which is difference of 9 minutes 59 seconds.

Figure 7.4 shows the average time for each scenario, whereas Figure 7.5 separates the average time for each scenario using a particular mode, and thus suggests interactions between the mode and the scenario where there are large differences. (It is important to note that the average for each unique mode and scenario combination is the average of just two participants however, so an outlier can have a significant impact on that average.) The main effects of the scenarios suggest there were two levels of complexity for the problem solving and communications task, assuming complexity is correlated positively with the task time. The ZDC, ZFW, ZID, and ZMP-1 scenarios produced the four shortest average task times for both modes, and ranged from 12 minutes 10 seconds to 14 minutes 7.5 seconds. The remaining scenarios' averages' ranged from 26 minutes 2.5 seconds to 36 minutes 15.5 seconds. The number of slides in each scenario varied, and the four scenarios with the lowest average task times had 4.25 slides on average, whereas the remaining five had 5.4 slides on average, but there is evidence that other factors influenced the task time. Pearson's correlation between the number of slides and the average voice and pointing mode task time = 0.251; with evidence at $\alpha = 0.315$ that the correlation is not zero. Pearson's correlation between the number of slides and the average text mode task time for each scenario = 0.426; with evidence at $\alpha = 0.078$ that the correlation is not zero. In addition, it can't be concluded that the task times within the same scenario for the two modes are correlated. Pearson's correlation between the voice and pointing and the text mode task time for each scenario = 0.462; with evidence at $\alpha = 0.053$ that the correlation is not zero.

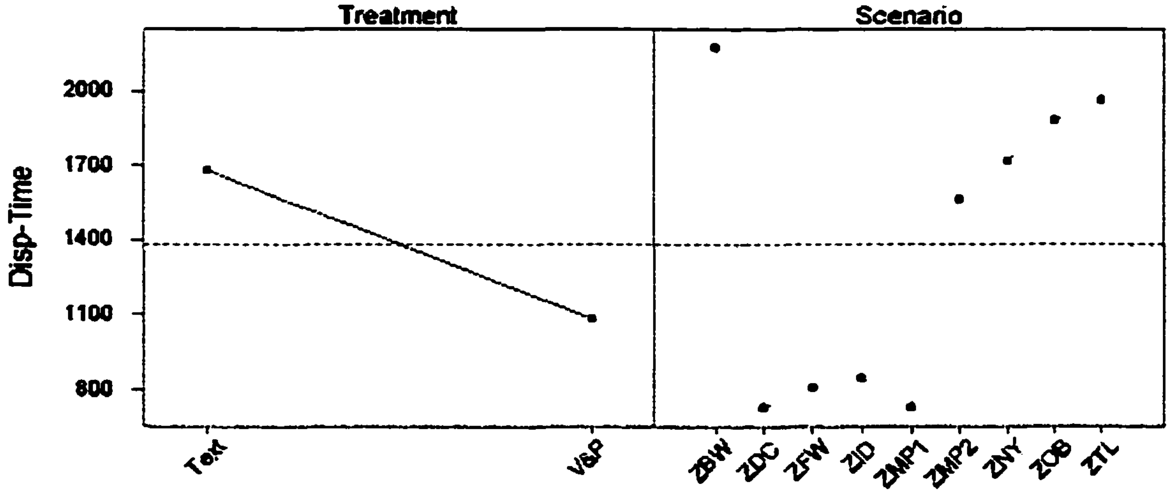

Figure 7.4 Main effects plot for dispatcher task times

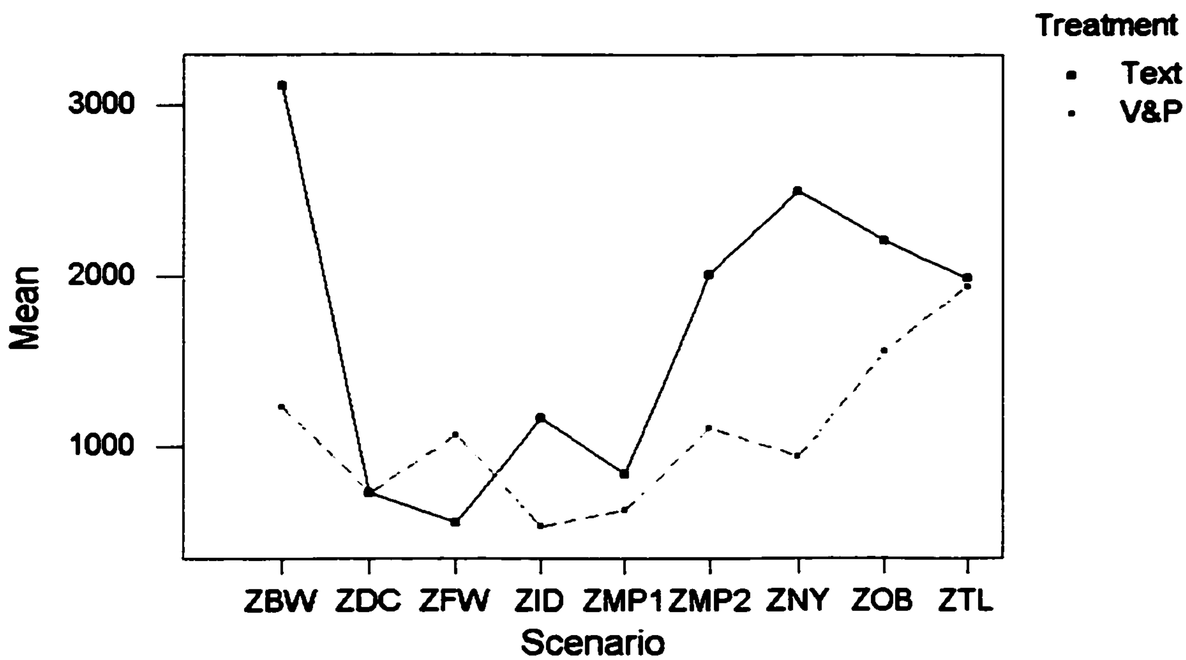

Figure 7.5 Interaction plot for dispatcher task times

The ZID scenario involved five slides, however after the first slide the remaining four only show what the mapping is between specific fuel burns and instances in the route map for the worst of these instances. The overall complexity of the slide show is therefore not that much more than the first slide. The ZFW scenario was just two slides with flown versus filed routes for those that were filed to the northwest of DFW on one slide and to the northeast of DFW on the other. The ZMP-1 scenario involved four slides; however, the information on the maps was essentially redundant after the first slide. The ZDC scenario involves six slides and with a scatter chart, flight instance information, holding, and instances most likely influenced by weather it is surprising this scenario did not produce longer dispatcher task times.

Dispatcher situation assessments

- *Dispatchers agreed that POET data demonstrated performance problems*

In this experiment dispatchers working with the same scenario were given a common set of slides to work with as a control, although if a dispatcher really had access to C-SLANT he or she would decide when a performance problem existed and create slides that would seem to help the communication. While not completely authentic, the experiment would clearly be more valuable if the dispatchers agreed there was a problem represented by the slides that were given to them. All but one dispatcher used language to express "concern" about one or more performance issue shown on the slides for their respective scenario. For instance, "some of these fuel burns are excessive"; "this flight is frequently on a route other than the filed route"; "a large percentage of these flights are getting held at this location"; or "the airtime for these flights suggests miles in trail are often applied", followed by one or more comments regarding the negative impact to the airlines and/or a question, suggestion, or idea regarding alternatives to avoid the problem. The one dispatcher who did not express concern merely explained how to interpret the POET screen captures without using such language to indicate he considered that a problem had actually been represented.

- *Dispatchers normally did not introduce the flights with some basic classifying data defining the situation*

Category	Dispatcher Text Mode	Dispatcher Voice & Pointing Mode
City pair	5/18	11/18
Time of day	1/18	4/18
Time of year	0/18	5/18
Number of flights involved	1/18	4/18

Table 7.4 Number of dispatchers mentioning certain flight classifying data

As Table 7.4 shows, when dispatchers started making comments about the scenario on the first slide they often did not mention certain basic flight classification data. Although this information was available by searching through the POET data on the first slide in each scenario, the context for the discussion could have been made clearer by drawing attention to this information with comments. In addition only one dispatcher used pen or arrow marks to annotate this information, (a text mode participant working with the ZMP2 scenario who used a yellow pen to highlight the city pair and date range), and none of the dispatchers working in the voice and pointing mode pointed to this data while recording their comments.

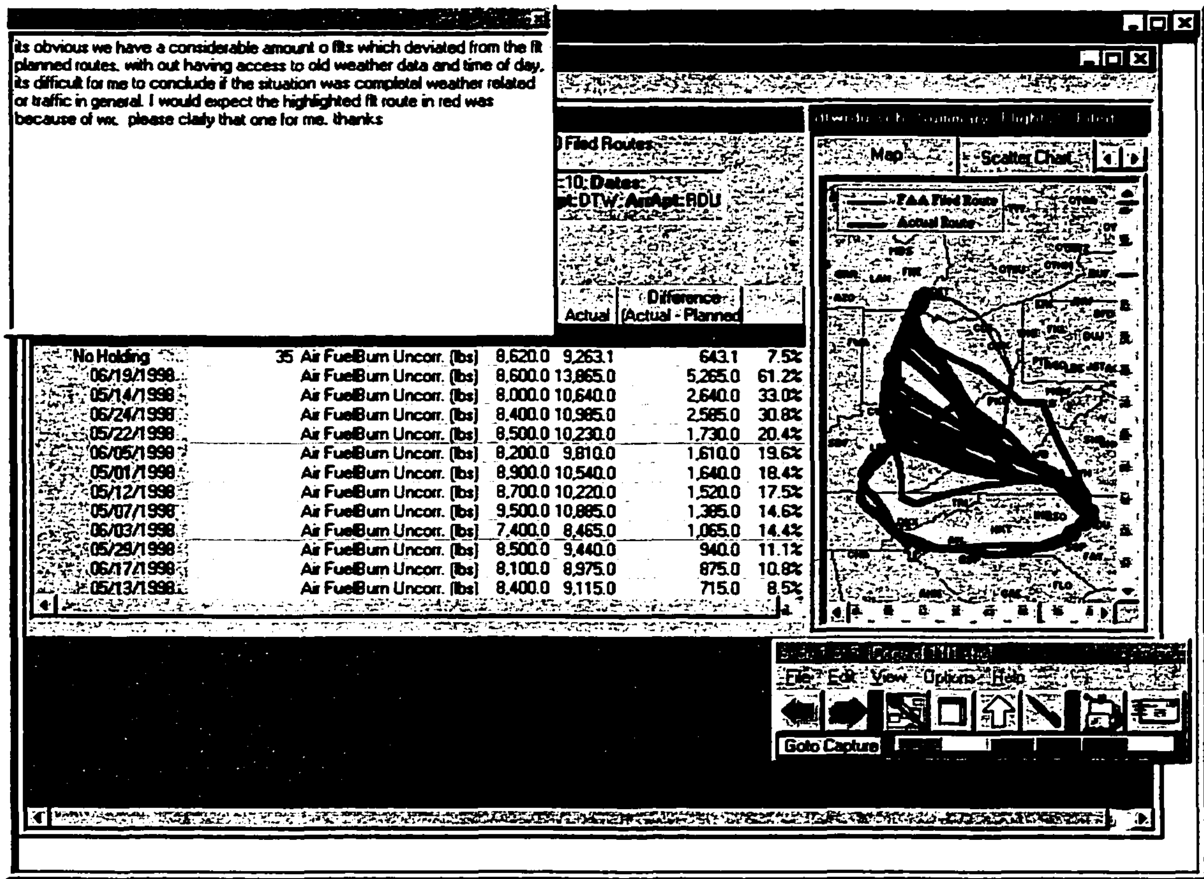

Figure 7.6 Loss of time of day information

Figure 7.6 shows the first slide communicated by a dispatcher working with the ZID scenario in the text mode. This was the only slide the dispatcher annotated and he wrote:

its obvious we have a considerable amount o flts which deviated from the flt planned routes. with out having access to old weather data and time of day. its difficult for me to conclude if the situation was completel weather related or traffic in general. I would expect the highlighted flt route in red was because of wx. please claify that one for me. thanks

Thus, the dispatcher clearly considered the time of day important, but didn't notice that information in the POET screen capture. Further, by creating the text box and not moving it from its default position of the top left hand corner he made it more difficult for the traffic manager to notice that he was wrong in stating that there was no information regarding the time of day in the slide show. In fact, the traffic manager did move the dispatcher's text box, but did not make a comment about the time of day, so it can't be determined if the traffic manager noticed it or not. The traffic manager left his text box over the time of day information, so in a further message iteration it might still have not been noticed by the dispatcher. In the ZDC scenario, one of the traffic managers looking at the information for a flight instance on slide four made the comment that the holding he saw might be connected to the time of day, but he did not see that information on the slide. In fact the time of day information for all the flight instances in that scenario were shown on slide one, but the dispatcher didn't mention it and the traffic manager either didn't notice it or remember it by the time he reached slide four. These examples demonstrate the need for this important information to be made more salient in POET and also the value of the dispatcher mentioning it in the initial message.

The distribution of dispatchers mentioning the categories shown in Table 7.4 across each scenario is shown in Appendix D. Using a Chi-Square test to measure the relationship between the mode and whether or not the city pair was mentioned, the p-value is 0.044, which indicates that there is evidence that mode and whether or not the city pair was mentioned are related at the $\alpha < 0.05$ level. The contingency tables for the other categories shown in Table 7.4 produces two cells with expected values of less than 5 in each case, but applying the randomization test (Box, Hunter & Hunter, 1978) produces the time of day p-value as 5/32 = 0.16; the time of year p-value as 1/32 = 0.03; and the number of flights p-value as 5/32 = 0.16. The time of year p-value is the only one of these that would normally be regarded as statistically significant. A difference between the two modes might be because the cost/benefit ratio is different, given the relative ease with which the information can be stated verbally versus typed. It is also perhaps a factor that the message creator in the voice and pointing mode feels more control over the message recipient's attention and the order and rate at which information is communicated, and thus feels more responsibility to introduce the scenario before discussing the details. In some ways reducing the recipient's workload is also more polite, and that has reported to be a difference between voice and text based communications (Neuwirth et al., 1994). A difference between the modes with regard to mentioning this type of information is important, but even the voice and pointing mode did not create an environment where the dispatcher chose to mention more than the city pair more often than not, possibly because it was assumed to be something the traffic manager would note for him or herself. In other words, to use Clark and Wilkes-Gibbs (1986) distinction discussed in Chapter 2, in both modes the dispatcher appeared to consider the situation one of *mutual responsibility* rather than *distant responsibility* to note this basic information on the slides.

- *Dispatchers problem solving focus varied*

To collaboratively identify the performance problems, the actual or probable causes and the alternative actions to improve performance, the following was necessary by the dispatcher:

1. The dispatcher needed to interpret the information on the slides;
2. The dispatcher needed to focus the traffic manager's attention on information the dispatcher considered important to completing the task, including the performance

problems, and the actual or probable causes of the poor performance, based on information on the slides or in the dispatcher's head;

3. To progress further the dispatcher could ask for more information to determine what is happening to the flights; ask why the ATC are taking the actions they are taking; ask how the problem could be avoided; or offer suggestions and ideas for improving performance.

Dispatchers varied in how much they focused on each of these subtasks. This will be shown in the following sections that identify the types of questions asked and the number of dispatchers who made suggestions to improve NAS performance. These differences could have occurred because they had different interpretations for how far in the process a first communication should go, even though they were all given the same set of instructions before creating their message.

Dispatcher direct questions

Question: "A sentence in an interrogative form, addressed to someone in order to get information in reply."

(Webster's Encyclopedic Unabridged Dictionary of the English Language)

In collaborative problem solving tasks, questions can serve to explicitly request information the person asking doesn't have, but they may also be used to ask if a proposed solution would be considered a solution by the other participant. Thus, some questions are simply requesting acceptance or rejection, while others request different information. However, as Clark and Schaefer (1989) note, there are sentences that are not questions that also are normally followed by acceptance or rejection during interaction. For instance, in this context, there were sentences of the form, "I wonder if we were to ...." and "Perhaps if we ....", when considering changes that might improve performance. During synchronous communications such expressions are often followed by a pause, to see if the comment is accepted or rejected, but it is possible the person is just thinking aloud (or in text) and actually is not proposing the other person respond. Thus, in this section a strict interpretation of a question is used, even though this means some sentences that were used with the intention of receiving a response will not be counted. Specifically, a question in the text mode had to be terminated with a '?' character, or require one to be grammatically correct, and in the voice mode a sentence had to require a '?' to be grammatically correct, when written down.

Problem	Text Mode		Voice and Pointing Mode	
ZNY	3C's	1C	2A's, 1B, 3C's	-
ZOB	1B, 2C's	1A, 1B, 3C's	-	-
ZID	1A	2B's, 1C	-	1A, 1B
ZTL	3B's, 1C, 1D	-	-	1A, 1C
ZFW	-	1B	-	1A
ZBW	6A's, 1C, 2D's	-	-	-
ZDC	1A, 1C	2B's, 1C, 1D	-	-
ZMP-1	1A, 1C	2B's 1C	-	-
ZMP-2	-	-	-	-
Total:	42: 10A's, 12B's, 16C's, 4D's		11: 5A's, 2B's, 4C's	

Table 7.5 Number of direct questions asked by each of the 36 dispatchers

The majority of questions asked fell into one of three categories:

- Question Type A: "Why is X happening to our flight(s)?"

  Sometimes X was general, such as "being held so often", or "being rerouted so often"; and sometimes it was more specific, such as "being held here so often", "being rerouted to the north through ZBW".

- Question Type B: "Was the problem caused by Y?"

Again, sometimes *Y* was general, such as "weather" or "traffic"; and sometimes it was more specific, such as "thunderstorms", "traffic from the east", or "traffic departing from Cincinnati".

- Question Type C: "Would doing *Z* help?"

  Again, sometimes Z was general, such as "taking a different route"; and sometimes it was more specific, such as "taking this route".

Of the 17 dispatchers who asked direct questions, 13 included at least one of type C – 11 in the text mode and 2 in the voice and pointing mode. As Table 7.5 shows, of the 53 direct questions asked, 42 were asked by dispatchers in the text mode (10 A's; 12 B's, and 16 C's), and 11 in the voice and pointing mode (5 A's; 2 B, and 4 C's). Overall, 15 were of type A, 14 were of type B, and 20 were of type C. The other four questions asked in the text mode (shown as type 'D' in the table) were, "Was the reroute predictable before the flight departed?"; "What is the reason for the gap in the data?"; "Is there any airspace available around the DCA area where the holding occurs?" and "Are we checking if these flights are over water equipped?" All the questions asked are shown in Appendix E.

Dispatcher ideas for improving performance

As was mentioned in the last section, there were 20 questions that specifically asked if doing *X* would improve performance (16 in the text mode by 11 dispatchers and 4 in the voice and pointing mode by 2 dispatchers); however, there were also suggestions and ideas raised that were not in the form of a direct question. Grouping these together produces the numbers shown in Table 7.6.

Problem	Text Mode	Voice and Pointing Mode
ZNY	4, 2	3, 1
ZOB	2, 3	3, 1
ZID	0, 2	0, 1
ZTL	2, 1	2, 7
ZFW	1, 1	2, 2
ZBW	1, 0	1, 1
ZDC	1, 2	0, 2
ZMP-1	2, 2	1, 1
ZMP-2	1, 0	1, 0
Total	27	29

Table 7.6 Number of dispatcher ideas for performance improvement

Table 7.6 shows 15 dispatchers in the text mode and 15 dispatchers in the voice and pointing mode made suggestions for improving performance. The total number of suggestions was 27 in the text mode and 29 in the voice and pointing mode. Thus, dispatchers generated a similar number of ideas, but less often in the form of a direct question when working in the voice and pointing mode.

Category	Dispatchers	
	T	VP
New preflight route	11	9
Enroute reroute	2	3
Change schedule	1	1
Ground delay/stop	3	4
Same route but miles in trail	0	1
Change Center staffs' workload / traffic volume	2	0
Share information for planning (fuel burn, filed route, etc.)	3	3
Hold at a different location	1	1
Change altitude	2	2
Fix balancing	0	1
Other	0	1
Totals:	25	26

Table 7.7 Classification of dispatcher ideas regarding performance improvement

Appendix F lists each performance improving idea that was produced by each dispatcher.

Table 7.7 is a classification of these per dispatcher. Thus, for instance, 11 dispatchers made at least one comment about a new preflight ("preferred" or "filed") route working in the text mode, and 9 working in the voice and pointing mode. Overall, it reveals that the routes were seen as an issue more often than other factors influencing performance.

Problem	Text Mode	Voice and Pointing Mode
ZNY	2, 2	1, 0
ZOB	0, 1	1, 1
ZID	0, 0	0, 1
ZTL	0, 1	0, 2
ZFW	1, 1	2, 2
ZBW	0, 0	1, 0
ZDC	1, 1	0, 1
ZMP-1	1, 1	0, 1
ZMP-2	1, 0	0, 0
Total	13	13

Table 7.8 Count of dispatchers' proposed routes

Appendix G lists each of the dispatchers' proposed routes, whether pen or arrow marks were used, and what deictic gesturing occurred. Table 7.8 shows the tabulated number of routes proposed to improve performance, which is the same in each of the two modes. The distribution was also similar with all dispatchers proposing between 0 and 2 routes.

Text Mode	2/13
Voice & Pointing Mode	4/13

Table 7.9 Count of dispatchers using pen or arrow marks with a proposed route

Table 7.9 shows the number of proposed routes that were annotated with arrow marks or the pen marker. In the voice and pointing mode the 4 instances where pen or arrow marks were used all involved doing so while speaking at the same time. Of the nine other instances, 5 involved pointing to or tracing the route referenced. The remaining four did not involve pointing, included two instances for the ZOB scenario where the comments clearly identified the occasionally filed routes to the north of the normally filed routes. The comment, "A filed route that can be flown without being rerouted consistently" by a dispatcher in the ZID scenario appears to reference a route the dispatcher couldn't point to on the map, because he doesn't have an instantiated route in mind. The fourth comment which didn't occur with simultaneous pointing to the referenced route occurred while the dispatcher placed a yellow arrow marker beneath another route he had just previously commented about.

Dispatcher	Voice and pointing mode proposed route description
ZNY V&P 1	A route to the north or south of this area where holding occurs
ZOB V&P 1	This northerly route because it appears to run into less traffic
ZOB V&P 2	A northern route because they don't appear to have holding
ZID V&P 2	A filed route that can be flown without being rerouted consistently
ZTL V&P 2	A different preferred route on a lower altitude out of DTW, coordinated with Cleveland and Chicago Centers
ZTL V&P 2	The route most often actually flown
ZFW V&P 1	Ideally a route through Kansas City to Fort Smith
ZFW V&P 1	From the routes currently flown, Kansas City to Tulsa.
ZFW V&P 2	A more direct route than the dogleg from Tulsa to DFW
ZFW V&P 2	This route we are actually flying after being deviated from Kansas City
ZBW V&P 1	A different preferred route to the north or south to avoid holding over Gardner
ZDC V&P 2	A north west approach on a route currently used with no shown holding, rather than one from the south west
ZMP-1 V&P 2	A route through the oclare3 arrival to reduce the enroute and holding time associated with oclare4

Table 7.10 Dispatcher voice and pointing mode proposed route descriptions

Table 7.10 lists the route descriptions in the voice and pointing mode. Two of these benefited from simultaneous pointing to not only help the recipient focus attention to the correct route quickly and unambiguously, but also to add information to the comments made. After noting that most of the traffic appeared to be rerouted to the west enroute to Atlanta, a voice and pointing mode dispatcher suggested that perhaps a new preferred route could be coordinated with the Cleveland and Chicago Centers. In doing so she suggested considering lower altitude restrictions out of Detroit to avoid Chicago's overhead traffic. While making this recording the dispatcher traced a partial route out of Detroit to the east when mentioning the possibility of developing a new preferred route, even though there was nothing in what the dispatcher actually said that suggested a route to the east. Thus pointing made it clear that she had a route in mind when making that comment and more specifically that it was a route to the east. A dispatcher working with the ZBW scenario commented that perhaps the flight could be moved a little more to the north or south to avoid holding over Gardner. While making this comment he traced two routes, one to the north and one to the south, both deviating from the filed route relatively close to BOS. Thus, he showed more precisely what routes he was thinking off, however, when tracing those routes he moved the pointer much faster than during his other pointer, which appeared to gesture that these were approximate routes.

Traffic manager task times

The traffic manager's task time involved time spent interpreting the POET slides, interpreting the dispatcher's comments, deciding appropriate responses and communicating those responses. Thus, the task time was recorded as the difference between the time the traffic manager started viewing his or her scenario and the time they finished the message, less any time taken by the traffic manager for other activities such as asking for and receiving assistance in interpreting a POET slide or performing an operation in C-SLANT.

- *Traffic managers took longer to complete the task in the text mode*

Problem	Text Mode	Voice and Pointing Mode
ZNY	3830, 2370	1170, 840
ZOB	1210, 1600	1140, 1230
ZID	780, 720	360, 240
ZTL	2700, 2580	1510, 1360
ZFW	810, 990	930, 1050
ZBW	2235, 1670	2010, 2415
ZDC	1410, 1020	1070, 1100
ZMP-1	1110, 800	540, 280
ZMP-2	500, 1070	1170, 660,
Average	1523	1060
Std. Dev.	886.99	561.45
Max.	3830	2415
Min.	500	240

Table 7.11 Traffic manager task time (in seconds) summary

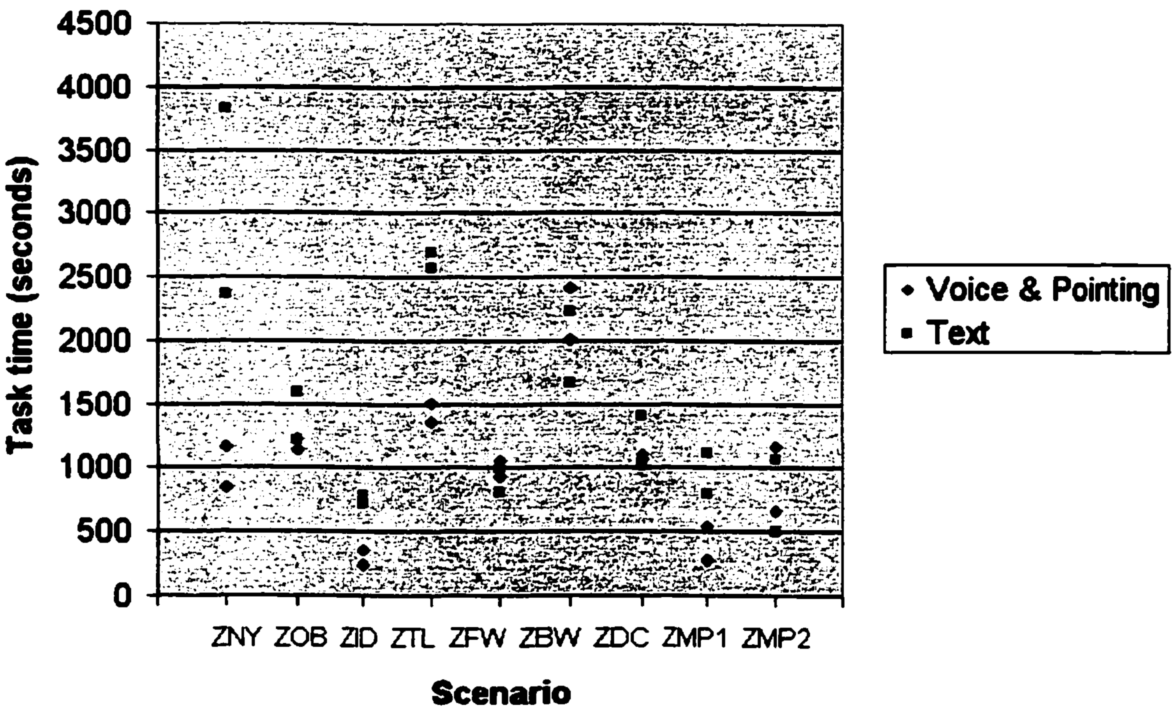

Figure 7.7 Traffic manager task time distribution

As Table 7.1 and Figure 7.7 show, traffic managers took longer to complete the task when working in the text mode compared to the voice and pointing mode. The average task times were 25 minutes 23 seconds (1523 seconds) and 17 minutes 40 seconds (1060 seconds) respectively, although there was variation between scenarios. 5 of the 6 longest task times were in the text mode, ranging from 37 minutes and 15 seconds to 63 minutes and 50 seconds. The longest task time in the voice and pointing mode was taken by a traffic manager working with the ZBW scenario who took 40 minutes and 15 seconds. This traffic manager was working with a scenario involving 6 slides and a dispatcher's comment on each slide. The traffic manager played each recording one time (for a total of 5 minutes and 46 seconds) and created a recording on slides 2 through 6 in response (for a total of 25 minutes and 24 seconds). He never played back any of his own recordings. For 4 of the 9 scenarios both text mode traffic managers took longer than either of the voice and pointing mode traffic managers for that scenario. There were no scenarios where both traffic managers working in the text mode took less time than both traffic managers working in the voice and pointing mode. Five of the six shortest task times were in the voice and pointing mode with the shortest time being 4 minutes by a traffic manager working with the ZNY scenario. This scenario involved 2 slides, with a recording of 2 minutes and 23 seconds on one slide by the dispatchers and a response of 1 minute and 20 seconds by the traffic manager.

Problem	Text Mode	Voice and Pointing Mode
ZNY	5260, 5940	2070, 1820
ZOB	3220, 4010	3180, 2310
ZID	1820, 2010	680, 980
ZTL	4650, 4605	2990, 3760
ZFW	1410, 1500	2040, 2070
ZBW	5066, 5081	3330, 3555
ZDC	1670, 2220	2020, 1610
ZMP-1	1950, 1630	1105, 970
ZMP-2	2700, 2900	2850, 1200
Average	3202	2141
Std. Dev.	1545.16	957.88
Max.	5940	3740
Min.	1410	680

Table 7.12 Dispatcher-Traffic Manager pair task time (in seconds) summary

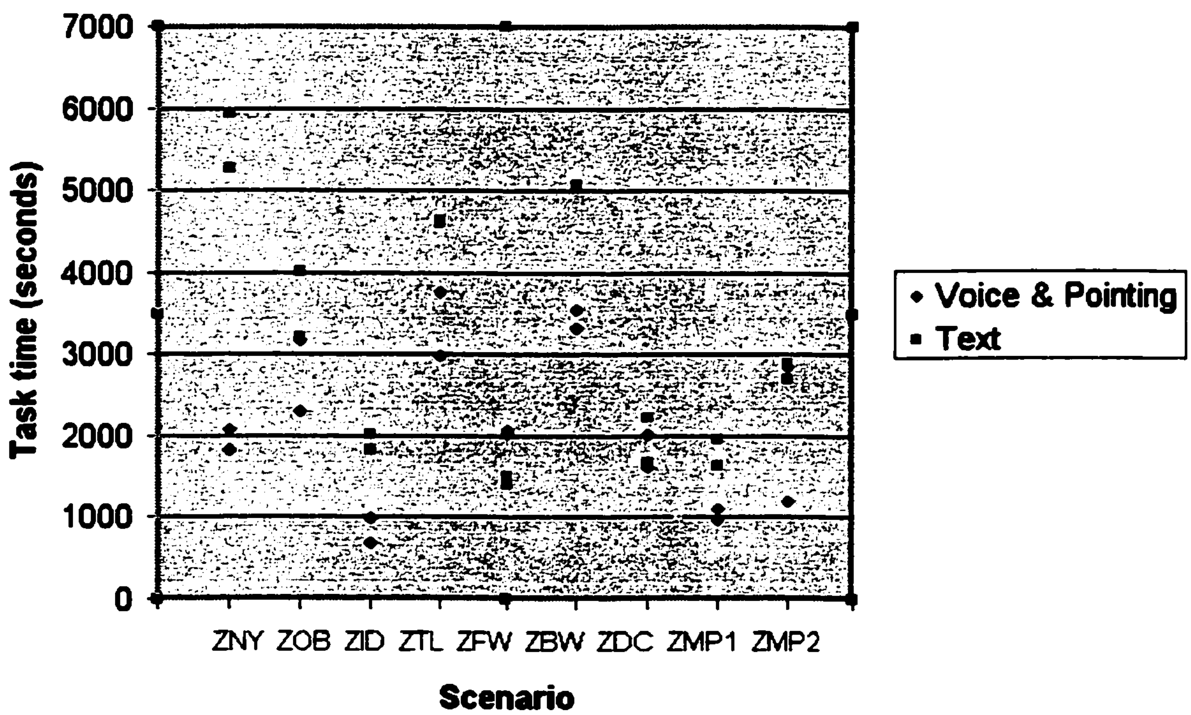

Figure 7.8 Dispatcher + traffic manager task times

Table 7.12 and Figure 7.8 show total task times for each dispatcher-traffic manager pair. The average task times were 53 minutes and 22 seconds (3202 seconds) and 35 minutes and 41 seconds (2141 seconds) respectively. The highest 7 task times were in the text mode ranging from 66 minutes and 50 seconds (4010 seconds) to 99 minutes (5940 seconds). The longest task time in the voice and pointing mode was 62 minutes and 40 seconds by a pair working with the ZTL scenario. In this scenario the dispatcher created 8 recordings on 7 slides and produced 9 minutes and 21 seconds of audio. She also played back her own recordings several times and deleted some first attempts, taking 40 minutes to complete her part of the task. The traffic manager created 6 recordings on the slides and produced 7 minutes and 30 seconds of audio. The traffic manager only played each recording one time, but also spent time looking for the arrival times because the dispatcher did not mention the departure or arrival times and a player window was left covering the departure time constraint on the POET search conducted. The traffic manager's task time was 20 minutes and 40 seconds. For 6 of the 9 scenarios both text mode pairs took longer than either of the voice and pointing pairs for that scenario, but the ZFW scenario was the one scenario where both text mode pairs took less time than either of the voice and pointing pairs, as it was for dispatcher task times. The shortest five task times were for pairs working in the voice and pointing mode.

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	1	10135733	10135733	10135733	60.41	0.000
Scenario	8	42235407	42235407	5279426	31.46	0.000
Treatment*Scenario	8	10930115	10930115	1366264	8.14	0.000
Error	18	3020250	3020250	167792		
Total	35	66321505				

Table 7.13 ANOVA for dispatcher + traffic manager task times

Table 7.13 shows that using an Analysis of Variance (ANOVA) statistical test on the data in Figure 7.8 the hypothesis that there is no difference between the dispatcher + traffic manager task times in the two respective modes (treatments) can be rejected (p-value < 0.05). The second text mode traffic manager's response in the ZMP-1 scenario was unusual in that she responded by stating the delay times were hard to believe as valid and then later that they must have been caused by weather. If this person's data is considered an outlier and removed however, it has no affect on the p values in the ANOVA table shown in Table 7.13 and the average task time for the text mode changes from 53 minutes and 22 seconds to 54 minutes and 55 seconds (3%).

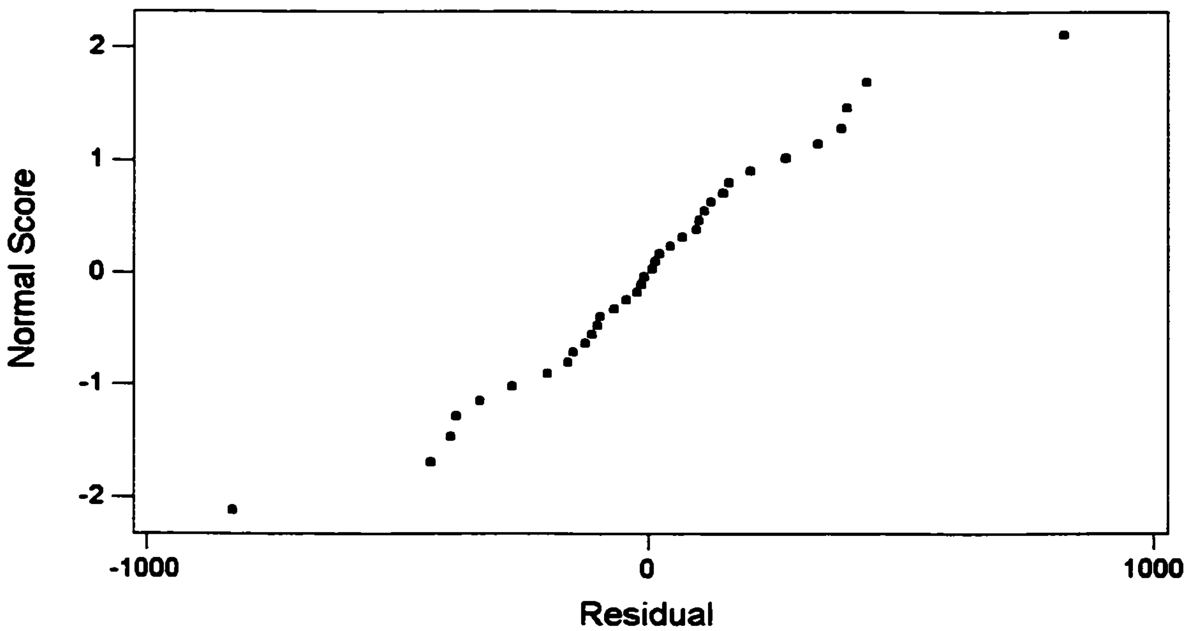

Figure 7.9 Normal probability plot of the residuals for dispatcher + traffic manager task times

The plot is approximately a straight line, but as shown in

Table 7.12 and Figure 7.8 the task times for the ZMP-2 participants differed by 27 minutes and 30 seconds, which produces the two significant differences from the observed values and the fit. Figure 7.10 shows the largest pair of residuals, but also that there is not a relationship between the average task time and the residuals. Table 7.14 shows the result of performing an ANOVA with that scenario removed.

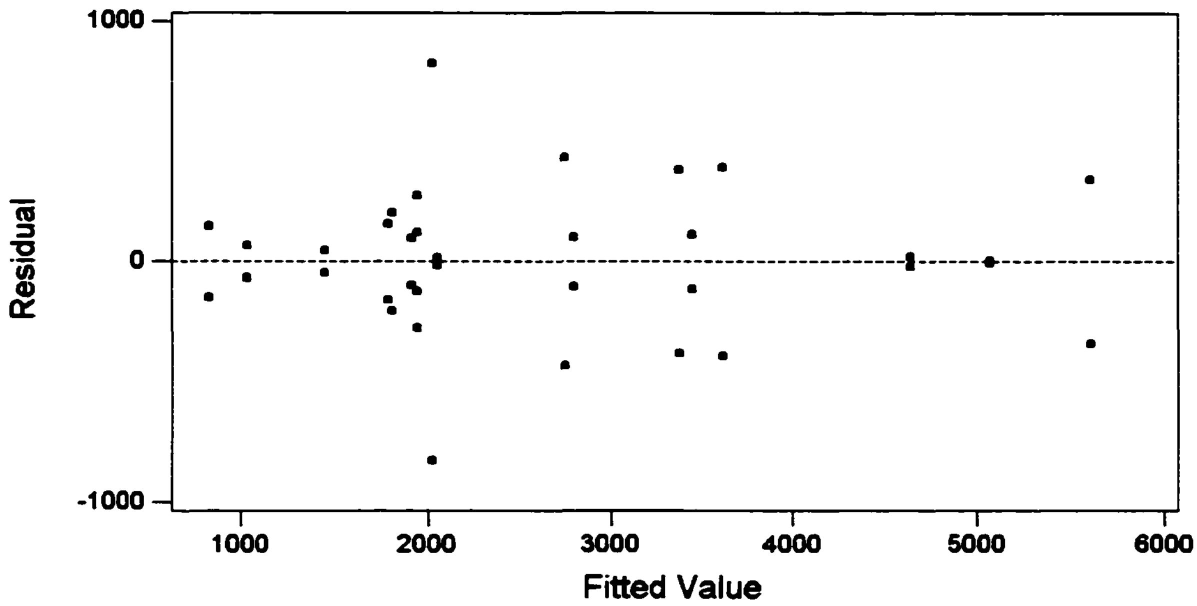

Figure 7.10 Residuals versus the fitted values for dispatcher + traffic manager task times

Source	DF	Seq SS	Adj SS	Adj MS	F	P
Treatment	1	9627272	9627272	9627272	93.98	0.000
Scenario	7	41933024	41933024	5990432	58.48	0.000
Treatment*Scenario	7	10837951	10837951	1548279	15.11	0.000
Error	16	1639000	1639000	102437		
Total	31	64037247				

Table 7.14 ANOVA for dispatcher-traffic manager task times (with ZMP-2 data removed)

The effect is that (1) the hypothesis that there is no difference between the dispatcher + traffic manager task times in the two respective modes (treatments) can be rejected (p-value < 0.01); the hypothesis that there is no difference between the dispatcher+traffic manager task times across scenarios can be rejected (p < 0.01); the hypothesis that there is not an interaction between the mode (treatment) and the scenario can not be rejected (p-value < 0.01).

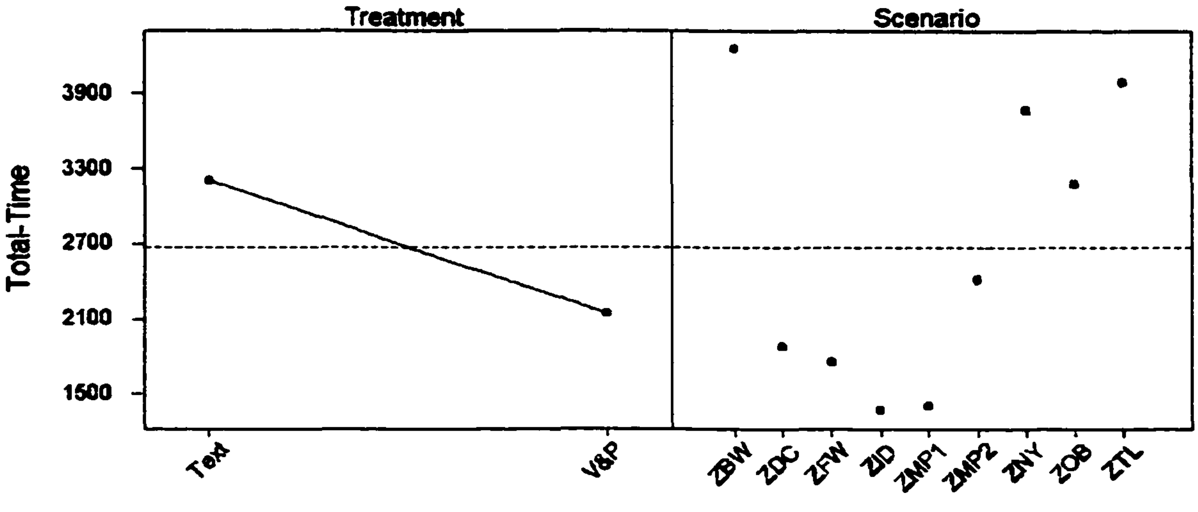

Figure 7.11 Main effects plot for dispatcher + traffic manager task times

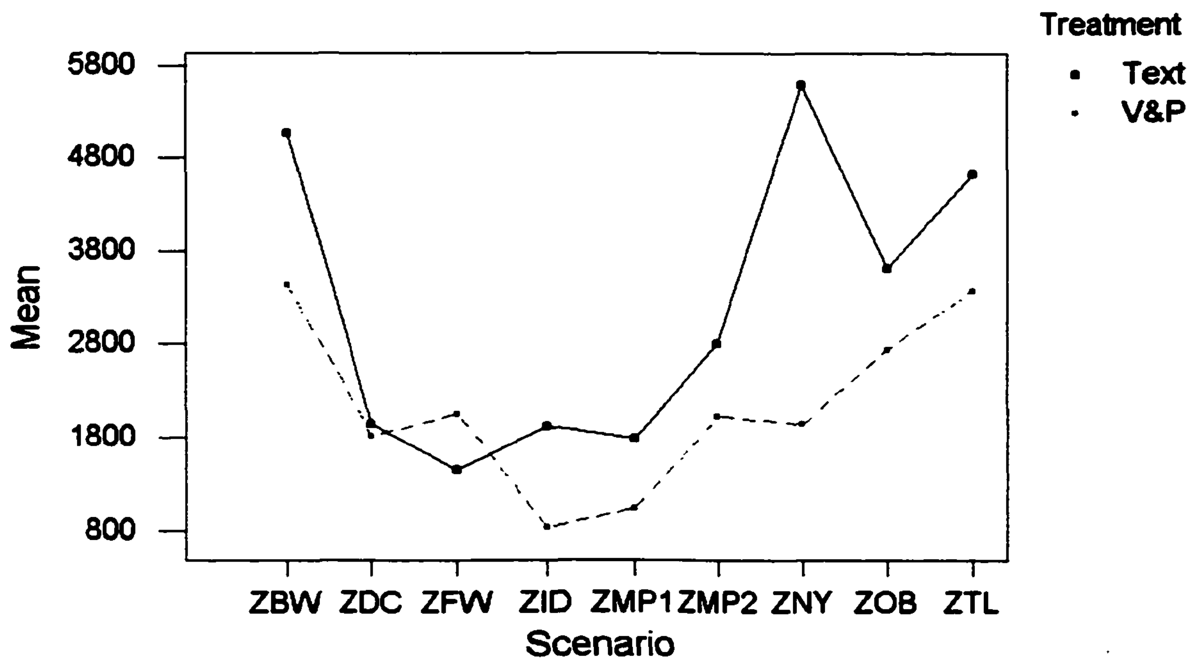

Figure 7.12 Interaction plot for dispatcher + traffic manager task times

Traffic manager responses to the dispatchers' performance questions and ideas

Given that the voice and pointing mode dispatchers produced a similar number of ideas for improving performance, but did not do so in the form of direct questions as often as those working in the text mode, an important question is whether or not the traffic manager's responded differently to ideas in the form of direct questions versus other forms. For instance, if they responded to significantly more ideas in the form of a direct question that would suggest an advantage of text based communications. Determining whether or not an idea is responded to is however more difficult in this asynchronous, slide show based communications environment than in a synchronous voice based environment (e.g. via telephone) or text based environment (e.g. via a chat program). This is because the dispatchers' comments are not as interleaved in time with the traffic managers comments as much as they would be in most conversations. This is not only a problem because the response may appear in a separate text box or recording, and on a later slide, but it may also occur on an earlier slide. Either because the traffic manager chose to do that, for instance, when that slide provides relevant information, or possibly because the traffic manager was actually providing a response to an idea he or she had not read or heard yet. (The mapping of dispatcher comments to traffic manager comments was less complicated when text mode traffic managers used the same text box as the dispatcher, and particular when the text was interleaved.)

In addition, in a dialog a person may respond to one idea by providing an alternative idea without explicitly referring to the first person's idea. For example, "Perhaps doing X would improve Y". The response, "Doing Z is the best way to improve Y" could be presented in response to the first statement, but it does not reference the idea of doing X. Because it does reference the dispatcher proposed action and only the goal, it may in some situations be less valuable. For instance, in achieving common ground or exchanging knowledge.

	Direct questions	Other form
Text mode	16/16	11/11
Voice & pointing	4/4	23/25

Table 7.15 Count of the performance improving ideas responded to by the traffic managers

Appendix F lists each idea presented by the dispatchers and each is mapped to what appeared to be the corresponding response primarily based on the semantics of the comments made. This may mean some traffic managers' comments that were intended to be responses to particular dispatcher ideas were missed, but most mappings appear to be unambiguous. Two ideas in the form of a non-direct question were not addressed directly. One voice and pointing mode dispatcher working on the ZTL scenario made the comment, "A delay program could have helped to improve spacing", but the traffic manager made no comment that appeared directly connected to this idea. This was one of seven ideas mentioned by this dispatcher, which was the most in either mode. However, the specific suggestion not responded to (on slide 6) was the only suggestion in a recording of 56 seconds. One voice and pointing mode dispatcher working on the ZOB scenario made the comment, "Another solution might be to fly at different altitudes". This was one of three ideas for this dispatcher, which was the second highest number of ideas by a dispatcher working in the voice and pointing mode. The actual recording containing the suggestion (on slide 4) was one containing two suggestions and was 1 minute 17 seconds long. The traffic manager made no reference to a different altitude in the suggestions he considered. All direct questions related to performance improvement were answered by the traffic managers. Thus, as shown in Table 7.15, in the text mode all 16 direct questions and 11 ideas in a different form were responded to, and in the voice and pointing mode the 4 direct questions and 23 of the 25 ideas in a different form were responded to, so there is no evidence of a relationship between the form of an idea and whether or not the idea received a response by the traffic manager. While having responses for each idea presented by a dispatcher is a positive attribute, as will be discussed in a later section of this chapter, there were instances of redundancy in the traffic managers responses to the dispatchers' messages.

Although it was not a question related to improving performance, it is worth noting the question, "Are we checking that these flights are over water equipped?" was not answered. It was raised by a dispatcher working in the text mode and given the ZBW problem, who asked 8 other direct questions (more than any other dispatcher). It is possible the question wasn't answered, because the traffic manager didn't notice, or remember the question; that the traffic manager didn't know the answer and chose not to state that; or that the question was intentionally ignored because it is clearly a delicate question concerning safety.

Category	Dispatchers		Traffic Managers	
	T	VP	T	VP
A. New preflight route	11	9	9	10
B. Enroute reroute	2	3	2	0
C. Change schedule	1	1	7	3
D. Ground delay/stop	3	4	1	1
E. Same route but miles in trail	0	1	0	0
F. Change Center staffs' workload / traffic volume	2	0	0	0
G. Share information for planning (fuel burn, filed route, etc.)	3	3	0	1
H. Hold at a different location	1	1	0	1
I. Change altitude	2	2	0	0
J. Fix balancing	0	1	0	0
K. Other	0	1	0	0
Totals:	25	26	19	16

Table 7.16 Classification of dispatcher and traffic manager ideas regarding performance improvement

Table 7.16 shows the number of traffic managers who accepted the category of their dispatcher's idea as a possible performance improving approach or added that category as an approach through their comments.

Scenario	Text Mode		Voice and Pointing Mode	
ZNY	aA, rB, rG, rF, nB	aA, aB	rA, rB, rD	rH
ZOB	rD, rH, n(ref)H	a2A, rI, nA	a2A, mI, nC	aA
ZID	(Leave as is)	ref(G), (ref)I	n(ref)A	rA(Leave as is)
ZTL	rD, rG, nA, nC	rA	rG, rK, nA	rG, aA, rJ, aA, aC, mD
ZFW	aA	aA, nC	rA, aA	rB, aA, n(ref)G
ZBW	rD	nC	rA(Leave as is)	rD
ZDC	aA, nC	aA, rA, n(ref)A	nA	rE, rA, n2A
ZMP-1	aC, rA, nA	rA, rF	aD, n2A, nC	rB
ZMP-2	aA, nC	nC, nD	rG	(none)
Totals:	a = 11 ; r = 14 ; n = 11 ; m = 0		a = 9; r = 18; n = 10; m = 2	

Table 7.17 Classification of communications outcome with respect to ideas for improving performance
(a: accepted; r: rejected; n: new idea; m: no response. (ref): referred to another center or military airspace manager. Classification of ideas A-K shown in Figure 7.16)

Table 7.17 summarizes the outcome for each dispatcher-traffic manager pair according to how each traffic manager reacted to the ideas presented by the paired dispatcher, and also what ideas he or she added, if any. Thus, for instance the second ZFW voice and pointing mode traffic manager is coded as rB, aA, nG to present the facts that the traffic manager rejected the dispatchers idea of an in-flight change of route; accepted the dispatchers idea of a preflight change to the filed route; and proposed the idea of providing new information to the airline via another Center to help planning. The table shows that, in the text mode, there were 11 dispatcher ideas that the traffic manager accepted, 14 that were rejected, 11 that were proposed by the traffic manager and all were responded to. The table also shows that, in the voice and pointing mode there were 9 dispatcher ideas that the traffic manager accepted, 18 that were rejected, 10 that were proposed by the traffic manager; and 2 not responded to. Thus the distributions are similar.

Other information exchanged

Most of the analysis thus far has focused on the number of performance improving ideas generated and the time taken to generate these ideas. In the section discussing dispatchers mentioning certain flight classifying information however, it was shown that more dispatchers commented on the city pair ($p = 0.044$) and the time of year ($p = 0.03$) in the voice and pointing mode than the text mode. This is significant because it may help the traffic manager achieve greater situation awareness for the problem solving task and suggests the dispatcher took greater distant responsibility (Wilkes-Gibbs, 1986). However, there was not sufficient evidence to conclude that more dispatchers commented on the time of day ($p = 0.16$) or the number of flights involved ($p = 0.16$).

Scenario	Text mode		Voice and pointing mode	
	Pair 1	Pair 2	Pair 1	Pair 2
ZNY				
ZOB				X
ZTL				X
ZFW			X	
ZBW		X		X
ZDC		X		X
ZMP-1				X
ZMP-2	X		X	
Totals:	3/16		7/16	

Table 7.18 Pairs commenting on the effect of the arrival airport's runway on performance

Other information highlighted and added in the process of generating performance improving ideas will be discussed in the section describing the annotation of flight route maps, where the map itself can be used as a reference for that information, such as traffic on other routes, departure sectors, and military airspace regions; but some useful information can also be exchanged that is not tied so directly to information on these maps. Table 7.18 shows which pairs made a comment regarding how the runway in use at the arrival airport could have an effect on performance. The mode is not statistically significant (Chi-squared, p= 0.127) in its effect, but the table shows that most pairs in both modes did not mention the effect of the arrival runway without information regarding the runway in use. Data from the ZID scenario was not included because that is the one scenario involving a city pair where the arrival airport is not a major airport and thus it is not surprising no participant mentioned the arrival runway. It is also perhaps worth mentioning that it was actually the traffic manager who raised the issue of the arrival runway in all cases, but the ZTL voice and pointing mode.

Analysis of Annotation Modes

Speech and pointing

- *Almost all voice ad pointing mode participants made deictic references while speaking*

	Dispatchers	Traffic managers
Participants making deictic gestures	18/18	17/18

Table 7.19 Count of voice and pointing mode participants making deictic gestures

As shown in Table 7.19, 18/18 (100%) of the dispatchers in the voice and pointing mode made deictic gestures during the creation of their messages. 17/18 (94%) of the traffic managers responding in this mode also made deictic gestures. The one traffic manager who did not make any deictic gestures (a traffic manager given the OMA to MSP problem) made only two relatively short recordings (42 seconds and 33 seconds).

- *Participants did not normally point continuously*

  While the majority of participants using this mode made deictic references, the mouse pointer did not remain in motion continuously, as in general, most did not move the mouse unless there was something to point to related to their comments. Thus, for instance, when the traffic manager working with the ZFW scenario recommended contacting the Kansas Center each day to "get a heads up" on what ZFW is doing and whether or not arrivals over UKW or BYP are in effect, he did not move the pointer until mentioning UKW and BYP, when he pointed to both those locations.

- *Objects and locations pointed to*

  The deictic gesturing that took place can be divided into two kinds: (1) deictic gesturing to objects and locations visible on the slide; and (2) deictic gesturing to objects drawn or locations marked with visible annotations. As will be discussed later in this chapter, most participants created pen and arrow marks and in the voice and pointing mode most did so while speaking.

- *Information added by deictic gesturing*

  1. Locations

     In this context the location of objects (such as named or unnamed holding locations, fixes, particular routes, arrival or departure approaches, Centers, "being metering" locations, merge traffic points, sequencing segments of a route, miles-in-trail segments, and route/jetway selection decision points) and events (such as vectoring, holding, deviations from the filed route onto a different route/jetway) can be made explicit in relation to an underlying map with synchronized speech. Information contained in tables and graphs could similarly be identified, and for these gesturing can clarify what is meant by phrases such as "high fuel burn" or "unacceptable delay". Depending upon the knowledge/beliefs of the recipient this could be new information or not, but regardless, it reveals the speakers knowledge/beliefs more precisely.

Thus, for instance, when the dispatcher working in the voice and pointing mode with the ZTL scenario suggested considering a new preferred route leaving Detroit at a lower altitude to avoid Chicago's overhead traffic, and traced a partial route to the east while doing so with no comments about the path for the route at all, she revealed that she had at least a partial route in mind.

2. Reducing ambiguity

Specifying the location of objects and events shown on a slide can reduce or eliminate ambiguity when there are multiple interpretations for the comments made. Thus, the comment "some of these flights have unacceptable delays that create significant problems for our operation and we would rather see a ground delay in those situations" would be ambiguous on a slide describing multiple flights, each with delays at different stages of the flight.

Thus, for instance, the dispatcher working with the ZDC scenario in the text mode, who wrote "would it be possible to move some of this traffic north and out of the dca area?", made an ambiguous comment if he was actually thinking of a a route or routes that could be described more specifically. The same comment tied to a drawn route or traced route in the voice and pointing mode would not be ambiguous. Similarly, the Traffic manager who referred to Volunteer as "about half-way between the Macey and Rome arrival" made his description more specific when he simultaneously pointed to a location half-away horizontally, but to the north of Macey and Rome.

3. Revealing incomplete or erroneous knowledge

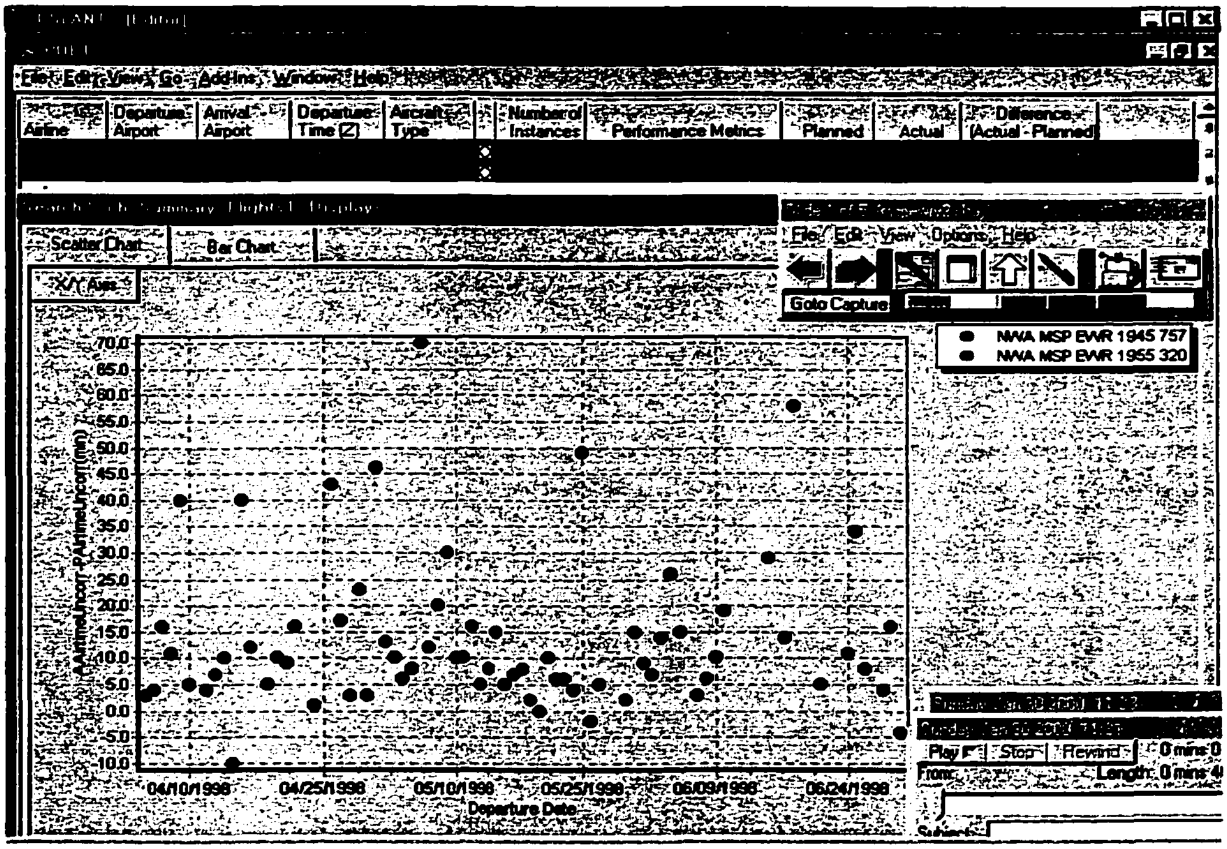

Figure 7.13 Example of a verbal error during pointing

The comments and pointing were synchronized for most participants most of the time, and the semantics of the pointing were also consistent with the semantics of those comments. Sometimes however, there were conflicting semantics. For instance, a dispatcher working in the voice and pointing mode with the ZOB scenario started a recording on the slide shown in Figure 7.13. by stating that the scatter chart showed flight times for instances between April 10th and the end of May for the 757 flight from MSP to EWR. In fact, this was not correct because the data she pointed to was for flights from April 1st and further, it was for the A320 flight. This error was likely caused by the top-to-bottom listing of the flights not matching what would intuitively be a left-to – right ordering of the flight data in the scatter chart, even though the key makes the mapping explicit. Because she pointed to the locations she was looking at when she was misreading the information on the slide it is easier to see the inconsistency than if just listening to the audio and possibly not being able to match each of the comments made to the data because of the additional workload involved in determining where to look. Similarly, a voice and pointing mode dispatcher working with the ZMP2 scenario commented that the airborne delays for the flight instances between OMA and MSP ranged from 20 to 32 minutes and that this seemed to be a little "extensive". In fact, the range was actually from 16 minutes, but the dispatcher read the 20 from the line below, which was the average airborne delay for a different group of flight instances. (Further errors of this kind when working with POET tables could be reduced by alternating the background color of each row in the tables that were all white.) In this case the dispatcher did not actually point to the '16' and '32' while speaking, but did place an arrow under each number, which made it easier to locate when the corresponding numbers were spoken.

4. Overriding verbal slips

Very similar to the mistakes just discussed were slips that were made. In these cases, the person speaking was not stating information that was incorrect because they believed that to be true, but because of errors made during the communication of those beliefs. Thus, for instance a traffic manager working with the ZTL scenario stated that the Volunteer transition is the shortest route. He also commented that "only when there is a major push will you be sent over Nashville on the Choochoo transition". As he said this he pointed to the Rome transition, but later in the recording when he referred to the same location he paused briefly and this time called it the Rome transition.

A traffic manager working with the ZDC scenario made the comment, "Generally, if you come up the east side the chances of coming in with a delay are less than if you come in off the west side", while tracing a path through ZDC to EWR and a path through ZOB respectively. In this case, he seems to have said 'west' instead of 'south' because 'the west' shares the attribute that it contrasts 'the east'.

A voice and pointing mode dispatcher working with the ZFW scenario gave the subject "dfw east arrival deviations" to a recording he made when he discussed deviations for flights filed to the west. This comment could mislead the reader, because flights filed to arrive from the east are shown in the scenario.

- *Negative effects from pointing*

1. Pointing was captured when moving to and from recorder buttons

   Because the pointer's positions were captured between pressing the start and stop buttons, movement to and from these buttons was captured in addition to any intended deictic gesturing. The problem was made worse by the fact the window containing these buttons was not visible during playback, so the viewer's attention is drawn to motion to and from locations that normally have no apparent significance.

2. "Doodle pointing"

   While the majority of participants did not move the pointer unless they were making a deictic reference or making a menu/button selection, some participants did tend to keep the pointer moving even if there was nothing to point at in the image that corresponded to what was being said. For instance, one traffic manager from the New York Center pointed to some text data on the last slide of his scenario, then while speaking for the remainder of the recording tended to move the mouse pointer slowly back and fourth while "drifting" in an area on the slide where there was no data.

3. Unsynchronized pointing

Although no attempt was made to precisely measure the synchronization of the speech and pointing that occurred, there were two participants where a lack of synchronization was very noticeable when following the pointer. In one case this occurred because the speaker actually pointed at objects well before he talked about them (a traffic manager working with the ZOB scenario) and in the other case the speaker was using the arrow marker to annotate a location and didn't adjust the speed of his speech to avoid stating the location followed by other words before placing the arrow marker. The former case is consistent with the finding of Oviatt (1997) that pointing generally precedes speech, although in this case the synchronization was noticeably worse than the others in the amount of the difference.

4. Slowed speech

Again, while no attempt was made to precisely measure the speed of speech and annotation with arrow markers or the pen, the speed of both varied across participants as for instance, some participants did more problem solving before speaking, gave more attention to the problem solving itself, found the problem solving more difficult, and found the task of using the pen and arrow marker to take more effort. In the majority of cases when the participants speech was about to get ahead of the pointing or using the pen and arrow markers the participant slowed down or paused the speech to achieve synchronization.

5. Pointing to complex imaginary objects not related to the image

In another instance a traffic manager from the Cleveland Center discussed information on a scatter chart then appeared to have imagined a map in the "white-space" area of the slide as he pointed to imaginary locations and paths that corresponded to his verbal comments. However, he made no visible markings while he did this. It is worth noting that this was the only instance were the participant pointed to an imaginary complex object, but there were other instances of pointing to small numbers of unmarked objects or locations. This would be a negative effect if the listener was able to process the communication at a faster rate.

- *The playback slider was very rarely used*

Although the effect of moving the slider on both the audio and pointer's position were demonstrated, participant rarely used it. There could be a number of reasons for this, including:

1. The demonstration during the training was too brief;
2. It is a novel concept, in an otherwise intuitive environment[15], so it didn't occur to participants to use it;

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[15] The claim is made that it is intuitive based on the debriefing questionnaire.

3. It wasn't obvious when it might be useful, because the participants had to remember if pointing occurred in distinct regions / stages, so that it would therefore be useful to speed up the search process;
4. There was not constant dynamic pointing on a slide;
5. The recordings were clear enough there was no need to playback the recording.

- *"Subjects" were rarely entered for recordings*

14 of the 18 dispatchers using the voice and pointing mode did not create any subjects for their recordings. 1 participant from the Washington center created a subject on only the first of five recordings ("intro"). 3 dispatchers created subjects for all of their recordings (although one of them just used, "dtw-bos", "dtw-bos2", and "dtw-bos3").
Most of the dispatcher subjects were *issue related*, such as "dfw east arrival deviations", and "mem-ewr southern routing", or *message structuring* such as "introduction to mem-ewr flight data".
11 of the 18 traffic managers using the voice and pointing mode did not create any subjects for their recordings. 1 participant from the New York center created a subject on only the first of three recordings. 6 traffic managers created subjects for all of their recordings. Again some subjects were not very meaningful, such as "slide one", "slide 2", but others were *issue related*, such as "route over tul" or *message structuring* such as "suggested remedy".
Subjects were intended to be static visual descriptions of dynamic speech and pointing, so without this, a potential summary and external memory aid is lost to what cannot be viewed "at a glance".

* *Dispatchers and Traffic Managers normally created no more than one recording on a single slide*

14 dispatchers and 15 traffic managers never created more than one recording on a slide. 4 dispatchers created more than one recording on at least one slide. (3 creating 2 recordings on a slide twice in their slideshows and 1 creating 2 recordings on one slide). 3 traffic managers created more than one recording on a slide (1 created 3 recordings on one slide and 2 created 2 recordings on one slide).

* *Some participants created very long recordings*

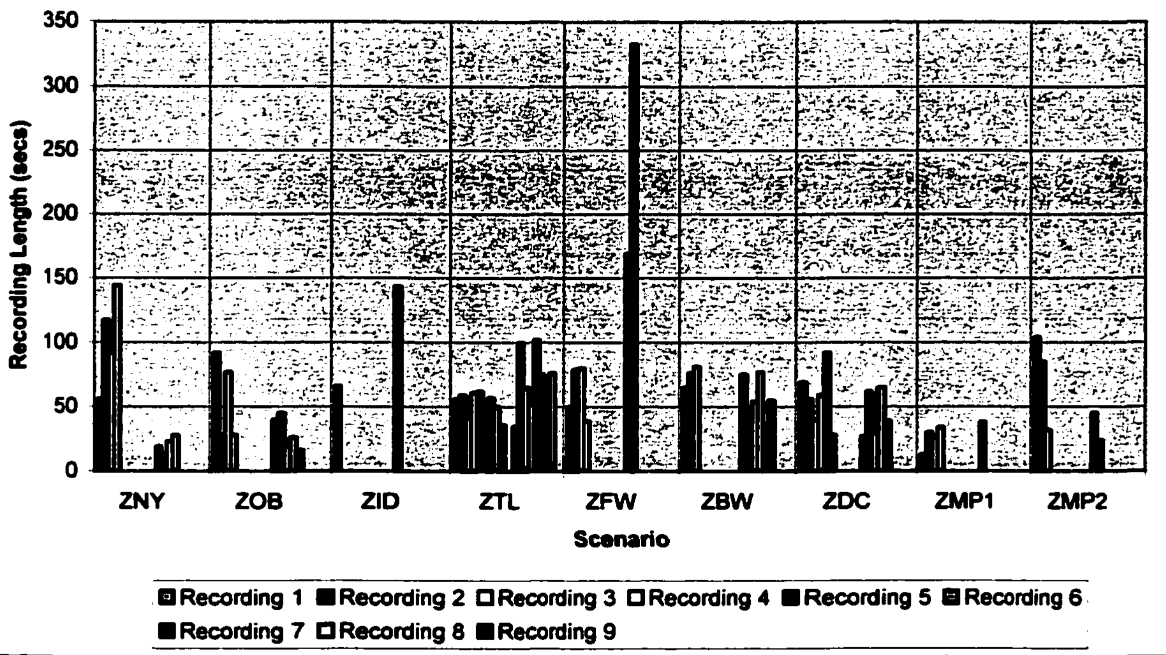

Figure 7.14 Dispatcher recording lengths

Figure 7.14 shows how many recordings each dispatcher made and how long each recording was. This figure shows that the most recordings made in a slide show was nine and this was made by one of the dispatchers given the Atlanta Center scenario. The second largest number of recordings was 8 and the other dispatcher given the Atlanta Center scenario created these. The smallest number of recordings was 1 and it was both dispatchers given the Indianapolis Center, and one dispatcher given the first Minneapolis Center scenario who created one recording. The longest recordings (5 mins : 33 secs; and 2 mins 49 secs) by a dispatcher were made by one of the dispatchers given the Fort Worth Center scenario. The shortest recordings by a dispatcher were 13 seconds. These were made by one dispatcher given the New York Center scenario (who made four relatively short recordings: 19 secs; 13 secs; 23 secs; 28 secs) and one of the dispatchers given the first Minneapolis Center scenario (who made three relatively short recordings: 13 secs; 30 secs; 34 secs).

The average recording length for all the recordings was 61 secs (with a standard deviation of 45 secs). If the data for the one dispatcher who created the two longest recordings is considered to represent an outlier and removed this average changes to 56 secs (with a standard deviation of 29 secs).

Given the ZTL scenario caused the two largest number of recordings and the ZID scenario the smallest number, this number of recordings would appear to be a function of the scenario in these cases (even considering the fact the ZID scenario involved 5 slides and the ZTL scenario 7). This demonstrates that even though some participants appeared to feel obliged to make at least one recording on each slide, even if it meant duplicating information, there were times when the scenario supported referencing information on multiple slides collectively, and some participants did that.

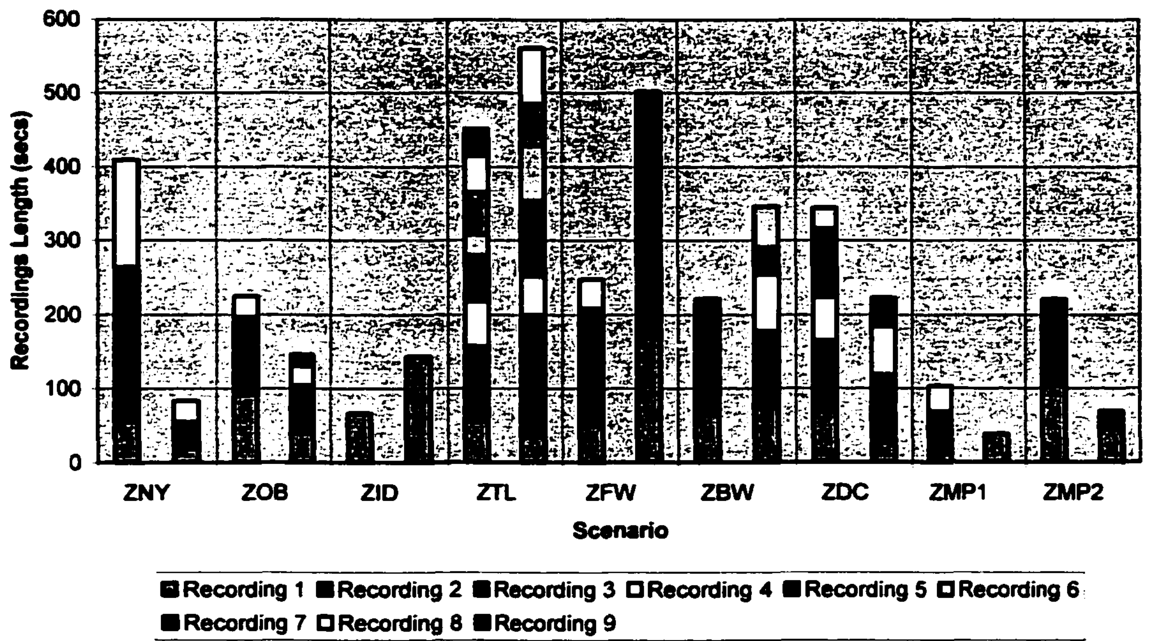

Figure 7.15 Dispatcher slide show recording lengths

Figure 7.15 shows the same data as in Figure 7.14, but shows the cumulative effect of each recording made in the slide shows on the total recording length for each slide show. The longest slide show, in terms of total audio recordings length, was that produced by one of the dispatchers given the Atlanta Center scenario, who made 8 recordings on 7 slides and produced 9 mins 21 secs of audio. The second longest slide show was 8 mins 22 secs, but was just 2 recordings on the 2 slides in Fort Worth Center scenario. The shortest total length was 38 secs, which was the only recording made on the first slide of the 4 slide Minneapolis Center scenario (MDW to MSP). The second shortest total length was 66 secs, which was created by one of the dispatchers in the Indianapolis Center scenario, who also only made one recording on the first slide (of the 5 slides in the scenario).

The fact the two longest slide shows, in terms of audio, were slide shows of 7 and 2 slides, demonstrates that the total recording length is not just a function of the number of slides.

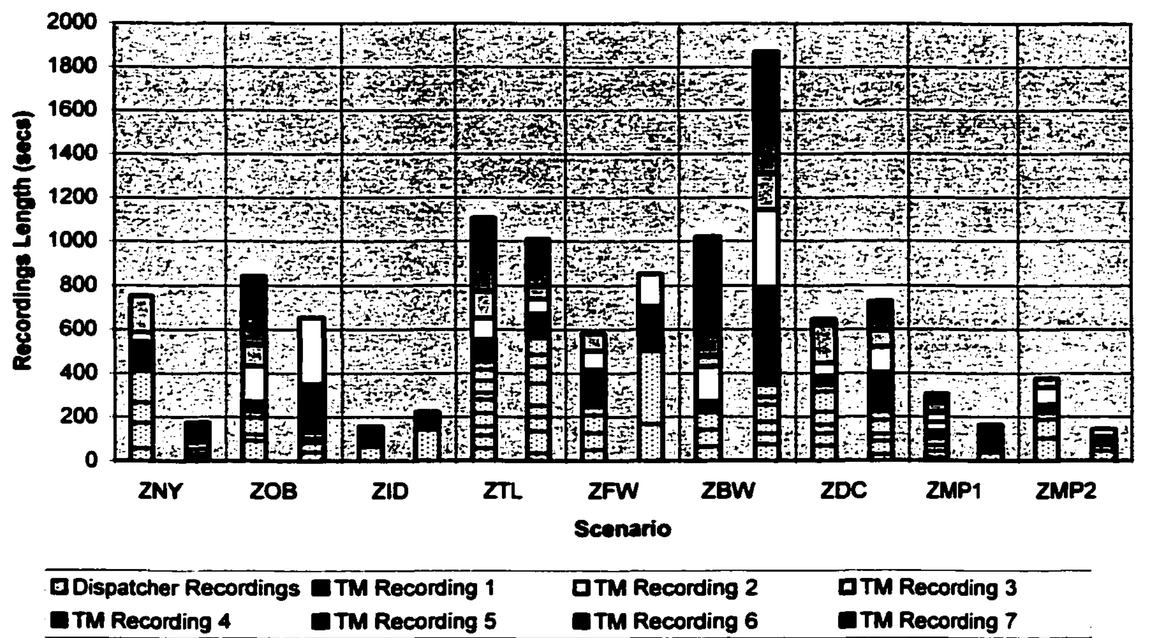

Figure 7.16 Dispatcher and traffic manager slide show recording lengths

Figure 7.16 shows the recording length for each dispatcher-traffic manager pair. The average length of the traffic managers' individual recordings was 1 min 57 secs, with a standard deviation of 85 secs. The longest individual recording was 7 mins 29 secs, and was made by a participant given the ZBW scenario. This participant made 4 other recordings, all above the average recording length. If his numbers are removed the average traffic manager's recording is reduced to 1 min 40 secs with a standard deviation of 59 secs. The shortest recording was the last one made by a traffic manager given the ZDC scenario, but the same participant made another recording of 2 mins 57 secs.

The average total amount of audio recorded by the traffic manager in a slide show was 6 mins41 secs with a standard deviation of 5 mins 56 secs. The longest was 25 mins 24 secs and the shortest was 1 min 15 secs.

The average amount of audio generated by the dispatcher - traffic manager pairs was 10 mins 48 secs. The shortest was 2 mins 24 secs and the longest was 31 mins 10 secs.

- *Recordings were not normally played back after being made*

Participants rarely played back their own recordings after making them. This sometimes meant a problem with the recording itself was not noticed and sometimes meant a problem with the recording in relation to other recordings was missed.

One of the voice and pointing mode dispatchers given the ZDC scenario had two extremely long pauses during his recordings: 17 seconds during one recording, after speaking for 28 seconds; and then 14 seconds during another recording, after speaking for 48 seconds. If he had played back his recordings he might have realized how long the pauses were and adjusted his technique to use the buttons to start and stop recording.

	Dispatcher	Traffic manager
ZNY-1	1, 2, 3, 4	2, 3, 4
ZNY-2	1, 3, 4, 6	6
ZOB-1	2, 4, 5, 3	1, 2, 3, 4, 5
ZOB-2	1a, 2, 4a, 4b, 1b	1, 5
ZID-1	1	2
ZID-2	1	1
ZFW-1	1a, 1b, 2a, 2b	2a, 2b, 2c
ZFW-2	2, 1	1, 2
ZTL-1	2, 3, 5a, 6, 7a, 1, 4, 5b, 7b	2, 3, 4, 5, 6, 7
ZTL-2	1a, 2, 1b, 7, 3, 4, 5, 6	2, 3, 4, 5, 6, 7
ZBW-1	1, 2, 6	1, 2, 3, 4, 5, 6a, 6b
ZBW-2	1, 2, 3, 4, 5, 6	2, 3, 4, 5, 6
ZDC-1	1, 2, 3, 4, 5, 6	3, 4, 6, 5
ZDC-2	1, 3, 4, 5, 6	2, 3, 4, 5, 6
ZMP-1-1	1, 2, 4	1a, 1b, 2, 3, 4
ZMP-1-2	1	1
ZMP-2-1	2, 1, 3	1, 2, 3
ZMP-2-2	1, 2	2, 3

Table 7.20 Order of recordings relative to the slides order

Table 7.20 shows that recordings were not always created in the same order as the slides. Five dispatchers and one traffic manager created a new recording on a slide earlier in the slide show than another slide that contained a recording already made. An example of a memory and/or mapping of comments to particular slides problem occurred with a dispatcher working with the ZTL scenario, who made a comment on slide 5 then made comments on slides 6, 7, 1, and 4, before returning to slide 5 to redundantly state (relative to the previous recording on the same slide) that at this time of day the traffic is handled very efficiently, staying on the direct filed route, so if the airline can be told what is being done differently at this time of day they should be able to get the same results at other times of day.

- *Traffic managers normally played the dispatcher's recording one time*

Traffic managers normally only played each of the dispatcher's recordings one time, which might have been because they felt they could remember the content of those recordings, and or because they did not want to take the time to listen to the recordings again. As discussed earlier, in this study all the dispatchers' questions and ideas for improving performance were responded to except two, which occurred in the voice and pointing mode. While this is not statistically significantly different from the text mode, there is evidence that the traffic managers would have benefited from a visual memory add of the most important issues and questions raised in the response of one traffic manager given the ZNY scenario who started a recording by saying, "Okay. You asked several questions and I'm trying to remember them all, but the first question that hit me was the fact you held and the actual location that you held."

Text comments

- *Normally no more than one text box was put on a slide by a participant*

15 of the 18 dispatchers working in the text mode created no more than one text box on any individual slide. 2 put 2 on 1 slide and 1 put 2 on 2 slides. 13 of the 18 traffic managers created no more than one text box on any individual slide. 4 put 2 on one slide and 1 put 2 on 2 slides and 3 on 1 slide.

- *Most text boxes were moved from their default position*

When a text box is selected in C-SLANT it appears in the top left corner of the screen. 11 of the 18 dispatchers moved all the text boxes they created, 1 moved some, but not all, and 6 never moved their text boxes. 13 of the 18 traffic managers moved all their text boxes, 2 moved some, but not all, and 3 never moved their text boxes.

- *Most traffic managers used a separate text box to create their responses*

6 of the 18 traffic managers always responded in the same text box as the dispatcher, 2 sometimes used the same text box, but not always, and 10 never used the same text box. Only one of the traffic managers who used the same text boxes intermixed responses in those text boxes. (This might be partly because this dispatcher's style was to make a numbered list of points that could easily be distinguished and responded to separately.) Not putting the responses in the same text box makes the order in which the text should be read non-obvious to any potential third user of the slide show, or the dispatcher if the traffic manager really had sent his or her response back to the dispatcher.

- *Text boxes were often enlarged*

When more text is entered into a C-SLANT text box than can be displayed, it automatically produces a scroll bar; however, many participants chose to enlarge the text box making more of the text visible without scrolling.

- Sometimes text boxes were left covering significant data on the screen

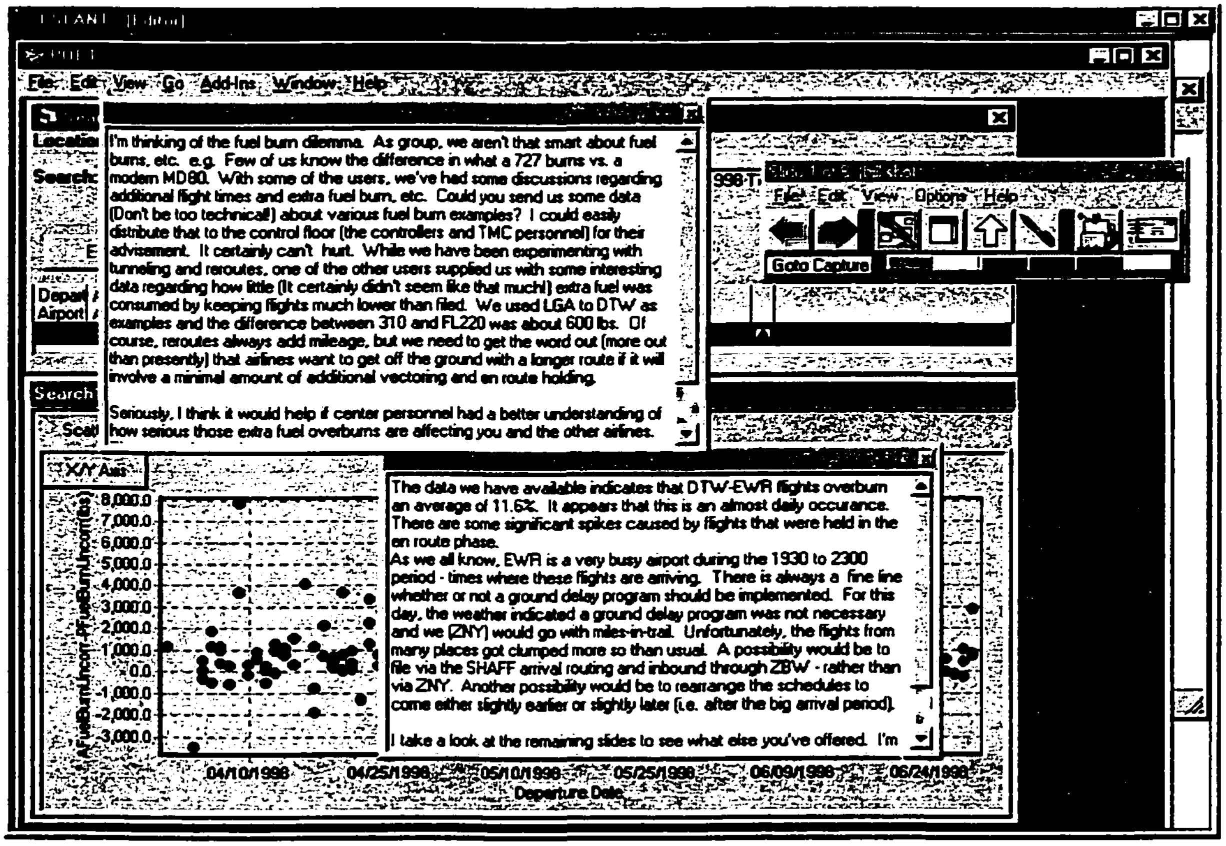

Figure 7.17 Text boxes left covering significant data

As demonstrated in Figure 7.17, which is the first slide from one of the text mode pairs given the ZNY scenario, enlarging the text boxes and leaving them in a position that the recipient notices quickly while scanning the image can leave important data covered and potentially not noticed during subsequent discussion.

Pen marks

The use of pen marks is first discussed here without reference to the particular contents of the slides. How window and data types were annotated with the pen and arrow markers are both discussed in a later section of this chapter.

- *Pen marks were used more by dispatchers than traffic managers*

	Dispatchers	Traffic Managers	Dispatchers and Traffic Managers
Text mode	15/18	3/18	2/18
Voice and pointing mode	11/18	6/18	4/18

Table 7.21 Participants that used the pen

As shown in Table 7.21, 15 of the 18 dispatchers working in the text mode used the pen at least one time in their slide shows. 3 of the traffic managers in this mode also used the pen, and 2 of those 3 were working with slide shows where the dispatcher had made pen marks, although only one (a traffic manager working with the ZDC scenario) made any pen annotations on an individual slide that had dispatcher pen marks and he used a different color and wrote, "... circled in red". 11 of the 18 dispatchers working in the voice and pointing mode used the pen at least one time in their slide shows. 6 of the traffic managers in this mode also used the pen, and 4 of those 6 were working with slide shows where the dispatcher had made pen marks, with 3 of those 4 using the pen on the same slide at least one time. These were three traffic managers working with the first ZMP scenario, the ZID scenario and the ZFW scenario and in each case the pen color selected was different from the dispatchers.

While it was not an issue in this experiment, when the pen was used it would be ambiguous, to a potential third person, who had made those markings unless they were made while pointing and speaking, or they were referred to directly or indirectly in the speech or text.

- *Dispatchers and traffic managers selected pen colors that contrasted with the background*

Yellow and red were the colors used by the most number of dispatchers. This is perhaps because these are common highlighter colors and because they contrast the most with the colors used in POET. Yellow was used the most in the text mode (10 used yellow; 7 used red; 3 used blue; 3 used black; and 2 used green) working in the text mode. More than one pen color in a slide show was used by 7 dispatchers, but only 3 used more than one pen color on any individual slide. In the voice and pointing mode red was used the most (5 used yellow; 7 used red; 1 used blue; 1 used black; and 1 used green). More than one pen color in a slide show was used by 4 dispatchers, but only 1 used more than one pen color on any individual slide.

Yellow and red were also the colors used by the most traffic managers. In the text mode, where 4 used yellow, 4 used red, 0 used black, 4 used blue, 1 used green and 1 used white, 4 used more than one color in a slide show, with 3 doing so on at least one slide. In the voice and pointing mode, where 2 used yellow, 3 used red, 0 used black, 0 used blue, and 0 used green, 1 used more than one color in a slide show, but did not do so on more than one slide. In the text mode, 1 traffic manager used the pen on a slide with pen markings by the dispatcher, but chose to use a different color. In the voice and pointing mode, 4 traffic managers used the pen on at least one slide with dispatcher pen markings, and in all cases except one the traffic manager selected a color not used by the dispatcher.

Arrows

	Dispatchers	Traffic Managers	Dispatchers and Traffic Managers
Text mode	12/18	3/18	2/18
Voice and pointing mode	11/18	7/18	5/18

Table 7.22 Participants that used the arrow marker

As shown in Table 7.22, 12 of the 18 dispatchers working in the text mode placed arrow markers at least one time in their slide shows. 3 of the traffic managers in this mode also used arrow markers, and 2 of those 3 were working with slide shows where the dispatcher had made pen marks, although only one (a traffic manager working with the ZNY scenario) made any arrow marker annotations on an individual slide that had dispatcher arrow markers and he used a different color and used direct references to them. 11 of the 18 dispatchers working in the voice and pointing mode used arrow markers at least one time in their slide shows. 7 of the traffic managers in this mode also used arrow markers, and 5 of those 7 were working with slide shows where the dispatcher used arrow markers, with 2 of those 5 using arrow markers on the same slide at least one time. These were traffic managers working with the second ZMP scenario and the ZTL scenario. A different color was used by the ZTL traffic manager, but not the ZMP traffic manager. The ZMP traffic manager put the same color arrows on a scatter chart as the dispatcher, but he put them just below the horizontal axis at the same horizontal position as the dots he wanted to annotate to group them separately from the arrows of the dispatcher.

- *Participants wanted to be able to place arrow markers pointing from a variety of directions*

On several occasions participants using the arrow markers wanted to have an arrow marker pointing in a direction other than in an up direction. This was perhaps to be able to place the arrow in a location where it would not cover data or cover the least important data.

Annotation mode interactions

- *More visible annotations were made by dispatchers*

	Dispatchers	Traffic Managers	Dispatchers and Traffic Managers
Text mode	17/18	5/18	5/18
Voice and pointing mode	15/18	9/18	8/18

Table 7.23 Participants that used arrows or pen marks

Table 7.23 shows that more visible annotations (annotations with the pen or arrow marker) were made by dispatchers than traffic managers in each of the two modes, but that more dispatchers made annotations in the text mode (17 versus 15) and more traffic managers made annotations in the voice and pointing mode (9 versus 5). It also shows that 5 pairs in the text mode and 8 pairs in the voice and pointing mode made annotations with the pen or arrow markers. 6 dispatcher-traffic manager pairs made annotations while simultaneously speaking.

- *Most voice and pointing mode participants made visible annotations while speaking*

	Dispatchers	Traffic Managers	Dispatchers and Traffic Managers
Voice and pointing mode	9/15	9/9	6/9

Table 7.24 Participants that made arrow or pen mark annotations while speaking

As Table 7.23 and Table 7.24 show, 15 of the 18 voice and pointing mode dispatchers made arrow or pen mark annotations and 9 of the 15 made annotations while simultaneously speaking. 9 of the 18 voice and pointing mode traffic managers made arrow or pen marks annotations and all 9 made annotations while simultaneously speaking. This is consistent with the results of Oviatt (1999, mentioned in Chapter 3, who found that 95% to 100% of users preferred to interact multimodally when they were free to use either speech or pen input in a spatial domain, but that users typically intermix unimodal and multimodal expressions.

Scenario	Dispatcher		Traffic manager	
	Text	V & P	Text	V & P
ZNY	5, 21	0, 6	0, 10	0, 0
ZOB	5, 12	0, 5	0, 0	0, 19
ZID	3, 5	0, 11	0, 0	3, 1
ZTL	2, 14	30, 12	0, 1	4, 17
ZFW	0, 1	17, 1	0, 0	0, 10
ZBW	9, 33	3, 2	0, 0	0, 0
ZDC	2, 3	7, 7	2, 0	0, 31
ZMP1	6, 17	15, 1	3, 0	10, 0
ZMP2	9, 14	7, 14	0, 1	8, 0
Average	8.94	7.67	0.94	5.72

Table 7.25 Number of pen or arrow annotations per slide show

Table 7.25 shows the distribution and average number of annotations made per slide show. The average number made by traffic managers in the voice and pointing mode was higher than the average in the text mode, although this was in part because a few traffic managers made a large number of annotations.

The fact that a higher percentage of traffic managers (9/9 = 100%) made annotations than dispatchers (9/15 = 60%) while working in the voice and pointing mode, and that more annotations were made by traffic managers in the voice and pointing mode (average = 5.72) than by traffic managers in the text mode (average = 0.94) is possibly influenced by not remembering their pen and arrow marks would not appear synchronized with the speech and pointing.

- *Text mode participants did not always use direct references to their annotations*

Arrow markers or pen marks can be used to draw attention to something on a POET screen or to add information to the screen capture, but then a reference to that annotation needs to be made in a text box when working in the text mode in order to make the purpose for that annotation explicit. 8 of the 17 dispatchers, and 2 of the 5 traffic managers, working in the text mode who made annotations created some with some direct references to them such as, "the red arrows show…", "the proposed route drawn in green…", or "the fuel burns highlighted in the table….". When direct references were not made more cognitive work is required to connect the relevant text to the annotations and sometimes ambiguity resulted. For instance, one of the dispatchers working with the ZNY scenario in the text mode asked the question, "Would it be possible to move some of this traffic north and out of the dca area?" The traffic manager voluntarily thinking aloud after reading this comment expressed confusion as to how far north the dispatcher meant. In this case the traffic manager decided the dispatcher could have been referring to routes through ZOB, or routes through ZDC (much closer to the DCA area), and covered both interpretations in his response. In a different situation the traffic manager might have assumed the wrong interpretation and not actually answered the question that was intended.

Annotation of POET windows

Annotation of Search Summaries

A search summary was included on the first slide of 8 of the 9 scenarios, because it shows the city pair involved in the scenario and also provides temporal context information. (The one scenario that did not include a search summary was the ZOB scenario, but the filed route table and scatter chart on the first slide together showed the city pair, departure time, aircraft type, time of year, and the number of flights involved.) Only one of the 36 dispatchers made visible annotations (with the pen or arrows) to draw attention to the city pair or the temporal context information, although some mentioned this information in their initial comments, as discussed earlier in this chapter. The one participant that did was a dispatcher working in the text mode with the ZMP2 scenario, who used a yellow pen to highlight the city pair and range involved. Given that other windows could be left covering this information, it would seem that in many cases the city pair involved would not be immediately obvious to a recipient of a message, and the temporal context may be impossible to determine with certainty.

Annotation of Scatter Charts

Scatter charts were used in 5 of the 9 scenarios. In each of these 5 scenarios a scatter chart was part of the first slide, to provide an overall summary on a performance metric (and in the ZTL scenario a scatter chart was also used on two other slides to introduce two different groups of flights for the same city pair).

In the ZNY scenario a dispatcher working in the text mode drew a horizontal line to indicate that flights above that level were considered to have serious performance problems. A traffic manager working with the same scenario (and a scatter chart not annotated by the dispatcher he worked with) in the voice and pointing mode, placed seven arrow markers below dots representing flight instances that were considered a problem. The traffic manager seemed to be suggesting again that it was a group above a certain level that were most worthy of investigation, but actually didn't mark all of them above that level. This is possibly due to cognitive work involved in placing markers and speaking at the same time, and trying to synchronize speech with the gesturing. One dispatcher working with the ZOB scenario drew a box with the pen to indicate it was flights within a certain range that should be the focus of attention. In the ZTL scenario a dispatcher working in the voice and pointing mode drew a continuous line through a collection of dots representing flight instances he was describing, and then marked three with arrows that were particularly bad, while speaking at the same time. The traffic manager referring to these flight instances placed arrows in the same color at the same horizontal position, but just off the graph to refer to the flight instances. The other voice and pointing mode dispatcher for the ZTL scenario drew short lines in yellow through each of the individual flight instances that he referred to while speaking. In the ZBW scenario a text mode dispatcher used a horizontal line to indicate a temporal gap in the data. The other text mode dispatcher used a yellow arrow to refer to a cluster of flights, a green arrow to refer to the worst performing flight instance, and multiple blue arrows at the same horizontal level to refer to a group of flights performing at that level. This dispatcher then made direct references to the first two arrows to help make the text less ambiguous and quickly interpretable. No participants made a visible annotation on the scatter chart of the ZDC scenario.

In general, annotations made on the scatter chart showed participants found both the arrow and pen useful when making visible annotations. They also used color or boundary forming lines to group and separate flight instances into categories. Line and rectangle drawing annotations tools in C-SLANT might improve the efficiency and appearance of some of the annotations participants were trying to produce.

Annotation of Tables

Every scenario had at least one expanded filed route table. 5 involved at least one flight table and 6 involved an expanded filed route table with an instance highlighted.

7 dispatchers in the text mode used a pen to make a visible mark in a table; 4 used an arrow; and 3 used both. 4 dispatchers in the voice and pointing mode used a pen to make a visible mark in a table; 3 used an arrow; and 1 used both. 1 traffic manager in the text mode used a pen to make a visible mark, but none used any arrow marks. 1 traffic manager in the voice and

pointing mode used a pen to make a visible mark in a table and 1 used the arrow marker, but they were not the same traffic manager.

The pen was most often used as a highlighter in the tables. The pen was also sometimes used to circle a block of numbers. Arrows were used to mark individual figures, including doing so when a line was highlighted in blue in POET making it difficult to annotate clearly with a highlighter.

Annotation of Maps

Every scenario includes at least one flight route map to allow discussion of routes, traffic flows, and the location of other related factors such as holding fixes. 13 dispatchers in the text mode made visible annotations on a flight route map. 12 dispatchers in the voice and pointing mode made visible annotations. 4 traffic managers in the text mode and 8 in the voice and pointing mode made visible annotations on a flight route map.

Semantics for object	Annotation for syntactic representation	Example Scenario
Route not shown in screen capture	Drawn with the pen or a sequence of arrows	ZTL Traffic Manager V&P pair #2, Slide 2
Route shown in screen capture	Highlighted with the pen or marked with one or more arrows	ZBW Dispatcher Text pair #1, Slide 2
Proposed route	Annotated as a route shown or not shown in the screen capture, dependant upon whether or not the route already exists in the image	ZTL Traffic Manager V&P pair #2, Slide 2
FAA 2nd, 3rd etc. choice route	Same as proposed route	ZDC Traffic Manager V&P pair #2, Slide 2
Enroute Fixes	Marked with an arrow	ZOB Traffic Manager V&P pair #2, Slide 5
Traffic merging point/region	Circled with pen	ZDC Traffic Manager Text pair #1, Slide 6
Traffic flow "switch" point for split	Marked with a line using the pen	ZFW Traffic Manager V&P pair #2, Slide 2
Traffic flow decision point for split	Marked with an arrow	ZTL Traffic Manager V&P pair #2, Slide 7

(Continued)

Table 7.26 Catalog of map annotations

Table 7.26 (Continued)

Sequenced route segment	Line with pen to indicate start of segment	ZDC Traffic Manager V&P pair #2, Slide 2
Holding (1st choice, 2nd choice, etc)	Circled with the pen, or marked with one or more arrows	ZBW Dispatcher Text pair #1, Slide 3
Departure sector	Mark with an arrow	ZFW Traffic Manager V&P pair #2, Slide 2
Turn for runway direction	Path drawn with pen	ZMP2 Traffic Manager V&P pair #1, Slide 2
Over-water holding	Circled with the pen, or marked with one or more arrows	ZBW Dispatcher Text pair #1, Slide 4
Vectoring	Marked with an arrow	ZNY Dispatcher Text pair #2, Slide 3
Center boundary	Marked with the pen or multiple arrows	ZTL Traffic Manager V&P pair #2, Slide 7
Military airspace	Filled polygon drawn with pen	ZID Traffic Manager V&P pair #1, Slide 2
Altitude cap regions	Circled with the pen	ZID Traffic Manager V&P pair #1, Slide 2

Table 7.26 shows the types of annotation that were made on the flight route maps with the arrow marker and pen. (In the ZBW scenario the international traffic flow into the BOS area and the "begin metering point" were referenced, but no pen or arrow marks were used to annotate them.) Because the annotation tools in C-SLANT were very simple and generic the result was that the annotations made focus attention, but are not immediately meaningful beyond that. Thus the comments must be used to interpret their significance. The annotations and comments made in this study could be used to determine additional information to be added to the POET maps directly and or be used to design a richer set of annotation tools in C-SLANT. Such information could also be useful for pre-flight analysis. To protect the integrity of C-SLANT's ability to be used for multiple domains and tasks, this might be implemented via templates. The design challenge would be to add a richer set of annotation tools while supporting novice users.

Participant	Path	Pointed to	Pen/Arrow marks
ZNY text mode traffic manager #1	PSB traffic merging with MIP traffic in an arrival sector	N/A	No
ZNY text mode traffic manager #2	Sector #75 has LGA arrivals via J46	N/A	No
ZNY voice & pointing mode traffic manager #1	Traffic flow from the west into the DTW area	Yes	No
ZOB voice & pointing mode dispatcher #1	Transient traffic crossing the filed route	Yes	No
ZOB voice & pointing mode traffic manager #1	Indianapolis Center holds Continental and other flights for us [said while tracing a traffic flow connecting to the filed route	Yes	No
ZOB voice & pointing mode traffic manager #1	The route used by arrivals from Europe	Yes	No
ZOB voice & pointing mode traffic manager #1	Traffic from the south which would arrive via J29	Yes	No
ZOB voice & pointing mode traffic manager #1	A route over Morgantown	Yes	No
ZOB voice & pointing mode traffic manager #2	Traffic from the south through the Washington Center	Yes	No
ZBW voice & pointing mode traffic manager #1	Departing route out of BOS to the north west	Yes	No
ZBW voice & pointing mode traffic manager #1	Departing route out of BOS to the north east	Yes	No
ZBW voice & pointing mode traffic manager #2	North Atlantic traffic	Yes	No
ZBW voice & pointing mode traffic manager #2	Departures out of BOS to the south west	Yes	No
ZFW voice & pointing mode traffic manager #1	Heavy traffic from the north east through Fort Smith	No (but there was little room to do so)	No
ZFW voice & pointing mode traffic manager #1	Heavy filing to the north west corner of DFW from the south west	Yes	No
ZFW voice & pointing mode traffic manager #2	Traffic that ZFW must merge for a BYP arrival from Little Rock and another route	Yes	Yellow pen mark
ZTL voice & pointing mode traffic manager #1	Other traffic from the west merge on the Rome arrival	Yes	No

(Continued)

Table 7.27 Comments about flight paths for other traffic

Table 7.27 (Continued)

ZTL voice & pointing mode traffic manager #1	Other traffic from the east merge on the Macey arrival	Yes	No
ZID text mode traffic manager #2	The CVG inbound push via the APE VORTAC	N/A	No
ZID voice & pointing mode dispatcher #1	The heavy traffic flow of the north east corridor	Yes	No
ZMP-1 text mode traffic manager #2	Blending the BAE and GRB streams together	N/A	No
ZMP-1 voice & pointing mode traffic manager #1	Other Northwest flights arriving at this time from the east coast	No (but he was talking over a slide without a map)	No
ZMP-1 voice & pointing mode traffic manager #2	South east departures out of MSP	Yes	No

Table 7.26 is a catalog of visible annotations that were made on the flight route maps, however Table 7.27 shows that when comments were made about other flight paths that were not the filed route or part of any other route being discussed as an alternative between the two cities, it was not normally drawn (i.e. 0 out of 4 for the text mode and 1 out of 11 for the voice and pointing mode).

Scenario	Text mode pair		Voice and pointing mode pair	
ZNY	0 + 1	0 + 1	0 + 1	0 + 0
ZOB	0 + 0	0 + 0	1 + 4	0 + 1
ZBW	0 + 0	0 + 0	0 + 2	0 + 2
ZDC	0 + 0	0 + 0	0 + 0	0 + 0
ZFW	0 + 0	0 + 0	0 + 2	0 + 1
ZTL	0 + 0	0 + 0	0 + 2	0 + 1
ZID	0 + 0	0 + 1	1 + 0	0 + 0
ZMP-1	0 + 0	0 + 1	0 + 1	0 + 1
ZMP-2	0 + 0	0 + 0	0 + 0	0 + 0
Totals:	4/18 pairs > 0		11/18 pairs > 0	

Table 7.28 Count of dispatcher + traffic manager pairs mentioning flight paths for other traffic

There is also a difference between the two modes as shown in Table 7.28, with 4/18 pairs in the text mode and 11/18 pairs in the voice and pointing mode mentioning such a path. This is a statistically significant difference at $p < 0.05$ (Chi squared, $p = 0.018$).

This is consistent with the fact discussed earlier that certain basic flight classifying information was described by dispatchers more often in the voice and pointing mode. The fact that participants normally pointed when mentioning these paths in the voice and pointing mode again makes the semantics more meaningful than just the same verbal comments alone.

Within Slide Window Management and Navigation

- *Players and text boxes left covering data*

Text boxes were normally moved from their default position at the top left corner of the screen, but they were very often still left covering data even when there were "empty" positions on the screen available. For instance, 66.6% of the dispatchers covered data on their first slide although there was always room to avoid this. The example of the text mode dispatcher working with the ZID scenario was mentioned earlier in this chapter as one where this caused a problem because he reported he didn't know the departure time of the flight, but in fact it was covered by the text box he was using to make that comment.

- *Some participants tried to interact with pictures of controls that were part of the screen capture*

As Figure 7.18 demonstrates there were times when participants mistook a control that was part of a POET image used in a screen capture for an active control. In this example the user tried to move the contents of the image map to the left while using the arrow marker, but the result was that an arrow marker was placed on the picture of a scroll bar.

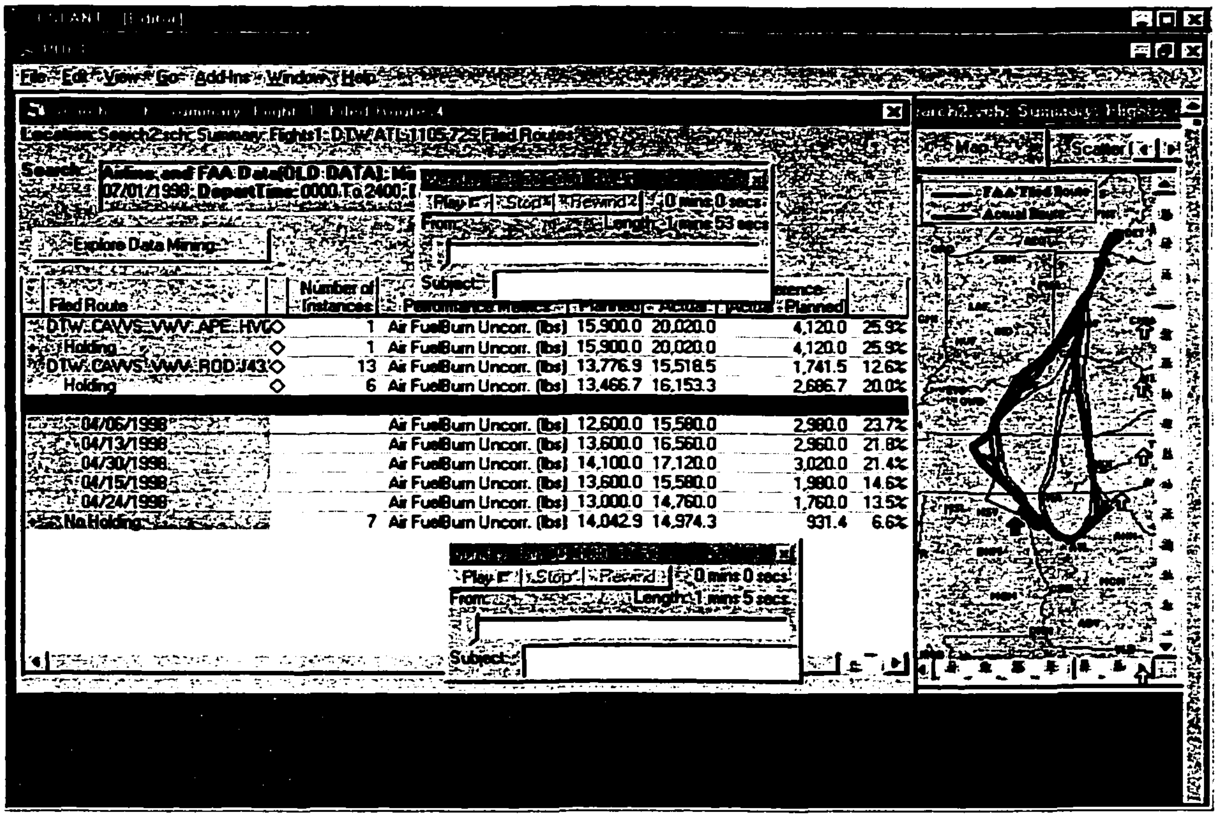

Figure 7.18 Example of confusion between controls in the image and C-SLANT

- ***When there were multiple recordings on a slide, traffic managers sometimes were not sure which one to look at first***

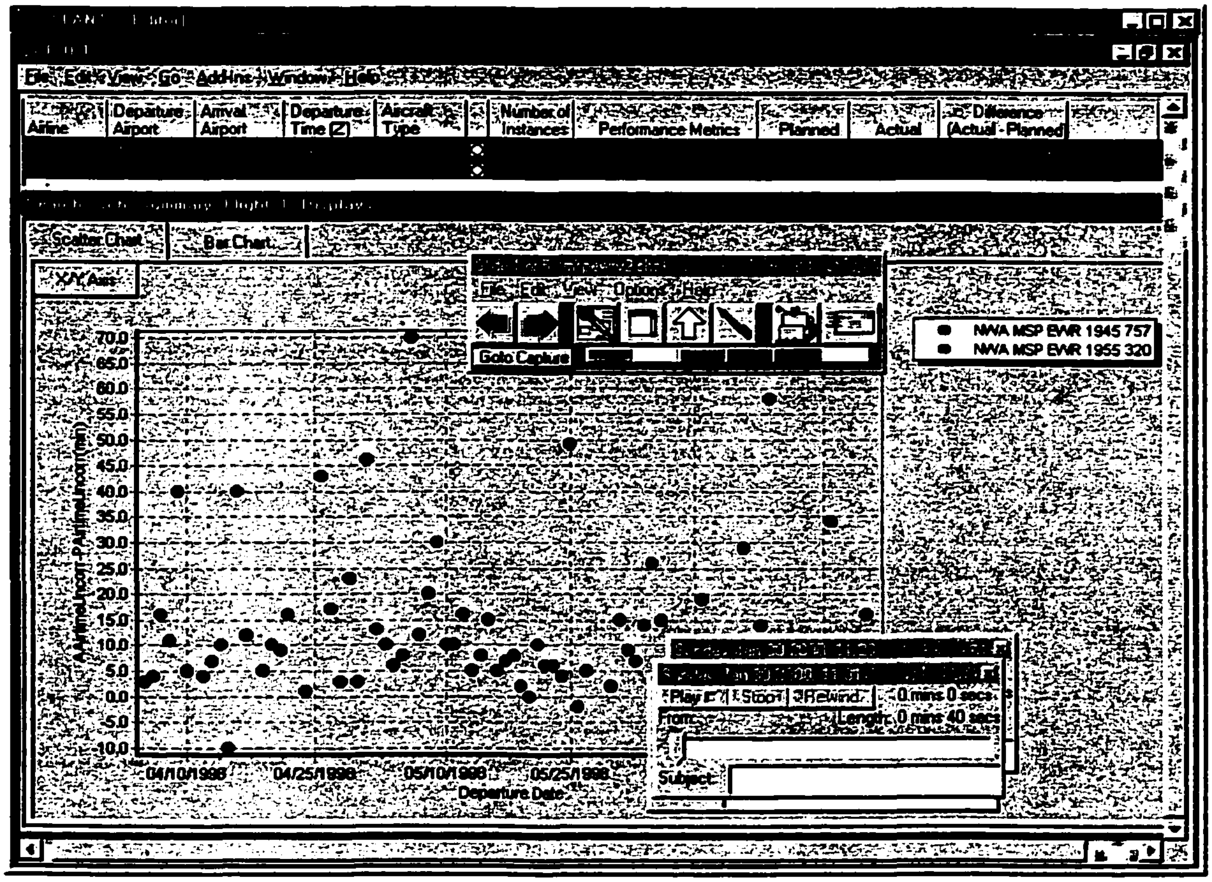

Figure 7.19 Poor arrangement of player windows

As Figure 7.19 demonstrates, the ordering of multiple recordings on a slide became difficult to determine and work with when player windows were not arranged in a logical non-overlapping order (such as left- to-right or top-to-bottom). In this case the dispatcher created recordings at 11:21, 11:23 and 11:31, but playing them back in the correct order requires revealing the hidden 11:21 window, then selecting each of the other two player windows in order to reveal the play button. The original design idea was to allow recordings to be placed close to that which they are related on a slide, but in this study there appeared to be little benefit of that kind.

Between Slide Navigation

The slide show structure allowed single or multiple comments to be associated with a slide, but comments were often related to the images on other slides too, and comments were also related to each other on the same or other slides. Comments could also be placed on slides in any order, and this would not necessarily be the order the recipient read/listened to them. Therefore slides were not as independent as necessary for the simple structuring of comments that was used, as demonstrated with the following examples.

- *Creating comments out of order on the slides could confuse the recipient*

A voice and pointing mode dispatcher working with the ATL scenario created recordings on slides 2, 3, 5, 6, 7, 1, 4, 5, and 7, in that order. On slide 1 the dispatcher commented that the graph indicated there were instances when the flight stayed on the filed route and there were other instances that had extreme reroutes causing very high over-burns. He then stated, "Again, information would go a long way in telling us when to use the filed route and when to use the overflow route". The "again" comment was made because the dispatcher commented first on slide 2 that "we should be advised of changes to the route so we can plan for fuel-burns"; on slide 3, "providing information to us in a timely fashion would allow us to save the gas", and on slide 7 that if the airline was told the filed route couldn't be flown before departure or before crossing Dayton the reroute and holding could hopefully be avoided.

A traffic manager working in the voice and pointing mode with the ZFW scenario showed he was aware of the potential ordering problem when after making a recording on the second slide he started his next recording with the comment, "I went back to slide one for a moment. I didn't want to put a recording there because it would be the latter of the two recordings."

- *Participants sometimes referenced information on other slides*

One of the traffic managers working in the voice and pointing mode with the ATL scenario started a comment on slide 6, "Here are the two instances of holding" because there was information about a flight that had two instances of holding on the previous slide. In fact, he actually was looking at information for a different flight. This is a simple example of a participant referring to information on another slide and one where he assumed the recipient will work through the slides in order.

A traffic manager working in the voice and pointing mode with the ZOB scenario started his first recording by commenting, "I've previewed the next four slides and in response I'll leave it on this slide for starters". This shows the traffic manager wanted the recipient to understand the traffic manager's comments were made in the context of more than the current slide, which can only be achieved in C-SLANT with a comment such as this one.

- *Traffic managers sometimes started responding after only viewing or listening to the recording(s) on the first slide*

One text mode dispatcher given the New York scenario used the scatter chart data on the first slide to point out that flights from Detroit to Newark were burning 11.6% more fuel than planned and that there were some burning much more than this because of holding. In subsequent slides he used the maps and further numeric data to indicate where the holding was taking place and that flight instances filing a northerly route through the Boston Center did not seem to have the same problem. The traffic manager responded after looking at the first slide only as follows:

As we all know, EWR is a very busy airport during the 1930 to 2300 period - times where these flights are arriving. There is always a fine line whether or not a ground delay program should be implemented. For this day, the weather indicated a ground delay program was not necessary and we (ZNY) would go with miles-in-trail. Unfortunately, the flights from many places got clumped more so than usual. A possibility would be to file via the SHAFF arrival routing and inbound through ZBW - rather than via ZNY. Another possibility would be to rearrange the schedules to come either slightly earlier or slightly later (i.e. after the big arrival period).

I take a look at the remaining slides to see what else you've offered. I'm curious how that 11.6% figure compares with flights to LGA or to other destinations. Also, is that 11.6% figure high in comparison to more fuel burned during other periods of the day.

After later viewing the other slides and seeing that the dispatcher then asked about filing the northerly route, the traffic manager could have modified this initial text (more easily than a person in the voice and pointing mode could do the equivalent), but he actually did not, and redundantly recommended the northerly route again.

Another example of the traffic manager responding to the comments of the dispatcher one slide at a time occurred with the ZBW scenario in the voice and pointing mode. In the dispatcher's recording he stated that he was sending a number of slides and then highlighted the data he saw as significant on the scatter chart of fuel burn data. In response, the traffic manager commented that it was hard to say why the extreme over-burn and under-burns occurred with just fuel burn data. He then commented that the jet stream may have been in favor for some instances and weather at Logan caused a lot of holding for others, but it was difficult to know without more information. He then went on to respond to each of the dispatcher's comments in order, but this was an example where he need not have guessed what the reasons were if he had looked at the information on the remaining slides.

- *Treating each slide separately creates redundancy in the comments for related slides*

As has been discussed already, some traffic managers treated each slide separately, in that they responded to the dispatchers' comments on each one before looking at the next slide. Some participants also repeated their previous comments if they again seemed relevant to the current slide, even though their information was available on the previous slides. This occurred for instance with the ZBW scenario where one of the voice and pointing mode traffic managers made a comment about Gardner as the primary holding location on each slide. When he reached the last slide he played the dispatcher's comments which started with the observation that most of the holding appeared to be taking place at Gardner. The traffic manager then stated that, "Yes, the area you have circled in red is the Gardner VOR, which is where we do most of the holding for flights filed on the Albany route", followed by the comment, "we are beating a dead horse here!" He then went on to respond to the rest of the dispatcher's comments and the information on this slide and took 40 minutes and 15 seconds to complete the task which was the longest for the voice and pointing mode traffic managers.

- *Some participants wanted to record across multiple slides*

A few participants tried to change slides while recording because they wanted to "tie" together something on one slide with something on another, using speech and pointing. C-SLANT wouldn't allow this and stopped the recording, upon clicking the next slide button, with a warning message. While not supporting this option may at times stop users from creating very long recordings, not being able to do this sometimes created negative effects in this study. For instance, a traffic manager working with the ZDC scenario created no comments on slide 1, then commented on slide 2 that he would explain the reason for the additional fuel burn shown on slide 1 on this slide and then proceeded to use the flight route map to explain how particular routes flown could be tied to the high fuel burns.

Analysis of Implementation Issues

An important implementation level issue is how large the files were that C-SLANT used to represent the messages created by the participants. Given the storage capacity of even modest computers today, the storage requirements are actually less of an issue than the transmission time between these target organizations. Because it can not be assumed that Local Area Network (LAN) transmissions speeds of up to 10 Mbps or 100 Mbps will always be available, the analysis below assumes only a 56 kbps (equivalent to 7 kilo bytes per second) connection, which is a typical modem speed.

File size and transmission time

Slideshow Description	Minimum		Average		Maximum		Standard Deviation
	KB	Min : Secs	KB	Min : Secs	KB	Min : Secs	KB
A. Images Only	58	0 : 8	128.0	0 : 18	180	0 : 26	36.8
B. Annotated Dispatcher's Message (Text Mode)	59	0 : 8	133.3	0 : 19	185	0 : 26	37.0
C. (B – A)	1	< 0 : 1	5.3	0 : 01	18	0 : 03	4.1
D. Annotated Dispatcher's Message (Voice & Pointing Mode)	414	0 : 59	1913.1	4 : 33	4275	10 : 11	1168.8
E. (D – A)	286	0 : 41	1785.1	4 : 15	4095	9 : 45	1132.1
F. Annotated Traffic Manager's Message (Text Mode)	59	0 : 08	135.3	0 : 19	187	0 : 27	37.7
G. (F – B)	1	< 0 : 1	1.9	<0 : 1	11	0 : 02	2.6
H. Annotated Traffic Manager's Message (Voice & Pointing Mode)	1151	2 : 44	4837.6	11 : 31	13254	31 : 33	3216.6
I. (H – D)	488	1 : 10	2924.5	6 : 58	10415	24 : 48	2517.0

Table 7.29 Slideshow storage and transmission time requirements (assuming a 56 kbps connection)

Table 7.29 summarizes how large the slideshows created were and how long it would take to send those messages with a modem connection. The storage requirements for the pen marks and arrows are not separated in the table, but they would be relatively small as they are represented by a set of x, y coordinate positions in a file. Row A shows that the average slideshow size before any annotations or comments were made was 128 KB. Row C shows the average storage needed for text mode comments and annotations made by dispatchers was 5.3 KB, and row E shows the average storage needed for voice and pointing mode comments and annotations made by dispatchers was 1785.1 KB. The respective average transmission times for the slideshows produced would be 19 seconds versus 4 minutes and 33 seconds as shown in rows F and D. The average additional storage requirement for the traffic manager's response itself in the text mode is shown in row G to be 1.9 KB. The traffic managers working in the voice and pointing mode created an additional 2924.5 KB on average, although the two ZBW traffic managers added the most to their slideshows and these were considerably more than the average (10415 KB and 5869KB). If these two outliers are removed the average additional storage is reduced to 2272.3 KB. The average size of the slideshow produced was 4837.6 KB, as shown on row H, which would take 11 minutes and 31 seconds to send with a modem. The largest slideshow was 13254 KB, which would take 31 minutes and 33 seconds to send with a modem. This extreme case on a LAN would take less than 20 seconds to send, if only half the maximum bandwidth of a 10 Mbps network is available; however, for a modem connection that might require a person to initiate a connection and disconnection, or might timeout, a transmission time of more than a few minutes may not be acceptable.

Slide Description	Average		Standard Deviation
	KB	Min : Secs	KB
A. Image Only	27.2	0 : 04	3.0
B. Annotated Dispatcher's Slide (Text Mode)	28.4	0 : 04	3.1
C. (B - A)	1.2	<0 : 01	
D. Annotated Dispatcher's Message (Voice & Pointing Mode)	444.4	1 : 03	407.8
E. (D - A)	417.2	1 : 00	
F. Annotated Traffic Manager's Message (Text Mode)	28.7	0 : 04	2.9
G. (F - B)	0.3	<0 : 01	
H. Annotated Traffic Manager's Message (Voice & Pointing Mode)	1065.6	2 : 32	783.3
I. (H - D)	621.2	1 :29	

Table 7.30 Slide storage and transmission time requirements (assuming a 56 kbps connection)

Table 7.30 shows per slide average storage and transmission time requirements, and provides a rule of thumb estimate of 1Mb and 2 ½ minutes per slide in the voice and pointing mode for each slide with both dispatchers and traffic manager comments.

The two tables show:

1. The voice and pointing occupied most of the storage required for voice and pointing mode slide ((417.2/621.2)/1065) = 97.5%);
2. The text mode slideshows were approximately 2.8% (135.3/4837.6) the size of the voice and pointing slideshows.

Improvement in the transmission time can be made by (1) improving the bandwidth of the connection; (2) changing the implementation of messages; (3) changing the interface of C-SLANT to encourage more succinct messages; or (4) train users to create more succinct messages.

Questionnaire Results

After saving their messages the dispatchers and traffic managers were given a questionnaire to get feedback on the perceived value and usability of C-SLANT and being able to use it in the type of context represented by the experiment. Traffic managers were also asked if there was anything they thought the dispatcher could have done to improve the message they received. Both groups of participants were asked questions to determine experience with relevant hardware and software and work experience.

Participants Profile

	Dispatchers	Traffic Managers
Gender	8 Female, 28 Male	4 Female, 32 Male
Age Range, Average Age	33-55, 45	31-57. 43
Experience with Organization (range, mean)	9-35, 18 years	3-32, 17 years
Computer w/sound	26%	34%
Word-processing Experience	81%	88%
Spreadsheet	61%	51%
Database	35%	48%
Presentation Software	23%	37%
Computer at Home	85%	91%

Table 7.31 Participant background and experience summary

As Table 7.31 shows both groups of participants involved more males than females, but that is representative of the respective populations. The age and experience levels between the two groups were also similar. More of the traffic managers had computers with sound cards, and generally had experience with more popular generic computer applications, although more dispatchers had experience with spreadsheet programs. These questions were asked in case background differences between dispatchers and traffic managers, might help explain observed differences and perceived usability and value of the system by participants.

Question: On the following scale, please indicate how comfortable you are using voice mail?					
Results	*Very uncomfortable*	*Uncomfortable*	*Neutral*	*Comfortable*	*Very comfortable*
Dispatchers	4	3	4	14	8
Traffic Managers	3	2	3	13	14

Table 7.32 Participant comfort levels for voice mail

Both groups of participants communicate frequently using voice-based communications as part of their work and are used to having their communications recorded. It was therefore expected that they would generally be comfortable or very comfortable using voice mail, which would suggest that the voice-recording feature of C-SLANT would not be an obstacle. Table 7.32 shows that this prediction was correct, although 21% of dispatchers and 14% of traffic managers were very uncomfortable or uncomfortable.

Participants use of E-mail

Question: How often do you currently use E-mail?			
Dispatchers		Traffic Managers	
19 (61%)	Daily	23 (66%)	Daily
1	3-5 times a week	1	Regularly
2	2 times a week	1	Often
1	Weekly	3	Weekly
1	Monthly	1	Monthly
2	Rarely	2	Sometimes
1	Yearly	3	Rarely
4	Never	1	Never

Table 7.33 Frequency of E-mail use

Table 7.33 shows that approximately two-thirds of both groups of participants responded that they use E-mail on a daily basis. This suggests that participants were equally comfortable with the concept of E-mail for communications. While this is a majority, Table 7.33 also shows that a significant minority does not use E-mail very often, if at all, so some training would be involved in introducing this form of asynchronous communications for frequent use. For instance, 13% of the dispatchers responded that they never use E-mail and 11% of traffic managers responded they rarely or never use E-mail.

Question: [If you use E-mail] How often do you send attachments?			
Dispatchers		Traffic Managers	
14 (45%)	Never	7 (20%)	Never
4	Rarely	4	Rarely
1	Infrequently	1	Occasionally
1	Not Often	2	Fairly Regularly
2	Monthly	1	Regularly
2	Weekly	5	Weekly
1	10%	1	20%
4	Sometimes	3	Sometimes
1	Often	5	Often
1	50%	1	50%
		5	Daily

Table 7.34 Frequency of sending attachments

Table 7.35 shows that 18 (58%) of dispatchers said they never or rarely send attachments, 11 (31%) of traffic managers said they never or rarely send attachments.

Question: [If you use E-mail and send attachments] What kind of attachments do you send?			
Dispatchers		Traffic Managers	
11/13	Images	10/24	Images/Pictures
7/13	Text	9/24	Word
1/13	Spreadsheet	8/24	Text
1/13	Audio	3/24	Excel
		2/24	Variety
		1/24	Data

Table 7.35 Type of attachments sent

Table 7.35 shows that 85% of the dispatchers sending attachments indicated they sent graphics files and 42% of the traffic managers indicated they sent graphics files. 54% of dispatchers indicated they sent text attachments and 79% of traffic managers indicated they sent text or Word attachments.

Question: [If you use E-mail and send attachments] How often do you include an audio attachment?			
Dispatchers		Traffic Managers	
11/13	Never	15/24	Never
1/13	Infrequently	5/24	Rarely
1/13	Sometimes	3/24	Sometimes
		1/24	Often

Table 7.36 Frequency of audio attachments

Table 7.36 shows that 85% of the dispatchers sending attachments never send audio attachments and 63% of traffic managers never send audio attachments. Overall, this suggests that both groups are not experienced using computers to send audio messages, but because they are generally comfortable using voice-mail, training to do so would likely be successful.

Perceived usability and value of C-SLANT

Question: On the following scale, please indicate how easy/difficult you found this software to use?

Results	*Very easy*	*Easy*	*Neutral*	*Difficult*	*Very difficult*
Text mode dispatchers	8	7	2	0	0
Voice & pointing dispatchers	2	11	4	0	0
Text mode traffic managers	8	8	1	0	0
Voice & pointing traffic managers	12	6	0	0	0

Table 7.37 Perceived usability of C-SLANT

Question: On the following scale, please indicate how useful you think this kind of software might be in your job?

Results	*Not useful at all*	*Not very useful*	*Neutral*	*Fairly useful*	*Very useful*
Text mode dispatchers	0	0	2	9	6
Voice & pointing dispatchers	0	3	3	9	2
Text mode traffic managers	0	1	4	8	4
Voice & pointing traffic managers	0	0	2	4	12

Table 7.38 Perceived utility of C-SLANT

Table 7.37 and Table 7.38 show the results from usability and utility rating questions, respectively. No dispatchers rated their version of the system as "Difficult" or "Very difficult" to use, and 82% overall gave a rating of "Easy" or "Very easy". Overall, 76% of the dispatchers rated their version of the system as "Fairly useful" or "Very useful". The "average" text mode dispatcher's usability and utility rating was higher than that of the voice and pointing mode dispatcher's.

No traffic managers rated their version of the system as difficult or very difficult to use, and 97% overall gave a rating of "Easy" or "Very easy". Overall, 80% of the traffic managers rated their version of the system as "Fairly useful" or "Very useful". The "average" text mode traffic manager's usability and utility rating was lower than that of the voice and pointing traffic manager's, which is in contrast with the relationship between dispatchers.

A preference by traffic managers for the voice and pointing mode over the text mode, but the reverse for dispatchers might be explained as follows:

- The task of responding to a message may have been easier than creating the original message, because traffic managers were normally discussing problems in the airspace they were most familiar with, whereas dispatchers were assigned scenarios at random. Responding to an initial set of observations and questions rather than creating them, could also be argued to be a simpler task in itself.
- If it is accepted that the task was easier and more "natural" for the traffic manager, it could be argued they would prefer the communication mode that supported the more rapid production of comments and would not need the greater flexibility in editing previously created comments that is provided by text based communications as they would be less likely to change their minds on what needed to be communicated.
- The tasks were also different because the traffic manager not only created a message, but also had to interpret the dispatchers message. Even though the dispatchers tended to rate the text mode higher for usability and utility the traffic managers may have

preferred to receive a message in the voice and pointing mode than the text mode and that could have influenced their ratings.

Question: If you had access to this software regularly how do you think you would use it?

Traffic Managers: All but two traffic managers gave an answer to this question. The categories for their answers are shown below with example comments.

<u>To analyze performance</u>

- *Analyze specific traffic flows; attempt to identify specific causes of delays.*
- *To find out where the traffic bottlenecks are.*
- *Evaluate present routes/alt usage compared to sector loading issues i.e. does excessive vectoring/alt. Changes in lieu of new routing prove to be cost effective and can the new routing be efficient.*

<u>To improve communications in general</u>

- *I would probably not initiate a request/question, but would be grateful for the opportunity to respond to a question, especially where our customers felt that they were being delayed.*
- *Exchange of info/ideas with other air traffic facilities.*
- *I think this would be a very helpful tool during severe weather season to explain to the users how/why we chose rte methods.*

<u>To communicate about a specific recent event</u>

- *To help answer specific questions, immediately (the next day) after the occurrence involved.*
- *I think this will be very useful in sending several types of messages (audio, maps, routing, procedures) in a timely manner and being able to receive feedback easily.*

<u>For training</u>

- *Reproduction of offload scenarios for flow effectiveness – as an additional training aid*

For personal or shared annotation of events

- *Just by leaving notes to fellow employees or in documenting situations that might be reviewed at a later date.*

Dispatchers: All but three dispatchers gave an answer to this question. The categories for their answers are shown below with example comments.

To analyze performance and strategic planning

- *I would use it to plan NWA's contingency fuel above and beyond normal reserve and alt (if needed).*
- *As a dispatcher – not much. For planning purposes based on past performance, it would be a great tool for recognizing trends.*
- *Use it to help identify problems as well as show what is working in the aviation system.*

To improve communications

- *Allows for very quick dissemination of information to proper persons/departments.*
- *Capture live data – insert dialog and prompts – share with chief dispatcher / ATC coordinators.*
- *Saving / capturing info for reports – following flight progress more closely.*

For training and briefings

- *As a question / response system as well as in-house historical info – such as playing back the previous day to improve how we do things.*
- *Document operational situations for use to best justify equipment training and to use scenarios to train other dispatchers.*
- *Communicating with ATC facilities and eventually communicating with flight crews during a pre-flight briefing.*

Wouldn't use it, because not real-time

(This suggests some participants didn't separate the functionality of POET from C-SLANT, because C-SLANT could be used to capture information from real-time displays such as

ASDs - or possibly that some didn't consider the task of finding patterns of performance in previous flights their responsibility. A number of dispatchers said they thought the software would be more valuable to the ATC Coordinator or others who normally look back at performance data. Many of them used the term "Monday morning quarterbacking" when discussing looking at historic data of individual flight instances. A number of traffic managers also indicated that the Traffic Management Officer (TMO) or person charged with looking back at performance data would find the application more useful.)

- *It loses the actual dynamics of the "real-time" situation so I don't think I would use it.*
- *Depends if it was new or after the fact. Now would be great.*

Question: Was there anything you particularly liked about this software?

Traffic Managers: 16 traffic managers using the voice and pointing mode and 12 traffic managers using the text mode answered this question. The categories for their answers are shown below with example comments.

<u>Simplicity</u>

7 of the traffic managers using the voice and pointing mode, and 7 using the text mode, chose to mention that they found the software easy to use. This does not include those that only mentioned a specific feature.

- *User interface – very simple! Any idiot could use this tool.*
- *Very easy to use.*
- *It worked well and was easy to understand how to use.*

<u>Voice and pointing</u>

- *Voice and pinpoint – this helps explain situations.*
- *Yes, the ability to utilize the voice feature associated with pointing and specific issues.*
- *Voice recording – pen. I like to be able to point and talk at the same time.*

Other annotation tools

- *I liked the ease of using the red arrow. The pointer.*
- *Highlighting.*

Slideshow structure and images

- *The ability to incorporate various slides you usually have on your desktop PC.*
- *The visuals – allows for a better mental picture.*

Electronic communications

- *Yes – voice over to ask questions. Capability to send electronically.*

Personal communications

- *I liked it because it makes the presentation more personable.*

Dispatchers: 15 dispatchers using the voice and pointing mode and 12 traffic managers using the text mode answered this question. The categories for their answers are shown below with example comments.

Simplicity

4 of the dispatchers using the voice and pointing mode, and 4 using the text mode, chose to mention that they found the software easy to use. This does not include those that only mentioned a specific feature.

- *Very easy to use.*
- *Easy to use; simple.*

Voice and pointing

- *Ability to be able to refer and highlight.*
- *Voice recording and highlighting seem useful.*
- *The sound and drawing capabilities.*

Graphical user interface

7 dispatchers specifically referred to the graphical user interface. This is perhaps because dispatcher's visual communications with flight crews and other airline personnel is text based.

- *Clarity – ability to display lots of info in windows form.*
- *Graphical data is always useful.*
- *Good graphics, fast, easy to read.*

<u>Other annotation tools</u>

- *Could attach post-it and highlight or arrow.*
- *Custom options – highlighter etc.*

<u>Electronic communications</u>

- *Like identifying the numbers than typing commands that go directly to someone.*

Participant suggested enhancements

Question: Do you have any suggestions for improving this software?

Traffic Managers: 17 traffic managers responded to this question with ideas. The categories for the traffic managers and example comments were.

<u>Interface suggestions</u>

- *Add timer clock to view.*
- *The ability to draw line segments.*
- *Equip the voice feature to type the spoken word into the post-its.*
- *Perhaps adding a "pointer" tool box to access after you've used pen or other tools.*
- *More colors. Arrows pointing in different directions. Eraser head.*
- *Indicate the origin of recorded message. The only way to differentiate between my or NWA recording is the date.*
- *It would be useful to be able to click on airways or fixes to highlight them.*

- *Maybe an "undo" function to cancel (erase) just the last mistake.*

Information not in POET

- *It would be beneficial to also include distance traveled i.e. filed route versus flown route.*
- *Need more data (wx, rwy configuration, details of the daily operation)*

Information in POET, but not included in the scenarios

(In reality, some of this information would likely be asked for and provided in subsequent communications as exchanges occur back and forth.)

- *Would like to see the routes filed and flown via flight plan into ex: dtw..fdy..rod..flm..bkw..sbk3..rdw.*
- *ETA Times area.*

Dispatchers: 15 dispatchers responded to this question. The categories for the dispatchers and example comments were.

Interface

- *To be able to review my verbal message (in writing) prior to sending it. I would also like to be able to go back and forth between slides, and to have all the slides on one page.*
- *Make buttons easier to follow for listing flights/filters.*
- *Access to all screens at once.*
- *Have an "undo" function for the arrow / pointers.*

Not in POET

- *Great tool for real-time briefing if it had a weather overlay. Could brief pilots at remote stations or their homes.*
- *Need wx overlay / turb info / more of traffic runway closures / dest wx winds / enroute wx – the influencing factors / variables. The audio was interesting, but I was not comfortable with not having an immediate response: "was I clear in my statement?" Could I be misinterpreted? That could be a problem with communication.*

Traffic Managers' critique of dispatcher messages

Question: [Traffic Managers] What advice would you give an AOC person sending you a message using this software?

a. With regard to using the interface itself to convey a message.

b. With regard to the content of the message in the aviation context.

The categories for the traffic managers' responses and example responses were:

<u>Be specific</u>

9 out of 29 answers to this question indicated the dispatcher should be specific. This might partly be because normally reviews would be at the individual flight level or limited to a particular time period on one day, relatively shortly after the event, when factors such as weather may by more significant than for a collection of flight instances over a longer period of time.

- *Don't try to involve too many situations at once. One issue at a time.*
- *Timely: try to send data when event is still fresh. Identify specific concern.*
- *Point out specific problems and solutions you are seeking. Also include your preferences and any advice possible.*

<u>Provide sufficient detail</u>

- *Make sure all details are either drawn or verbally expressed.*
- *Be as thorough and complete as possible – and tell me your name (1st name is ok) so that I can talk to <u>you</u>.*
- *Be very specific with your question. Supply all necessary data, i.e. weather along route of flight, any statistics.*

<u>Be concise</u>

- *Keep it short.*
- *Be concise – what are your goals – what is your request / final outcome?*

- *Use concise messages when possible.*

Ask questions

- *Asking for help on different circumstances. Ex. If we file this route would it help? What about time frame?*
- *Ask definitive questions. How/why/what can we do?*
- *Ask specific questions, and identify concerns. I cannot relate to 3,000 pound extra fuel burn. What impact to operation are we addressing?*

Explain what is on the slides

- *Explain the purpose of the included slide – the receiver needs to know the point of the exchange.*
- *Explain your concerns or points on all the data or slides that are presented.*

Other interface issues

- *Preferable to the "post-its", use the arrows and drawing tools. "A picture is worth a thousand words".*
- *Speak clearly + use pointer to annotate what they are discussing.*

Structured Interview with the ZNY TMO

The results of this experiment provide evidence for how novice users of C-SLANT and POET might interact, because none had previously used either application. The TMO from the New York ARTCC used C-SLANT for several months as a beta tester, and also gained experience with POET during that time. The TMO's position is particularly interesting because that person communicates frequently with the airlines and other FAA organizations and is often asked to review the performance of the New York ARTCC after a significant event. The TMO's responses to questions during a structured interview via E-mail to determine the nature of the questions

asked by these other organizations, and his prediction for the impact of using C-SLANT, is presented below.

1. **What types of question do you get, asking you to explain the decision making that took place to strategically manage traffic through ZNY?**

   E.g. Why did you need 30 MIT from Boston Center to (ATL) during a restriction period in which Washington Center placed 15 MIT to ATL on New York Center? Perhaps there were only 3 or 4 airplanes coming from Boston Center so it seems like the 30 MIT is an overreaction.

   E.g. Why didn't you get traffic on to J-XX sooner. We showed the weather clearing that route at XXXX. It could take hours to run replays of the sector and search for the Terminal/TRACON and Center picture at the time to determine if the question is even valid. Sometimes it is relatively easy, other times it can get very complex. Then how do you explain it? Verbally over the phone with no visual references? In an E-mail trying to describe where the weather was, when and what other traffic was in the sectors? Normally we are in a defensive posture, defending the actions of our facility.

2. **What percentage of these types of question do you get asked as opposed to others working in the facility?**

   The TMO is the focal point for the operation. Generally speaking, unless it's a purely Quality Assurance issue, i.e. systems error or pilot complaint, my office receives the questions. The TMO, or representative is the focal point for the Airlines and other system users, as well as adjacent facilities and the ATCSCC.

3. **Who asks these questions? (i.e. what organizations are involved and what positions do those people hold?)**

   Other TMOs, ATT4, who is the ATCSCC individual responsible for coordinating and communicating areas of concern to the field facilities, ATCSCC National Operations Manager (NOM)for Severe weather or NOM for the EAST side in the ATCSCC, User groups such as the Teterboro Users Group Rep., NBAA, Airline ATC reps., Tower Managers at the NY airports, those types.

4. **How many of these questions would you be asked in a day on average?**

   Things have changed since 9/11. During the summer, after a SWAP event there could be several questions the next day. Lately we have been so engaged keeping our head's above water, and working with the military blocks that these things have dwindled. Let's say it averages one per day.

5. **How often are you asked the same question?**

It can be streaky. We tend to get wrapped around an issue for a week or two, then move on as we react to the latest crisis. Questions about the need for, and effectiveness of MIT restrictions are continuous. That is why I want to get better at POET as a training tool for the ZNY TMCs to see the results of their actions, as well as demonstrate what the issues are to other people.

6. **How often are the questions asked by telephone versus email versus any other form?**
   Issues are generally raised on a Telcon or by telephone.

7. **How often can you answer the question using just the information you have in your head about the events that took place?**

   Rarely. Unless it was brought up during the event and I have explanations from the people who worked the event in the TMU.

8. **When you have to investigate further, what is typically involved?**

   A SATORI replay review. Contacting the STMC and/or TMCs involved. Reviewing reroutes that were used. Sometimes talking to Controllers and Supervisors. It could also involve a call to a customer or adjacent facility to see what their perspective was at the time of the event.

9. **How long do these telephone conversations usually last?**

   Too long! We've spent 8 man hours, over the course of days to respond.

10. **Can you think of ways that using C-SLANT might improve the efficiency of answering these particular types of questions?**

    Yes, especially if I could get good convenient slides of weather overlaid on the airways. You could do a review every day, with a little practice I don't believe it would be a great deal of work. The MIT review relies more on POET. POET screen capture with voiceover would be a good way to go. The analysis could then also serve as an archived training tool in the off season. "OK let's look at this scenario from last summer. Here's what you can expect when the weather is here, etc, etc."

11. **Can you think of any disadvantages of using C-SLANT to replace or supplement these phone calls?**

    A process must be developed to familiarize users with the tool and all need the software.

12. **Any other comments?**

    I think that it is very powerful when weather is involved, because the person can see the picture and the expert can interpret it via voice to explain the impact. I experimented doing a voiceover using the CCFP. That's another area to explore. Then you archive it via the subject on the cover *page[16]. You might have a training class two years after the event, but the weather is consistent in that it's always there (brilliant)! Another item that just recently came up in the meetings I attended was feedback to the Severe weather people in the ATCSCC. They don't get any of this review and analysis. Think about it. They work the shift, go home and most often never hear or see what other stakeholders have to say about their operation. They are not available for the telcon the next day and are usually completely out of the review loop. That's significant, but no one has figured out an effective, timely, workable way to create the feedback, and deliver it. We could be using CSLANT right now to send voiceovers to explain to the military and users the impact of military blocks, because we have a picture of the block on an airway chart. The picture itself is somewhat meaningless without an explanation.*

The TMO's comments provide important information for potential further research using C-SLANT or similar applications in this domain:

1. The study here involved analysis of performance for particular city pairs based on historic data normally involving several months and one airline. In the comments made by the TMO established and ongoing discussions were described that focus on the events for some portion of one day.
2. Miles in Trail (MIT), sector volumes, and weather are important factors for traffic going through ZNY and they need to be represented clearly when performing analysis.
3. The TMO and those he listed as individuals he interacts with, when reviewing decision making to strategically manage traffic through ZNY, could form an appropriate group of users for C-SLANT. The group is already established, their task is clearly defined, and they already comment at a distance. One of the reasons cited in Chapter 3 for the failure of FREESTYLE was that a critical mass of appropriate users was not given the system to use, so knowing the existence of a group such is this is very valuable. They currently communicate synchronously, but there appear to be problems with that as the primary form for communications, because it requires significant preparation and the information

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[16] The idea of a modification to C-SLANT where a "cover page" would overview the slide show and provide data that could be used for archiving the slide show was mentioned to the TMO before he responded to these questions. This is discussed in more detail later in this chapter.

is often graphical so it is difficult to visualize this with verbal descriptions. The TMO's idea of developing daily reviews using C-SLANT, POET images and images from other applications would be one approach. These could be made available on the web for responses by, for instance, telephone, C-SLANT, or an application like Microsoft Netmeeting, if a synchronous communication is needed between participants who need to see the images at the same time. In this case the TMO discussed reviewing operations, but a similar approach could be taken when projecting forward while, for instance, looking at weather maps and discussing what will be done or is proposed to deal with that.

4. C-SLANT could be used in combination with the CCFP to discuss weather in the system when projecting forward or looking back to discuss the quality of the forecast made and its impact.

Discussion of Results

Comparison between the text and voice and pointing modes

Although C-SLANT will support the creation of messages involving text and/or voice-based communications with deictic referencing, one or the other of these features was disabled in this experiment in order to understand better the effect of each mode in this context where the efficiency of working with data represented by screen captures is important. To estimate how often the modes would be used when users are given a choice, eight dispatchers, not involved in the main experiment described here, were given slide shows to annotate using C-SLANT with no modes disabled. Four chose to use voice and pointing alone, three chose to use text alone, and one used both modes. This suggests there is value in supporting both modes to accommodate user preferences, as well as flexibility for task and environment variations.

The text based mode is also a more traditional form of computer supported asynchronous communications, so now that the technology exists to support voice and pointing based communications it is valuable to understand the impact of using it.

Aviation context issues

This study was not only an investigation of the differences between a text based and a voice and pointing based communications mode in this context, but also an investigation of the interactions that would occur when these two groups were given POET data and allowed to discuss the actual performance problems that it represented. It thus provided an opportunity to learn more about the effectiveness of POET as well the information these two groups could exchange when working collaboratively.

- Enhancements suggested for POET

Weather and traffic density information were the two most commonly requested additional sources of information. The runway configuration in use was also often mentioned because it can impact the arrival rate, the taxi-in and out time, and the direction of approach. In general, this type of information can help explain not only what happened to particular flights, but also why it happened. Figure 4.16 in Chapter 4 showed many of the factors that influence the performance results stored in POET. The more of them that the system has information on, the more of the "story" for a particular flight instance can be told; the more patterns can be revealed for multiple flight instances; and the more criteria are available to conduct searches. Thus, all of the additional factors shown in Table 7.39 could have been useful when using POET 1.0.

Data	Example Search Criteria
CCFP weather information	coverage > 50% and sector = ABC
Sector traffic density	density > 15 and sector = ABC or DEF
Planned and actual distance traveled	actual – planned > 500
Playbook play	play = ZNY2
Ground stop	groundstop = LGA
Runway	arrival = EWR and runway = 2
Holding fix	holdingfix = ABC

Table 7.39 Potential flight or airspace attributes for POET 1.0

A basic problem solving strategy that can be used with POET when looking to identify poor performance and potential improvements is to conduct comparisons between what are or might be alternative options. For instance, alternate routes between the same city pair, alternate times of day, and flights held versus those not held. When information can be displayed about two alternatives on the same screen, those options can be compared without having to change screens and remember the attributes of one of the options. POET supports displaying many alternatives of this kind on one screen, but it does not support the display of multiple instantiations of the flight route map window to allow juxtaposition where, for instance, the filed versus flown routes can be unambiguously be seen for multiple filed routes without interacting with the window. This would appear to be a useful alternative method for comparison, and particularly useful if trying to produce a snapshot of information on POET screens to become the focus of discussion, where in general, a smaller number of screen captures will be easier to work with. In creating the ZFW and ZMP scenarios, there was some "tweaking" of the screen captures to actually simulate that ability and reduce the number of screen captures needed.

The comments and annotations made in this study show certain information (such as shown in Table 7.26 is used or discussed in explaining the events that have taken place when analyzing or predicting performance. Including information the traffic managers used to explain the system to dispatchers in POET (such as altitude cap regions [e.g. the ZID and ZTL scenarios], the prioritization for traffic on certain routes [e.g. the ZDC scenario] and decision points and reasoning for determining whether to reroute enroute or not [e.g. the ZFW and ZTL scenarios]) should make the system more useful.

The study also revealed certain minor interface problems with POET as participants misunderstood some information on the displays. As discussed earlier, the scatter chart was misread because of problems reading the scale for the date range, the mapping of the flights table to the scatter chart data caused confusion because the table ordering of top-to-bottom didn't map to left-to-right for multiple flights, and a table was misread when the user incorrectly matched information on one line to information on another.

Further Enhancements to C-SLANT

C-SLANT 0.3.7 was used by all the participants in the experiment described in this chapter; however, it has continued to be developed further, with several significant changes implemented as a direct result of the observations made during this study. In this section the results described earlier are discussed and the redesigns implemented or proposed for C-SLANT in response are described.

Improving discourse

Problem	Redesign Idea
Annotations and text box comments did not have their author's name recorded	• Assign an author, date and text value to text box windows • Support session layering and key creation for annotation markings
The ordering of discourse contributions is not recorded for text and requires too much cognitive work for voice and pointing	Maintain both text and voice & pointing comments within a table of a separate window. Support text labeling as another form of annotation

Table 7.40 Resign ideas to improve discourse structure

- *Improving the distinction between annotators*

For the experiment, participants were not asked to enter their name as is an option when starting C-SLANT. If this were done the audio recordings would have had the name of the person shown in any player windows created, as well as the date and time of creation (as was shown). However, text boxes, pen marks and arrows carry no explicit indication of who created them. When analyzing the slide shows created it was sometimes necessary, to go back to saved copies of the dispatcher's message before the traffic manager responded to separate the authors (although the color of the text can be changed and for this experiment the default color for the traffic managers' text was changed to be different from the dispatchers'). Because a traffic manager's response might easily be sent to a third person in reality, for instance a traffic manager at a different center, this is a potential problem. One approach to solving this problem would be to put all annotations in a temporal context and reveal them as layered sessions. Another approach would be to include an annotation key that assigns color (or some other distinguishing characteristic) to specific annotators.

The author, date and time could also be associated with each text box, as is done with E-mail messages. Then a separate window could be used to manage those comments in a table as is also done in E-mail programs. The same approach can be taken with voice and pointing recordings. As was shown in the analysis for this experiment, the sequencing of those recordings can be difficult to determine when multiple recordings are made on a slide and player windows overlap.

- *Threading recordings to aid context and navigation*

Given that participants didn't always make comments on every slide (and with further iterations and possibly more people involved in the discussion that might be expected to continue), having a single window for all text based comments and voice & pointing based comments should help navigation through those comments and context. In fact the current version of C-SLANT supports this management of voice & pointing recordings, as shown in Figure 7.20, but not text based communications.

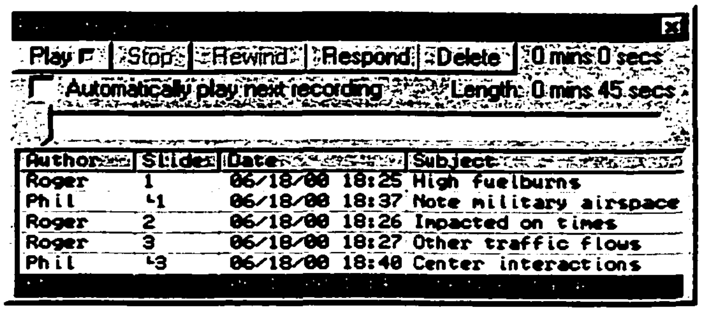

Figure 7.20 C-SLANT's recordings window

Multiple recordings are allowed on a slide to provide a mechanism to make distinguishable topics and sessions tied to the same slide disjoint, and responses to specific recordings are visibly noted as such to help capture the context of the response. The user has the option to sort a table of recordings by annotator, slide, date and time of recording, or topic. The user may also select an "automatically play next recording" option in this table to be presented with an interruptible "show" of slides and recordings, using the current ordering in the table. The combination of these last two features allows the user to, for instance, listen to all the recordings by a particular person across the slides; listen to the recordings by temporal ordering; or listen to the recordings by slide ordering.

Given that some participants wanted to refer to multiple slides in a single recording, while describing related information, it would appear to be an enhancement to C-SLANT to support this feature. The tradeoff is that long individual recordings could be created when the recording could actually have been divided into separate recordings, because the comments were significantly disjoint. Separate recordings when appropriate would be simpler for the recipient to manage. Training and automatic feedback when recordings are becoming long would appear to be important when supporting this feature. Richer frames of reference for the recordings could also help with their management as discussed in the section "improving voice and pointing communications".

Allowing a responder to interleave responses within a single recording could also be supported. This would be analogous to interleaving responses in a text-based E-mail message. How well that would really work requires further research, but one potential benefit could be more efficient matching of users' individual comments.

Improving problem solving in this domain

<table>
<tr><th>Problem</th><th>Redesign Idea</th></tr>
<tr><td>Flight groupings, performance measures, questions and suggestions, and answers are significant types of contribution to discourse that should be more salient and distinguishable.</td><td rowspan="2">Add configuration options to C-SLANT to support message structuring. (Like FREESTYLE, C-SLANT was not initially designed for structured workflow, but templates could be used to selectively provide structure to achieve the benefits of structured collaboration described by Kraemer and King, and discussed in Chapter 2.)</td></tr>
<tr><td>Participants considered the communications useful, and almost all the questions asked and issues raised received a response, but the communications efficiency was sometimes poor.</td></tr>
<tr><td>Visible annotation marks on the maps were used to represent a small set of semantic types.</td><td>• Implement an (advanced) user-defined set of symbols to supplement the arrow markers
• Implement an (advanced) user defined key to allow semantics to be associated with pen marking types</td></tr>
</table>

Table 7.41 Redesign ideas to improve problem solving

- *Adding structure to C-SLANT messages to improve efficiency*

The traffic managers' responses to the questionnaire question, "what advice would you give an AOC person sending you a message using this software?" were summarized earlier and are noticeably similar to Grice's Maxims of Relevance, shown in Table 7.42. Providing true, unambiguous information and comments put in context is a significant goal when designing asynchronous interactions about POET data using C-SLANT. The results from this experiment provide evidence that multimodal communications involving voice based communications with deictic gesturing can be used to solve problems of this kind and participants responded favorably to doing so, but there was also evidence of some inefficiency in the voice-based communications and the use of a slide show structure.

Maxim	Application to this context
Quantity: provide as much information as needed in a context, but not more information	• POET uses filters to provide focused results, showing influencing factors and alternative options • Recipients can provide more information or request it • Assigning blame or complaining without details in the discourse provides no information
Quality: speak true information	POET data reduces speculation
Relation: make your contribution relevant to the context in which you are speaking	• Recordings associated with particular slides suggest that slide is the context • Recordings related to each other should be linked to aid context
Manner: speak as clearly as possible, avoid ambiguity, say things as simply as possible	• Maps, graphs and tables aid perception • Speech and pointing provide converging evidence of meaning and reduce complexity • Speech is not visible and slower to interpret or scan than text • Asking direct questions simplifies communications and reduces ambiguity for what is requested • Structuring messages may make them simpler to manage

Table 7.42 Summary of C-SLANT based on Grice's Maxims of Relevance (1975)

One approach to reducing those inefficiencies would be to provide task and domain specific structure to the design, to make it more focused, organized and simple to navigate. However, in adding such structure, C-SLANT could lose value for other types of communication (e.g. training) between these groups or for other domains. Adding structure through configuration options (as can be done by system administrators with Microsoft Netmeeting) rather than hardwiring it would however, allow a generic system to be available, while supporting optimization for particular tasks and domains. The concept is also somewhat similar to the templates available for particular types of presentation in Microsoft PowerPoint.

One approach to supporting structure in C-SLANT would be to allow, through configuration options, a "cover page" to be designed for slide shows. For this task and domain it might consist of fields for each of the following: flight grouping information; poor performance indicators; questions and suggestions, and answers, author and contact information. Its purpose would be to serve as an overview for the content of the slide show, with key information summarized succinctly with text. A "table of contents" might also be useful to give summarizing title to each slide. The slide show itself would be an "expansion" of what is summarized, but it would exist within a framework that is established quickly and initially when working with the C-SLANT message. Participants tended to put summary information on the first or last slide, but one text mode traffic manager given the ZNY scenario explicitly asked, "If I want to make a general comment to provide an overview, where can I do that?".

An alternative approach might be to modify the list of recordings window to try to achieve much of the same effect. The flight grouping information could be displayed in a fixed location, and "comment types" such as performance indicators, questions, suggestions, and answers, could be associated with individual recordings (or text boxes assuming they are combined with the list of recordings). When starting a new comment the type would be first selected.

- *Domain specific symbols and annotations*

The semantics of the arrow marker is a static deictic gesture, but combined with some verbal or text based description of what is being referenced at that point the intention is more specific. As was noted in the analysis, these were often placed while speaking and talking, but when used in the text mode the language was more ambiguous, and the recipient had more cognitive work to connect the referent to references (that were often indirect). Supporting label annotations in addition to text boxes would provide another method for avoiding such ambiguity, but specific symbols would also reduce ambiguity. Thus, symbols for holding fixes, airports, corner-post, and metering initiation points, placed in a "symbol markers" configuration file could all be useful.

The pen marker was often used specifically to propose a new route, but so too was a collection of arrows, possibly because the pen mark proposed routes were too difficult to distinguish from the POET produced filed and actual routes. The ability to have a configurable set of pen colors and line styles (e.g. dotted or dashed), and assign these to a key, would reduce ambiguity in the message communicated.

Improving annotations

Wojahn et al., (1998) present a set of requirements for annotation interfaces that were compiled with text-based annotation systems in mind, but are also relevant here for the voice and pointing mode, and can serve to provide further guidance considering the actions participants took and the redesign of C-SLANT. Some of the issues described in Table 7.43 have already been discussed and the others will be in their respective sections.

Requirement	Comment
There is a minimum of motion required to make an annotation	• Connecting a reference to the referent in a message requires little effort once recording starts in the voice and pointing mode • Text requires typing which is slower than speech, unless modifying previously created comments • Text requires additional words to unambiguously reference an annotation • Pen marks don't involve using a stylus, but a mouse pointer • Initiating annotation modes requires mouse movement and visual button clicking - middle and right buttons could be assigned additional functions
The primary text is easily distinguishable from the annotation text	• Speech and pointing contrast with visual images • Pen marks contrast with most objects composed of straight lines and with text, but not routes in a map • Arrow markers contrast with most images • Text boxes contrast better with images without captured windows
The annotations are visible "at a glance" while reading the primary text	• This is not achieved with the voice and pointing mode, because it is not possible to "glance" at it and see a sufficiently rich representation of the annotation • Scrolling text is not completely visible • Pen marks and arrow markers are visible
The relationship between the primary text and the annotations is easy to see	• Deictic referencing ties verbal comments with points and objects • Text boxes can't always easily be placed near to that which they refer - labels could be • The value of the textbox reference to a referent depends on how descriptive the semantics are to the reader • Pen marks and arrow markers are placed at the point or area to which they refer
Different annotators are readily distinguishable	• User login names are associated with recordings through labeling • There are no distinctions made between different users' text boxes, pen markings and arrow marks

Table 7.43 Summary C-SLANT based on guidelines by Wojahn, Neuwirth and Bullock (1998)

Improving voice & pointing communications

Problem	Redesign Idea
The recipient's attention is sometimes misled in the image due to: 1. Unintended pointing during movement to interface options; 2. A visible pointer when pointing is not desired; 3. A visible image when the image is not being referenced.	• Move the C-SLANT record buttons to a fixed location. • Allow the deictic gesturing pointer to be hidden and reappear at the click of a mouse button or use of a function key • Turn on and off recording with a mouse button click or use of a function key • Allow the background image to be hidden, dimmed or masked in some other way
Subjects were often not given to recordings	Force something to be entered or require a "cancel" command
The recorder and player windows don't capture the speech and pointing dynamics in a static representation	• Incorporate SoundBrowser's design for representing audio dynamics • Use speech recognition to generate text and tie setting the text cursor's position to the audio and pointing positions' • Include an option to display a trace of the pointing path • Mark temporal segments in the slider where pointing occurred
More polished presentations require additional speech and pointing preparation	Provide better support for pausing and resuming recording
The user is not discouraged from creating very long recordings	Implement a configurable maximum recording length and show a countdown display, or accumulating recording length and storage requirements.

Table 7.44 Redesign ideas for improving voice and pointing based communications in C-SLANT

- *Avoiding distractive pointing and supporting dialog composition*

One option in the current version of C-SLANT that would seem specifically useful for an audio and pointing recorder is the ability to start and stop recording by use of a mouse button rather than a visible button. The problem with the latter approach is that the viewer's attention is mislead watching the pointer go to and from the start and stop recording buttons when the recording is played back. Further, because those buttons are positioned relative to C-SLANT's main control window, and that can be moved, pointing when played back can appear to move towards or from a particular point for no particular reason. (For this reason the recorder controls should be given a dedicated screen position, if the interface involves these buttons.) Making it simple and accurate to start and stop recording also might help the user to improve the narrative as there is the potential to focus on a point to be made, then stop and think about the next point carefully, and then focus on the narrative again. In the research of Bly (1988) and (Tang 1989; Tang 1991; Tang & Leifer 1988) summarized in chapter 3, they both emphasized the importance of smooth transitions between annotation methods as they observed participants do so rapidly and smoothly in team paper and pen design situations. Transitions between speech and pointing stages/events also need to be "smooth". The use of a mouse button to start and stop recording would produce better results for the recipient, but there is not a visible memory aid for this interface feature, suggesting that both methods for controlling recording should be available to support the novice and more experienced user. It would be difficult to achieve the simplicity of GroupSketch, described in Chapter 3, because C-SLANT has a lot more functionality, but making document ed more advanced features available, but not immediately obvious (to protect the novice from being overloaded) is the design approach suggested here.

- *Improving the frames of reference for recorded audio and deictic gestures*

In a study of the interface to SoundBrowser (Degan et. al., 1992), shown in Figure 7.21, it was reported that users found the following useful:

1. The ability to place coded 'markers' in the recording to make it easier to retrieve particular audio segments.
2. A visual representation of amplitude to make it easier to retrieve particular audio segments.
3. The ability to zoom in on a portion of the recording when the amplitude representation was too dense, as long as a global reference to the entire recording was mentioned.

4. The ability to play the recording back at up to 200% the original recording speed using a pitch maintaining algorithm.

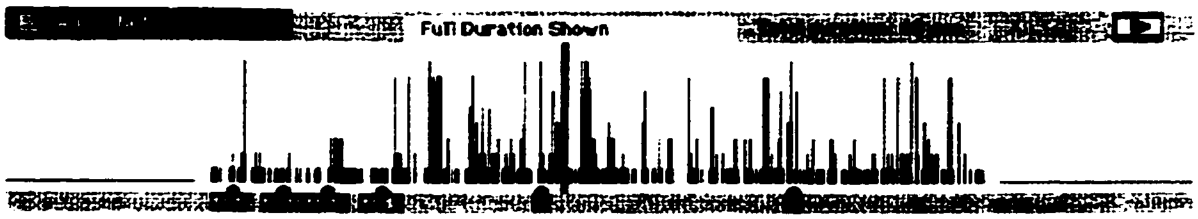

Figure 7.21 The SoundBrowser window (Degan, et. al., 1992)

It would appear that C-SLANT might benefit from applying these findings, as the recorder and player windows have no visual information other than possibly a completed subject field and the current position and length of the recording. Further, another horizontal axis might be used to indicate which periods of time there was motion of the pointer. This type of display could be particularly useful when a sender has paused for long periods while thinking and does not speak or point, but keeps recording – as was the case with the traffic manager given the ZDC scenario and discussed in the analysis. The visual display would reveal such pauses and therefore potentially cause the creator to remove them or allow the recipient to stop over them. The ability to place coded markers could, for instance, allow the listener to note where there was a question or issue to respond to and then continue listening, having made a visible note of something to be returned to. This might have been useful for the ZNY scenario participant who appeared to be having problems remembering all the questions asked.

A speech recognition module could be added to C-SLANT to generate a text version of the audio, and the user could then be given the option of setting the current position, or range, in the audio by doing so to the corresponding text. If this were done it might be better to only have the text appear after the recording is completed or it could be too distracting.

Another visual reference to assist in the process of scanning saved deictic gestures would be to have the option to display a static trace of the path taken and then perhaps allow the user to click on a particular point to set the current position in the recording. This would be somewhat analogous to scanning text, which can be done so much more efficiently than scanning audio (Streeter, 1988).

- *Require or encourage a text subject for the speech and pointing recordings*

  Subjects were not given to any recordings by 14 of the 18 dispatchers working in the voice and pointing mode. In the version of C-SLANT used in this study the player window appeared after a recording was made with a blank subject and participants needed to notice it was blank and complete it. In the current version of C-SLANT the user is prompted for a subject after the recording is saved and must select "Cancel" to have a blank subject.

- *Discouraging long recordings*

A message consisting of a small number of recordings may require less recordings management than a message with a lot of short recordings, but long recordings can present significant cognitive demands because they don't have the chunking benefits of multiple small recordings. Providing better frames of reference on the recording may help, as discussed earlier, but if they are long because the speaker had not paid sufficient attention to succinctness, they can present storage and transmission time problems. To encourage shorter recordings the current length and storage could be displayed and updated during recording or a countdown could be displayed. The most aggressive approach would be to impose a strict recording length and simply stop recording when it is reached.

Improving text based communications

Problem	Redesign Idea
• Text boxes were left covering data in the image • The order text boxes should be read was not always obvious	• Separate "message boxes" from "labels" • Put links to displayable text messages in the recordings window, as an alternative to a voice and pointing message

Table 7.45 Redesign ideas for improving text based communications in C-SLANT

- *Text boxes were sometimes obstructive and difficult to navigate*

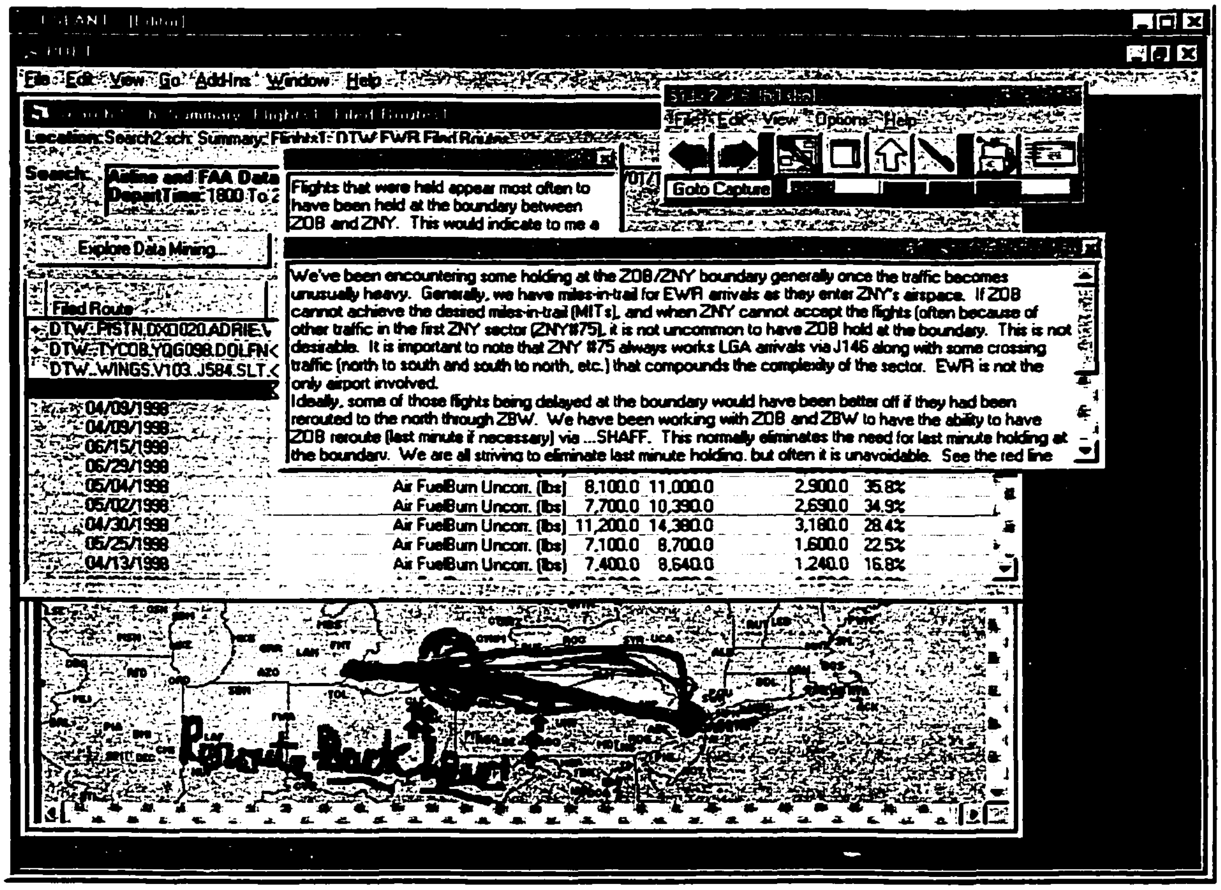

Figure 7.22 Example of the demonstrated need for "labels"

All the text boxes created in this experiment were message comments (with sentences) rather than "labels". As discussed earlier, supporting a separate text label annotation type would be an enhancement because it efficiently enables information to be added in relation to a specific location in the image, and Figure 7.22 demonstrates a situation where a traffic manager would have benefited from using one in the ZNY scenario. In combination with a line annotation, the label can also be linked to a specific point or object with some flexibility when trying to avoid covering data. As also discussed earlier, traffic managers tended to open new text boxes when responding rather than reusing the dispatchers' text boxes they were responding to. Even though the text of the authors was assigned a different color, multiple text boxes were sometimes created by one person (and if there were further message iterations this would continue) making the order in which they should be read difficult to quickly determine. These problems could be eliminated by organizing this type of text comment as part of a recordings window, and thus actually support mixed mode communications with a consistent interface. This flexibility might be useful to allow selection based on the characteristics of what is being communicated and the current environment. If the comments involve details such as a list of fixes representation of a proposed flight path where the sender wants to be sure they are communicated clearly, because they will be entered into another system, the text format is better. Alternatively if the sender wants to discuss what will happen at several locations along the proposed path, in terms of other information on the map, it would be more efficient to do so while pointing and talking. In other situations a person may not have a sound card, or be in a situation where they can make verbal comments because of the environment they work in (although that seems unlikely in this domain). It may also be a matter of personal preference as to which mode the user prefers.

Improving visible annotation markings

As discussed earlier both pen markings and arrow marks were anonymous and this might cause owner identification problems when messages are exchanged several times. Session layering would be one approach. Assigning sets of markers to different authors would be another.

Problem	Redesign Idea
Pen Marks:	
Pen marks for proposed routes didn't contrast sufficiently with POET filed and actual routes	Provide a wider range of colors and line forms
Wobbly lines were drawn where straight lines would be appropriate	Support a line annotation tool
A rough box was drawn with the pen	Support a box annotation tool
Long arrows were drawn with the pen	Support a flexible length arrow annotation tool
Arrow Markers:	
Arrows could only point in one direction	Provide at least four directions

Table 7.46 Redesign ideas for improving visible annotations

- *Pen markings for drawing routes*

As mentioned previously, participants sometimes used a sequence of arrow markers instead of a pen for proposed routes and it was suggested this might be because they used the annotation method that contrasted most with the map and would be the least ambiguous for the recipient. A pen tool that produced dotted or dashed lines (or some combination thereof) might not match the real-world metaphor of a pen as well as solid-line pens, but would allow for more contrasting pen marks. Alternatively, a tool allowing a series of connected straight lines (with the dotted or dashed pattern) between points could be implemented and this would be consistent with lines and boundaries used on many maps and potentially be a more accurate representation of proposed routes.

- *Other uses of the pen*

The pen was sometimes used to produce approximations on horizontal lines and rectangles in both the scatter charts and tables, and on two occasions it was used to draw a longer arrow than a arrow marker. This suggests annotation tools specifically for those types of annotations would be used if implemented.

- *Arrow markers in multiple directions*

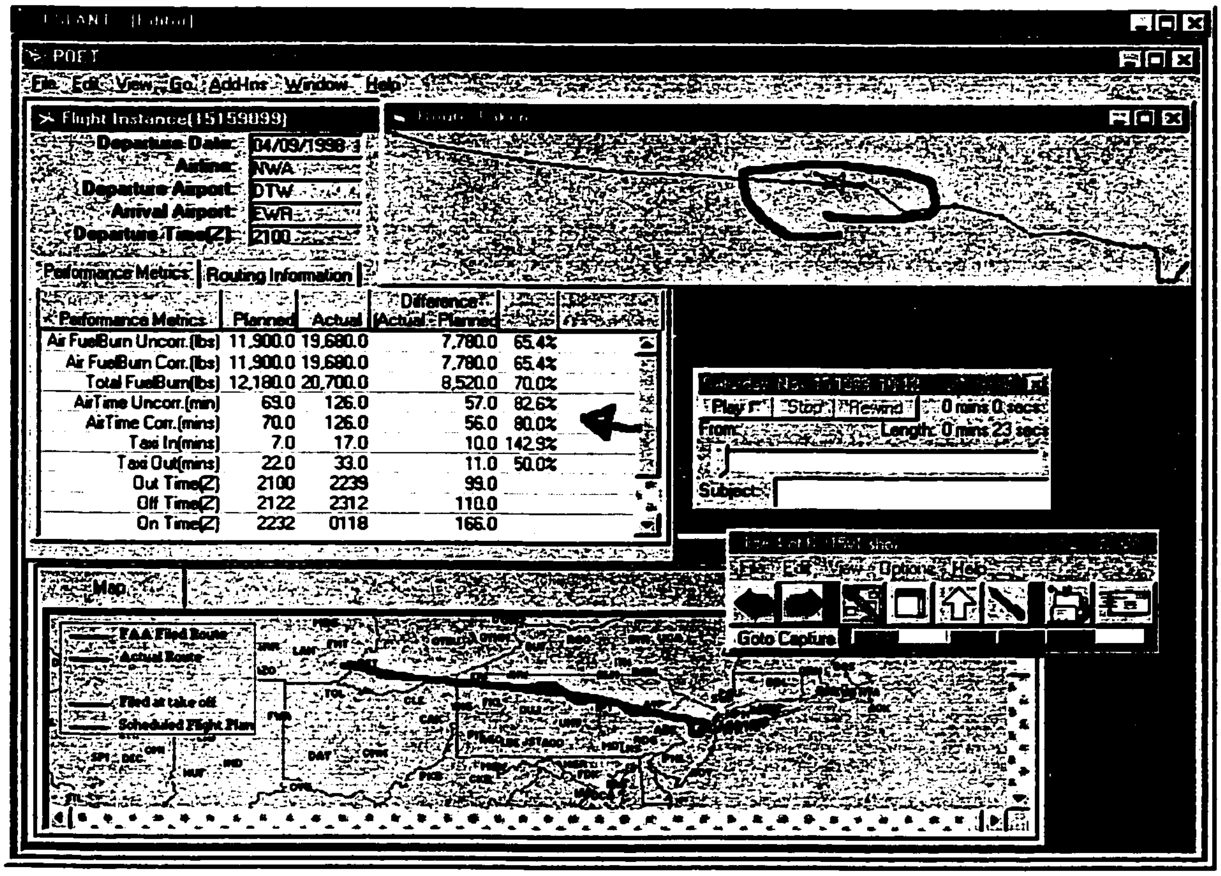

Figure 7.23 Example of the need for more sophisticated arrow annotation tools

Arrow markers were frequently used, but a number of participants wanted to place them in a direction other than the one direction supported. Providing either 4 or 8 directions would enable arrow markers to be more easily placed in positions to avoid overlapping data or other arrow markers. Figure 7.23 demonstrates a situation where a dispatcher wanted to place an arrow pointing to the left. Providing a flexible length arrow marker, similar to those used in the other programs with annotation features, would also be useful.

Improving single slide operations

There are issues regarding the design of C-SLANT related to events that occur at the individual slide level and others that exist when there is more than one slide. At the individual slide level the annotation options have already been discussed, but there are also design issues related to the management of the underlying image itself (some of which were not captured in the experiment because participants were given a slide show already created).

Problem	Redesign Idea
Users sometimes thought the screen captured image was an active window	Use a mask over the background image or use distinctive skins for C-SLANT's windows
C-SLANT does not handle images of a different size than the screen very well	Support zooming, and automated scrolling, with multiple views and support these actions as part of a recording
C-SLANT doesn't allow multiple images to be pasted on a single slide	Include a simple Paintbrush- like interface to combine images

Table 7.47 Redesign ideas for single slide operations

- *Contrasting more with the background*

To help the user distinguish between the real controls of C-SLANT and those that might just be part of the image from a screen capture, the latter could be made slightly less "real" by masking it to, for instance, make its color lighter. Alternatively, the C-SLANT controls could be made more distinct by giving them a "skin" different from standard Windows controls.

- *Supporting small and large images*

The version of C-SLANT used in this experiment did not support any zoom in or out operations. The current version supports this to a limited extent, with pull down menu options for percentage zoom levels, but not by zooming at an x-y position, selected with the mouse, which would be preferable. When working with large image maps, in particular, it would be easier with a zoom feature to provide a micro and macro view. Voice and pointing annotation while zooming in and out is analogous to annotating over video, which would present visibility challenges in that video stream, and not just the audio as is currently the case. Similar challenges would exist if attempting to support annotation while scrolling.

- *Enhancing background image creation*

When screen captures are taken the resultant image is the size of the current resolution (e.g. 800x600 or 1024x768), if a full screen capture is taken, or the size of a window, if only an individual window's image is captured. The ability to paste more than one image on a slide would potentially allow more information to be viewed at one time and thus reduce navigation and memory requirements. An interface similar to Microsoft Paintbrush's for this feature would be simple and consistent with that program that is a standard application in the window environment.

Improving navigation across slides

Problem	Redesign Idea
Recipients of a message started responding before viewing/listening to all of it	Provide a better overview of the slideshow structure with thumbnails and the recordings window. Warn the user if necessary
Recording was not allowed over multiple slides	Allow recordings over multiple slides, but show them as two linked entries in the recordings window

Table 7.48 Redesign ideas for slide navigation

- *Providing a better overview of the slideshow and warning if "interrupting"*

Responding to an original message (spread over multiple slides) after the first slide suggests the person either forgot there were more slides, or didn't realize that his or her response may no longer be as appropriate after viewing or playing the recordings of the other slides. Putting the current slide more clearly in perspective of the slide show should help with this problem. This could be achieved by using thumbnails for each slide, as is done in programs like Microsoft PowerPoint. The recordings window also makes it much clearer that there are additional slides and if the user has the automatically play new recording option set, he or she can hear all the recordings at one time. If the user still creates a response without viewing or listening to all the originator of the message sent, a warning message could also be issued, but that should be a configuration option as some users may not consider it helpful. The reason being that there is a tradeoff - the more the user listens to before responding the less likely there will be something later causing the response to be less appropriate, but there is also more to remember from what is being listened to in one session. Allowing memory aiding markers to be placed on the players at significant points and adding more structure to the messages themselves are two approaches already discussed that might help address this problem.

Improving message management

Problem	Redesign Idea
There is no C-SLANT specific message management system	Add features appropriate for slide show manipulation and message management
There is no method for searching slideshows	Support search of text based message components such as text boxes and message attribute fields

Table 7.49 Resign ideas for message management

- *A C-SLANT message management system*

The C-SLANT program opens and saves individual slide shows, but there are no options to manage multiple slide shows at one time. As individual files, the slide shows can be manipulated like any other files in the Microsoft Windows operating system and can be sent as an attachment to an E-mail message or put on a file server for transmission, but additional functionality could be implemented considering the specific properties of these files. For instance, with multiple slide show views, slides could be copied from one slide show into another. If the management system included mail or file transfer protocols, message exchanges for a particular slide show could be tracked specifically. In a client server, rather than a peer-to-peer communications architecture, a slide show could be a "topic" in a pseudo newsgroup environment, where multiple participants could contribute to the discussion. In such an environment the recordings window could be managed by the server to coordinate the exchange of comments.

- *Searching slide shows*

As part of a C-SLANT slide show management system, searching through multiple slide shows could be supported. This could involve searching text box content, but if the structured messaging fields were part of a slide show, as discussed earlier, those fields could also specifically be searched. Thus, messages discussing particular city pairs, performance concerns, or performance improving strategies could all be searched for.

Improving storage and processing time requirements

Problem	Redesign Idea
The system was sometimes slow	Provide more compression options
Transmission time can be long	Stream the audio or only transmit changes to a slide show
The system is platform dependent	Use Java and/or a Web based implementation

Table 7.50 Redesign ideas for low-level computer efficiency

- *Improving system response time*

C-SLANT files are compressed to reduce the size of the slideshow that is sent and to reduce the amount of disk space needed. However, the compression and decompression processes take time, and on slower machines this can be noticeable. To provide the most flexibility the current version of C-SLANT allows several configuration options. Slides can (1) be compressed and decompressed automatically as the user moves between slides; (2) be compressed only at the slideshow level; or (3) not be compressed at all. As machines get faster and storage larger, compression for transmission becomes the most important speed related issue.

- *Improving transmission time*

C-SLANT files transmitted by E-mail are subject to two potentially significant delays: (1) the delay due to the queuing of the E-mail system itself, and (2) the delay due to the bandwidth of the communication's connection relative to the size of the C-SLANT message. The first problem could be addressed by using a more direct connection. The second problem could be reduced by only sending changes to a message or by streaming message components. Solutions to these problems are discussed in more detail below:

1. Immediate file transfers

A peer-to-peer environment could be created, if for instance two parties both ran FTP (File Transfer Protocol) client and server software. The advantage in doing that would be the message could be sent more directly between the machines and therefore normally more quickly, but the disadvantage would be the lack of the inherent queuing capability of E-mail systems, (which means both parties don't need to have a connection established before the communication can begin). If a peer-to-peer environment were highly desirable and queuing were not required, FTP client and server functionality could also be built into C-SLANT, which should make the process less cumbersome for the user than using separate FTP applications.
Another way to speed up the file transfer would be to use a messenger program like Microsoft's MSN Messenger or Yahoo Messenger to transfer the file through that system. This approach might also facilitate switching between asynchronous and synchronous communication modes when both parties agree.

2. A better E-mail based system

Assuming the E-mail systems used provide a sufficiently responsive service, but the time to send a C-SLANT message is more a problem because of the file size itself, C-SLANT could be modified to not send message components to a recipient who should already have them. For instance, if person A creates a message and sends it to person B, and the message components, such as a voice and pointing segment or an image are given unique machine: component identification tags, the system should realize there is no need for B to send A's original content back to A.

3. A Web based version of C-SLANT

A Web based version of C-SLANT would have a number of advantages over the current version:

- Messages could be managed on the web server and potentially be made accessible to anyone on the Internet. This might be particularly appropriate when messages could usefully be shared by groups of people with a common interest. Thus, for instance, there could be a Web page for each of the FAA Enroute Centers;
  - The audio portion of the recorded voice and pointing could be streamed, reducing the transfer time;
  - If the underlying format for a slide was changed to SMIL (Synchronized Multimedia Integration Language[17]), it would be playable by any SMIL player, although for creating new slides and for providing the full set of C-SLANT functions an SMIL based version of C-SLANT would be necessary.

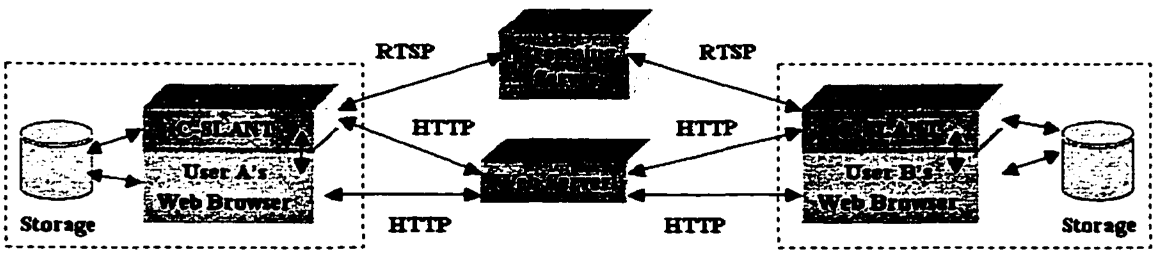

Figure 7.24 C-SLANT asynchronous communications via the Web

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[17] Defined at: http://www.w3.org/TR/REC-smil/

The basic architecture for a Web based implementation of C-SLANT is shown in Figure 7.24. In this particular scenario a separate server is dedicated to providing Real Time Streaming Protocol (RTSP) service, for efficiently streaming audio, and an HTTP (Hypertext Transfer Protocol) service is provided separately for all other objects on a Web page.

- *Developing a platform independent system*

C-SLANT will only run on Microsoft Window's machines, which excludes potential users who have, for instance, Unix or Macintosh computers. A Java based version of C-SLANT would not have this problem, because its code would be compiled to produce Java Virtual Machine code, which would then be translated to the machine language of a particular computer by a platform specific translator. This is shown in Figure 7.25.

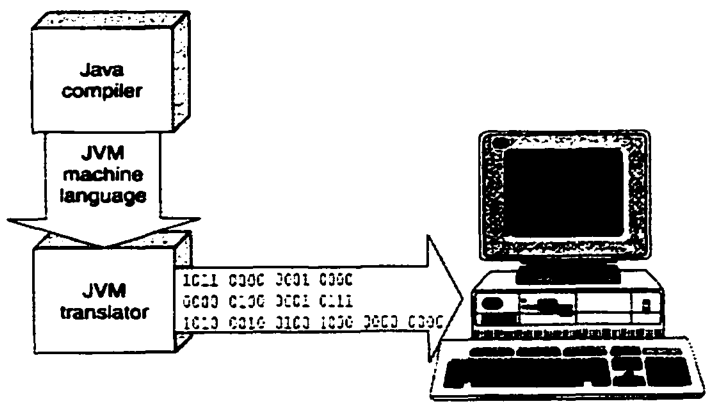

Figure 7.25 Java based applications (adapted from Slack, 2000)

CHAPTER 8

SUMMARY AND CONCLUSIONS

Introduction

In this chapter the most significant research findings are summarized and discussed. The context of the research is also noted and used in combination with the results to consider the application of the findings presented.

Summary of results

The most significant results are organized into two sections: (1) the problem solving summary focuses on the most tangible results for the overall collaborative task of identifying applicable strategies to improve performance; and (2) the context referencing summary focuses on results related to the fundamental design goal of supporting asynchronous communications rich in context, based on the theory that doing so would lead to more effective communications.

Problem solving summary

- *The communication mode failed to demonstrate a significant difference in the number of ideas for improving performance generated by dispatchers*

It was decided a priori that the number of dispatcher questions asked would be a useful measure in the analysis of the collaborative problem solving because, in general, it was assumed more questions would lead to more feedback for the issues raised by dispatchers. In analyzing the comments made by dispatchers it was determined there were 42 questions asked by participants working in the text mode and 11 in the voice and pointing mode. Further analysis revealed that the majority of these questions could be classified as semantically equivalent to one of three question types: *Why is X happening to our flight(s)? Was the problem caused by Y?* and *Would doing Z help?* The 42 questions asked by dispatchers in the text mode were divided into each category and the count was 10, 12 and 16 respectively, with 4 questions that could not be classified as one of these three types. Similarly, the voice and pointing mode produced 5, 2, and 4 questions of each type respectively. Particular attention was given to the third type of question and while the number of *Would doing Z help?* questions was greater in the text mode, when the number of performance improving ideas was counted for dispatchers in the form of a question and not in the form of a question (typically stated as a hypothesis such as "A different preferred route in bad weather might help"), 27 were found in the text mode and 29 in the voice and pointing mode as was shown in Table 7.6. (A list of these ideas are shown in Appendix F.). Thus from a pragmatic perspective there was no significant difference detected if they were responded to similarly. Further analysis revealed that normally that was the case.

Problem	Text Mode	Voice and Pointing Mode
ZNY	4, 2	3, 1
ZOB	2, 3	3, 1
ZID	0, 2	0, 1
ZTL	2, 1	2, 7
ZFW	1, 1	2, 2
ZBW	1, 0	1, 1
ZDC	1, 2	0, 2
ZMP-1	2, 2	1, 1
ZMP-2	1, 0	1, 0
Total	27	29

Table 7.6 Number of dispatcher ideas for performance improvement

- *Almost all the dispatchers' ideas were responded to by traffic managers in both modes*

	Direct questions	Other form
Text mode	16/16	11/11
Voice & pointing	4/4	23/25

Table 7.15 Count of the performance improving ideas responded to by the traffic manager

As Table 7.15 showed, all the dispatchers' ideas presented in the form of a direct question were responded to by the corresponding traffic managers. Almost all the ideas not presented in the form of a question were also responded to: 11/11 for the text mode dispatchers and 21/23 for the voice and pointing mode dispatchers. The two ideas that were not responded to were "A delay program could have helped to improve spacing" (in the ZTL scenario) and "Another solution might be to fly at different altitudes" (in the ZOB scenario). The difference between modes for the number of ideas in a non-question form is not statistically significant, but the fact that 2 out of 15 dispatchers who raised issues regarding performance improvement did not receive a response to all of them may be enough evidence to warrant attention to this potential problem when considering environments were greater memory or attention demands are involved for the recipient of a voice and pointing based message.

- *The mode did not impact the performance improving strategies presented*

Category	Dispatchers		Traffic Managers	
	T	VP	T	VP
A. New preflight route	11	9	9	10
B. Enroute reroute	2	3	2	0
C. Change schedule	1	1	7	3
D. Ground delay/stop	3	4	1	1
E. Same route but miles in trail	0	1	0	0
F. Change Center staffs' workload / traffic volume	2	0	0	0
G. Share information for planning (fuel burn, filed route, etc.)	3	3	0	1
H. Hold at a different location	1	1	0	1
I. Change altitude	2	2	0	0
J. Fix balancing	0	1	0	0
K. Other	0	1	0	0
Totals:	25	26	19	16

Table 7.16 Classification of dispatcher and traffic manager ideas regarding performance improvement

As Table 7.16 showed, the type of idea the dispatchers had was also found to not be dependent on the mode, and in both cases changing the route was produced as an idea more often than other ideas such as changing the schedule, or the altitude for some segment of the route.

Scenario	Text Mode		Voice and Pointing Mode	
ZNY	aA, rB, rG, rF, nB	aA, aB	rA, rB, rD	rH
ZOB	rD, rH, n(ref)H	a2A, rI, nA	a2A, mI, nC	aA
ZID	(Leave as is)	ref(G), (ref)I	n(ref)A	rA(Leave as is)
ZTL	rD, rG, nA, nC	rA	rG, rK, nA	rG, aA, rJ, aA, aC, mD
ZFW	aA	aA, nC	rA, aA	rB, aA, n(ref)G
ZBW	rD	nC	rA(Leave as is)	rD
ZDC	aA, nC	aA, rA, n(ref)A	nA	rE, rA, n2A
ZMP-1	aC, rA, nA	rA, rF	aD, n2A, nC	rB
ZMP-2	aA, nC	nC, nD	rG	(none)
Totals:	a = 11 ; r = 14 ; n = 11 ; m = 0		a = 9; r = 18; n = 10; m = 2	

Table 7.17 Classification of communications outcome with respect to ideas for improving performance
(a: accepted; r: rejected; n: new idea; m: no response. (ref): referred to another center or military airspace manager. Classification of ideas A-K shown in Figure 7.16)

Table 7.17 summarized the traffic managers responses relative to the type of strategies the dispatchers proposed. The table reveals no detectable differences between the distribution across the ideas rejected, accepted, added and missed by the traffic managers (i.e. 11, 14, 11, and 0 versus 9, 18, 10, and 2, respectively).

- *Dispatchers took longer to create a message in the text mode than the voice and pointing mode*

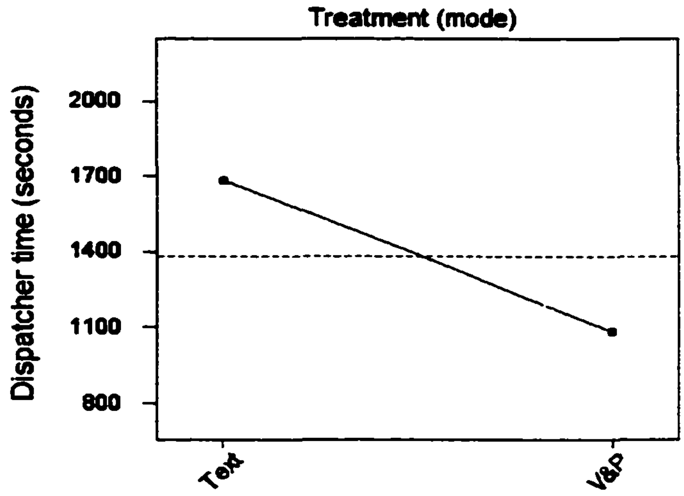

Figure 8.1 Main effect of the mode on dispatcher time (adapted from Figure 7.4)

Figure 8.1 shows the main effect of the mode for dispatchers task time. The average task times were 18 minutes 1 second (1081 seconds) for the voice and pointing mode and 28 minutes (1680 seconds) for the text mode. This is a difference of 9 minutes 59 seconds or 55%. Because it was unusual for dispatchers to playback their own recordings or rerecord them much of this time difference can be accounted for by the difference between typing and modifying comments versus making a voice and pointing recording.

- *The combined task time was longer for participants working in the text mode than the voice and pointing mode*

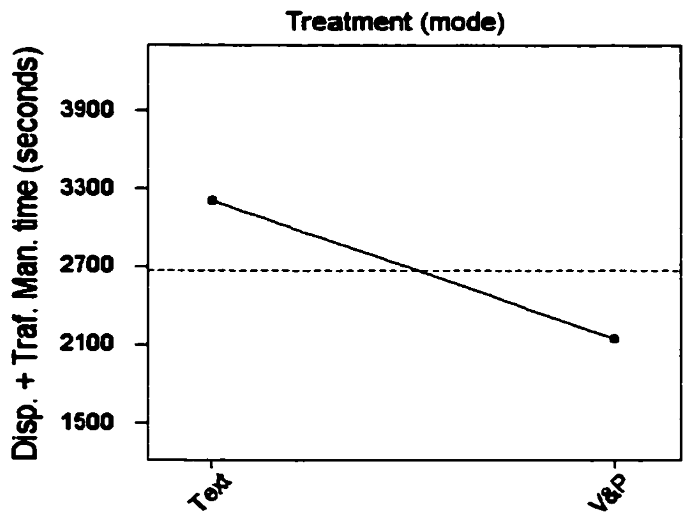

Figure 8.2 Main effect of the mode on dispatcher+traffic manager time (adapted from Figure 7.11)

Even though voice and pointing mode traffic managers had to listen to the dispatchers comments, rather than read them, and listening is generally performed slower than reading, Figure 8.2 shows the main effect for the dispatcher + traffic manager task time increased from the dispatcher's time shown in Figure 8.1 in absolute terms. The average task times were 35 minutes and 41 seconds (2141 seconds) for the voice and pointing mode and 53 minutes and 22 seconds (3202 seconds) for the text mode. This is a difference of 17 minutes 41 seconds or 50%.

Thus, the task time was less in the voice and pointing mode, even though the performance in terms of generating applicable strategies for improving performance was very similar. This is consistent with the study by Chapanis (1975), Neuwirth (1994), and Daly-Jones et al., (1997) who all found efficiency benefits from voice or voice and pointing over text based communications.

Context referencing summary

The design of C-SLANT included three features primarily intended to help provide context to the comments message creators would make: (1) the context framing images forming the slide shows; (2) the voice and pointing recorder which can capture context for the comments by connecting them dynamically to individual locations or sequences of locations in the image; and (3) the static annotations using the arrow marker and pen to help focus attention as the comments are interpreted. Analysis of the messages created revealed two other important dimensions of context: (1) the context created through the comments made themselves; and (2) the temporal context as comments placed on the slides in a particular order during the dispatchers' problem solving / message creation process and, comments were made by traffic managers in a particular order during their interpretation of dispatcher comments / problem solving / message creation process.

- *Dispatchers normally did not introduce the flights with some basic classifying data defining the situation*

Category	Dispatcher Text Mode	Dispatcher Voice & Pointing Mode
City pair	5/18	11/18
Time of day	1/18	4/18
Time of year	0/18	5/18
Number of flights involved	1/18	4/18

Table 7.4 Number of dispatchers mentioning certain flight classifying data

Some basic data defining the situation (the city pair; time of day; time of year; and number of flights involved) was not normally introduced by dispatchers as was shown in Table 7.4. This suggests that in most cases the combination of the information on the slides and their mental model of how the traffic managers would proceed through the task caused them to predict the traffic managers would make note of the information without any verbal prompts from the dispatcher. However, there were instances were not noticing this information caused the participants to indicate it was difficult to determine what was happening to the flights under consideration, suggesting its salience is an important issue. There was also a difference between the two modes in this regard, with more dispatchers mentioning each of these categories in the voice and pointing mode (although only the difference between the number mentioning the city pair and time of year were statistically significant at $\alpha < 0.05$). The reason for this difference could simply be the relative ease with which comments can be made with speech or possibly that a different schema is activated and more of a "story-telling" process is used which begins by "setting the scene".

- *Almost all voice and pointing mode participants made deictic references while speaking*

	Dispatchers	Traffic managers
Participants making deictic gestures	18/18	17/18

Table 7.19 Count of voice and pointing mode participants making deictic gestures

As Table 7.19 showed, all 18 dispatchers working in the voice and pointing mode made deictic gestures, and 17 of the 18 traffic managers working in the voice and pointing mode made deictic gestures. These participants didn't point continuously, but the locations of various objects verbally described were made explicit with synchronized pointing. This reduced ambiguity in some cases because of ambiguity in the language (such as "a northern route") and in others because the recipient would not have the knowledge to know where a named location is (e.g. holding at Scupp). This synchronized pointing also helped identify verbal slips and errors. In some cases participants created negative effects in this mode, by not keeping the pointer motionless when speaking about topics that were not related directly to information on the slides, or by producing noticeably slowed speech as they used other annotation tools while speaking.

(although this should be qualified with the fact they were novice users of C-SLANT). Thus the value of pointing is certainly a function of (1) the comments made; (2) the synchronization; and (3) the knowledge of the recipient.

- *Participants working in the voice and pointing mode still created static annotations*

Scenario	Dispatcher		Traffic manager	
	Text	V & P	Text	V & P
ZNY	5, 21	0, 6	0, 10	0, 0
ZOB	5, 12	0, 5	0, 0	0, 19
ZID	3, 5	0, 11	0, 0	3, 1
ZTL	2, 14	30, 12	0, 1	4, 17
ZFW	0, 1	17, 1	0, 0	0, 10
ZBW	9, 33	3, 2	0, 0	0, 0
ZDC	2, 3	7, 7	2, 0	0, 31
ZMP1	6, 17	15, 1	3, 0	10, 0
ZMP2	9, 14	7, 14	0, 1	8, 0
Average	8.94	7.67	0.94	5.72

Table 7.25 Number of pen or arrow annotations per slide show

As Table 7.25 showed, 17 dispatchers working in the text mode and 15 dispatchers working in the voice and pointing mode created pen or arrow marks. The difference between traffic managers was greater, with 5 traffic managers working in the text mode creating pen or arrow marks and 9 traffic managers working in the voice and pointing mode creating pen or arrow marks . This suggests the voice and pointing mode participants felt it valuable to leave a static annotation on the slide and they found it valuable to capture the pointing/drawing dynamics as these static annotations were created (although these would be limited because the static annotations are not recreated dynamically during playback - just the movement of the pointer is), or they forgot how limited the capturing of the dynamics was.

- *Voice and pointing mode participants created static annotations while speaking*

	Dispatchers	Traffic Managers	Dispatchers and Traffic Managers
Voice and pointing mode	9/15	9/9	6/9

Table 7.24 Participants that made arrow or pen mark annotations while speaking

At Table 7.24 showed, 9 of the 15 dispatchers who created pen or arrow marks created them while recording their speech and all 9 traffic managers who created pen or arrow marks created them while recording their speech. This suggests they tended to feel the simultaneous tasks manageable and the results acceptable for the recipient (because both the effect of annotating while speaking and not were included in the training, and none changed to not performing the tasks simultaneously after starting simultaneously).

- *The slide image provided a context for comments, but the slide show structure created context problems*

Two types of problem were caused by the slide show structure used in C-SLANT: (1) temporal context problems; (2) multiple-slide perspective problems.

A loss of temporal context occurred either because the participant created comments out of order (relative to the slides) or because, in the case of the traffic managers, responses were created on one slide before reading the comments made by the dispatcher on a later slide. This sometimes created inefficient commenting as the traffic manager repeated or corrected previous comments when reaching the later comments. To avoid this situation the respondent needs more encouragement to parse the slide in two stages: a high-level parse first to learn the main points made, followed by a low-level one to work with the details.

Participants sometimes refer to multiple slides at once with a comment when, for instance, addressing a common issue or performing juxtaposition, but because of the single slide perspective of the versions of C-SLANT used in the experiment these comments were only made on the slide in a one-to-one relationship and not the one-to-many relationship that was needed. Thus, the limited 'parcel post model' (Tarter et al., 1991), mentioned in Chapter 2, was actually implemented again here.

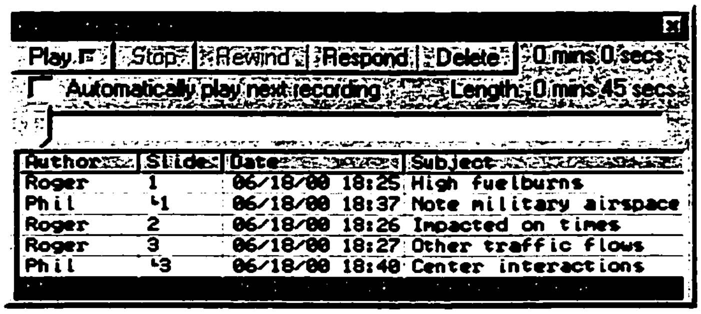

Figure 7.20 C-SLANT's recordings window

Perhaps the most significant redesign of C-SLANT that occurred as this research was conducted was the creation of a "recordings window" as was shown in Figure 7.20. This feature was actually implemented and provides an overarching structure for showing where the recordings took place and what the relationship is between recordings. Further modification of the implementation could support recording across multiple slides to obtain the one-to-many relationships needed and also support a textbox as a format that could be used as an alternative to a recording in the table of linked comments.

- *The comments made provide a vocabulary of syntax and semantics for a more task specific version of the system*

The use of POET images and C-SLANT combine a context specific application that represents information with graphics and tables with an image based asynchronous communications tool. C-SLANT is not an aviation specific application although its uses with POET was the priority as it was developed. As demonstrated in Table 7.29, the data collected here revealed a vocabulary of syntax and semantics that could be used to help design more task specific annotation tools for C-SLANT and/or which could be used to modify the interface of POET. If changes are made in C-SLANT to achieve this, they could be implemented using a template/configuration file to maintain the generic integrity of the system. The structured interview responses made by the ZNY TMO who used C-SLANT for several months after the study to evaluate it demonstrated that value could be seen by using it in combination with POET, but also in combination with other applications such as the CCFP (Collaborative Convective Forecast Product). In that case a different set of annotations could be developed after analysis of communications using a generic set first as was done in the research reported here.

Conclusions

In this section the research context for the results reported here is described and the application of these results considered.

Research context summary

While considering the results presented here it is important that the context of this research be noted to provide some control and guidance for extrapolation, given the design choices that were made. The participants used a particular software application and dataset and although the study was relatively authentic, within practical constraints and the goal of having control of certain parameters for experimental design reasons, it was not a naturalistic study.

Task	**Two person collaborative problem solving to identify strategies for improving performance**
Data format	**Maps, tables, and statistical graphs detailing past performance**
Communications format	**Images annotated with pen marks, and arrow marks, plus voice and pointing or text for comments**
Navigation structure	**Slide show based**
Communications time-space	**Different time (asynchronous) with 2 iterations, different place**
Poor performance indicators	**Tabular data values, patterns in analog images, and patterns in statistical data**
Knowledge distribution	**Heterogeneous and homogeneous**
Authority distribution	**Heterogeneous**

Table 8.1 Research context summary

As stated in Table 8.1, the task was a two person collaborative problem solving task. As the comments made indicated another Center was sometimes referred to by traffic managers as being appropriate for the dispatcher to contact for further discussion of an idea for improving performance. There might also be situations where the next stage for the pair would be to contact representatives from all airlines involved in a traffic problem or several neighboring Centers to check the feasibility of an idea. Such an idea might be, for instance, changing a filed route to one that passed through a different set of Centers or changing the schedule of flights during a rush period. Including more people in the same context would mean the identification of each person's comments and annotations would be more important, as would the need for clear temporal frames of reference. Content summaries would also be more valuable to allow scanning to refresh memory and preview topics. The redesign ideas presented in the last chapter address these issues. The fact there were 2 "rounds" of message sending also should be noted. Supporting more iterations is somewhat similar to supporting more people, but the temporal context becomes particularly important. The number of iterations that would occur in reality would be impacted by the fact that the collaborative problem solving doesn't necessarily have to occur with C-SLANT as the only communications tool. Variations on this might be, for instance, to have one or more exchanges via C-SLANT followed by a telephone call or other synchronous communication to complete the process. Another approach might be in initial synchronous communication followed by asynchronous communications as communicators follow up by gathering information and discussing it. The goal would be to support both types of communication well and also the transitions between them.

The task of identifying strategies for improving performance in this case involved participants predicting what would happen to the NAS by changing some actions one or more agents performs, based on the data displayed and their own knowledge. In a more natural environment they would have supplemented this information with images or comments representing knowledge they acquired during the problem solving from other sources. They might even use some other planning application to make predictions and include the results in their responses. This would make the time slides were added and removed important information.

In terms of the results presented here it may mean that a significant change in the image type means some of the results are less applicable. Largely text-based data, versus largely map based data would change the relationship between the comments made and the image in that more accurate reference to geographical locations, aviation specific events, and sequences of locations forming a flight path, would not be the primary benefit from pointing, but literal text and interpretations of text would be. However, there are still common "primitive" costs and benefits of voice and pointing based comments, such as controlling attention to specific positions as comments are made and the fact the comments themselves are "invisible" unless repeated or summarized in a text form.

The distribution of authority/control is heterogeneous in that they each have control over different agents and processes in the system. However, when speaking of possible changes to the route filed or flown the traffic manager can speak to what is realistically likely to be approved and so it is perhaps not surprising most of the questions were asked by dispatchers and the traffic manager tended to be giving "advice" for what was possible and not possible. A different relationship between participants, for instance, two traffic managers at neighboring Centers would perhaps involve a more balanced number of questions, but there is no obvious reason to think this change would have no impact on the difference between the voice and pointing and text modes.

The distribution of knowledge is shown as both homogeneous and heterogeneous in Table 8.1. These groups of participants were both professionals in the aviation industry with a similar distribution of years experience as shown in the questionnaire results, and both groups work with flights to coordinate/manage them and therefore there is a basic knowledge they will have in common (e.g. the names of fixes, the general areas of very high traffic density, such as the New York area and the potential impact of weather on individual flights). However, their perspective and experience is also different with the dispatcher having less knowledge of the cumulative effect from all airlines sending traffic through a particular Center as scheduled and the events that trigger certain actions by the traffic manager, or which are automated in the system through technologies, and the traffic manager does not fully understand the reasoning the dispatcher uses when flight planning. These knowledge similarities and differences affects the language that can be used and understood without explanation, and also the value of pointing to connect comments to locations if the listener can't do that without that information being made explicit. The knowledge gap affects the value of pointing and it seems reasonable to conclude the perceived knowledge gap impacts the language used and the pointing. In a synchronized communications situation the feedback for comments made would occur more quickly, so this perception could more easily be modified as the communication continues in a process to achieve common ground (Clark and Brennan, 1991).

Application of this research

A number of factors contribute to the successful introduction and continued use of a system as described, for instance, by Neilson (1993) and summarized in Figure 8.3. In this case the contribution of certain factors was measured for two versions of the system to learn more about their effect in each mode for this system and more generally for systems of this kind. The majority of the data collected in this research was performance data, but a questionnaire was also used to gather information to supplement this data.

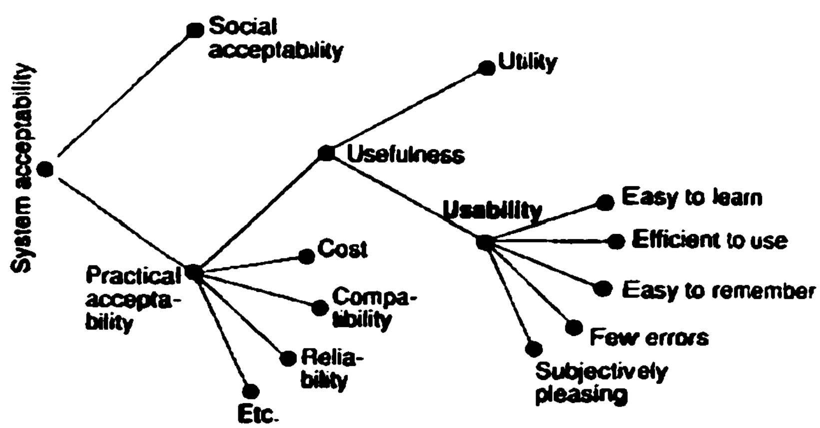

Figure 8.3 Factors influencing system acceptability (Neilson, 1993)

Table 7.37 and Table 7.38 summarized the participants ratings regarding usability and utility of the version of the system they used and in general the ratings were positive for both modes by all participants.

Question: On the following scale, please indicate how easy/difficult you found this software to use?					
Results	*Very easy*	*Easy*	*Neutral*	*Difficult*	*Very difficult*
Text mode dispatchers	8	7	2	0	0
Voice & pointing dispatchers	2	11	4	0	0
Text mode traffic managers	8	8	1	0	0
Voice & pointing traffic managers	12	6	0	0	0

Table 7.37 Perceived usability of C-SLANT

Question: On the following scale, please indicate how useful you think this kind of software might be in your job?					
Results	*Not useful at all*	*Not very useful*	*Neutral*	*Fairly useful*	*Very useful*
Text mode dispatchers	0	0	2	9	6
Voice & pointing dispatchers	0	3	3	9	2
Text mode traffic managers	0	1	4	8	4
Voice & pointing traffic managers	0	0	2	4	12

Table 7.38 Perceived utility of C-SLANT

Social acceptability might be an issue for the voice and pointing mode in some work situations where the users could not record or listen to the recordings because of auditory demands in that workplace. In this case audio communications, and further the recording of audio communications, is socially commonplace. The utility of the system in each mode was ultimately measured by the number of performance improving ideas that were generated and evaluated. The performance was the same in each mode in this regard. It took approximately the same amount of time to train the participants how to interpret the POET screen captures and use each version of C-SLANT and users in both modes asked very few questions, if any, with regard to the operation of the system. Some users did not keep the pointer motionless while speaking about something not on a slide and users often left windows covering data. These "habits" could be reduced or removed with experience using the system or formal training. In addition the redesign ideas presented in the last chapter may reduce or eliminate these problems. The quality of the comments in terms of their efficiency was not evaluated in detail, but there were incidents of redundancy and inconsistencies across slides, which was due to the largely single-slide perspective given to users and the sequential processing of data performed by users. Some redesign ideas to address this problem were also presented in the previous chapter. The problem of not being able to scan audio comments at a semantic level and edit audio comments easily also reduced the quality of some of the comments made as participants sometimes created redundant or inconsistent comments within the same slide. It is difficult to determine when the participants were aware of these problems, and when they were it may be they decided the points were still made sufficiently clearly and that this was more analogous to a relatively casual recording on an answering machine than a formal presentation of ideas that may ultimately be distributed widely. Even so, redesign ideas were presented in the last chapter to address the problem of making it easier to edit recordings and to make the semantics more visible. The efficiency was measured carefully in terms of the time taken to complete the task and the task time was shorter for the voice and pointing mode by 55% for dispatchers and 50% for dispatcher-traffic manager pairs.

What is an error is open to interpretation, but as has been discussed there were incidents of verbal slips during deictic gesturing, unnecessary covering of important data with windows before sending a message, misreading and non-reading of relevant POET data, incorrect reasoning that weather data was necessary to make deductions, and redundancy or inconsistency in the comments made. These errors provided feedback for redesigning C-SLANT or POET, and for training of participants who might be involved in communications like this. A number of redesign ideas were presented in the last chapter which assumed both the voice and pointing mode and text mode should be supported. The question may be asked, however, as to whether it is necessary to support the voice and pointing mode given that the same number and type of ideas were generated in each mode by dispatchers and the responses by traffic managers were similar in terms of the number of ideas responded to and added by traffic managers. As shown in Table 7.37 and Table 7.38 the "average" usability and utility ratings were higher by dispatchers working with the scenarios in the text mode than the voice and pointing mode. Further, the storage requirements are much higher for the voice and pointing mode, and scanning and editing or audio comments is more difficult. However, the results here show that the task time was shorter for participants working in the voice and pointing mode and the "average" usability and utility ratings were higher by traffic managers working in the voice and pointing mode. While redesign of the system to add more structure and visual summaries might eliminate the difference, using the version described here, dispatchers introduced more basic flight summary data on the first slide in the voice and pointing mode.

Further, other research reported in Chapter 3 provides evidence of advantages of voice or voice and pointing based communications over text-based communications. Chapanis (1975) conducted a much-referenced early study involving human cooperative problem solving and found that speech based communications involved many more words per minute than text based and that tasks were solved faster when speech was used. Faraday and Sutcliffe (1997) investigated attention and comprehension by users interacting with multimedia, and from this study a set of guidelines for controlling attention in multimedia presentations was produced, including: (1) the guideline to use object motion to control attention and viewing order, because participants' attention was drawn to motion and fixations tracked the moving objects path; and (2) the guideline that speech information should reinforce image, because propositions given only in the image or animation without speech cueing were poorly recalled. In this study they used a system that had popup annotations to link text to animation in the primary image, but this was created with a traditional authoring/programming system rather than a communications system, and that environment would be too complicated for the average communicator. Neuwirth et al. (1994) compared the nature and quantity of voice and written comments produced in each mode, and when reviewers gave feedback to writers they found: (1) reviewers used more words in voice than text mode during the same time period, but that the same number of annotations were made on average. The additional words were attributed in part to providing more reasons why the reviewers thought something was a problem and for polite language that mitigated the problem; and (2) evaluations of reviewers were less positive when reviewers produced written annotations than spoken. Daly-Jones et al. (1997) conducted a study where 'manager-secretary' pairs were asked to complete an asynchronous appointment-scheduling task and an equipment-booking task in three conditions : Fax-only involved using Microsoft Paintbrush ; voicefax involved using Lotus Screencam (an application that continuously records what is displayed on the user's monitor, including the mouse pointer, while synchronizing it to any speech input to create a 'movie' that includes any voice and pointing over the potentially dynamic images) with a Paintbrush image; and voice-only that involved just audio. For both sending and receiving, voicefax was rated most useful, then fax-only, then voice-only. Subject took the same amount of time to complete the tasks in each condition, but fewer messages were sent with voicefax.

To estimate how often the modes would be used when users are given a choice, eight dispatchers not involved in the main experiment described here were given slide shows to annotate using C-SLANT with no modes disabled. Four chose to use voice and pointing alone, three chose to use text alone, and one used both modes. This in combination with the results reported by Bargeron et al., (1999) and discussed in Chapter 3, who found that participants were as likely to use text to reply to audio annotations, as they were to use audio, supports the redesign idea for C-SLANT of not only allowing either text or voice and pointing mode comments to be made, but to allow one mode to be used as a response for the other.

Hardware and compression algorithm developments for computers and communications make voice and pointing based communications more practical today than it has ever been. However, while it is valuable to study differences between voice and pointing and text-based modes to understand them better, and support them effectively, it is not necessary to choose between voice and pointing and text when developing a system if they complement each other. In the context studied here it was determined there were some advantages with voice and pointing, but there is evidence some users would prefer to use a text-based mode. There were incidents of some undesirable pointing, and there was also some inefficiency due to the lack of visibility with the voice and pointing mode. One redesign idea presented to improve pointing was to support more recording and annotation options through mouse clicks. This however may be complex for the novice user. Another redesign idea was to use "text" to complement the voice and pointing, by supporting text labels and summaries to make critical information visible on individual slides and message structuring information visible across slides. Text comments can still be supported and included in the recordings window as an alternative to voice and pointing, and the corresponding text message would simply appear when the "play/display" button is pressed.

Supporting both modes means the user has the option to be sensitive to storage requirements, consider if audio is practical in the working environment, and depending upon how much pointing is involved, select that feature or not. Even if voice and pointing is mostly used, it may be beneficial to at least type important details that might be misheard, such as a series of fix names to describe a route, or numbers that require a lot of words when spoken. Certainly training could help provide guidance as to what the advantages and disadvantage there are for each mode and the kinds of errors that can occur, and the research presented here could be used to design such training. Users would also likely adapt with experience as they receive both positive and negative feedback, but training could ensure coverage of the important issues without relying on them occurring naturally and with cost when the feedback is negative.

The slide show structure used in C-SLANT has the advantage that it allows multiple context framing images to be structured in a conceptually simple aggregation, but navigation issues demonstrated here suggest it is important to provide an overarching structure that shows how comments have been placed across the slides with a clear temporal frame of reference. This would appear to be an important consideration for all systems involving slide shows, or for that matter hyperlink structures, as the underlying message structure for asynchronous communications.

Freestyle (Francik and Akagi, 1989; Francik et al., 1991; Francik 1996) developed in the late 1980's was perhaps the "grandfather" of deictic gesturing communications systems. It was innovative at that time with direct manipulation (Zielgler and Fahnrick, 1988; Shneiderman, 1998) combined with the direct referencing of deictic gesturing, but it did not survive to become part of today's popular software applications. The reasons are ultimately that the system was not "acceptable" at that time, in the targeted workplaces. Research on asynchronous deictic gesturing systems is very limited and such systems are also rarely used. For such systems to emerge and work well in the future it is essential to learn more about designing interfaces for these systems and to do so considering the context carefully. This research was intended to contribute to the specific goals in this domain, but also to contribute to the general application of systems such as C-SLANT.

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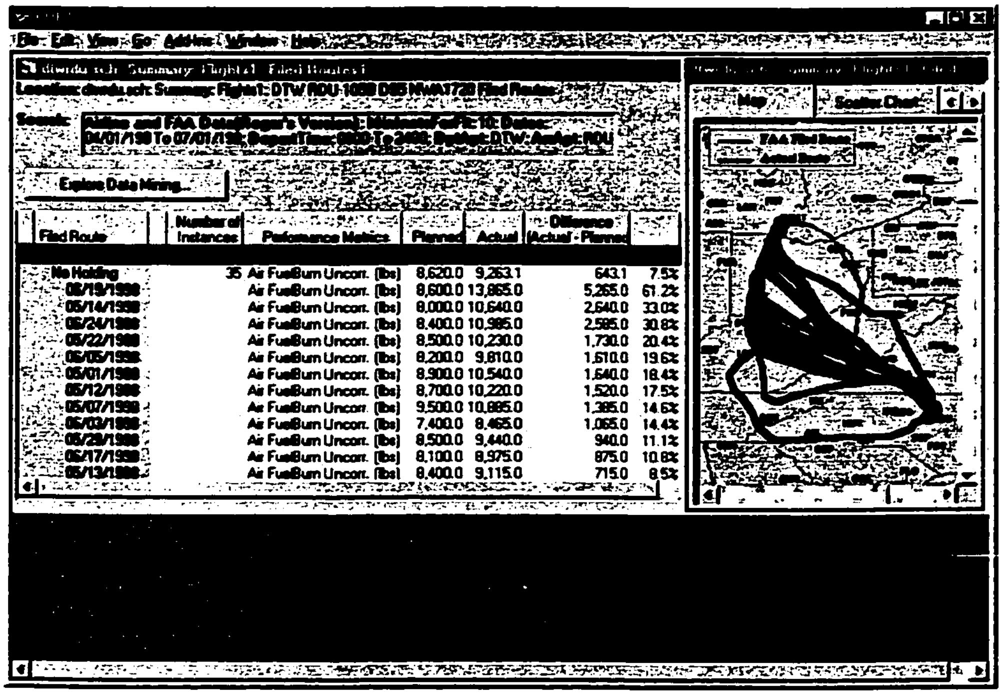
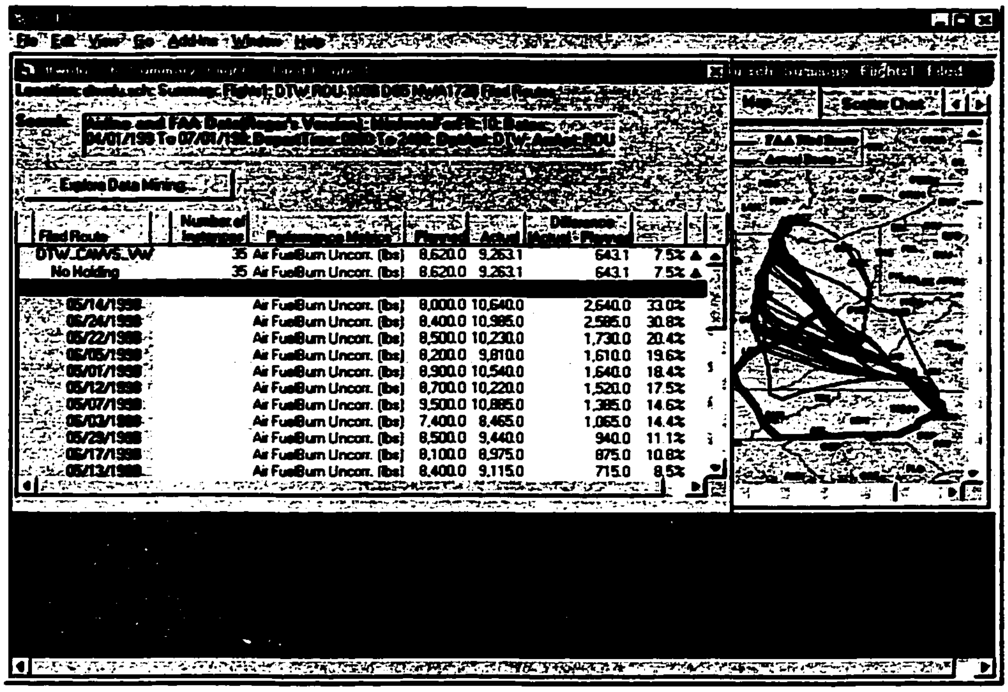
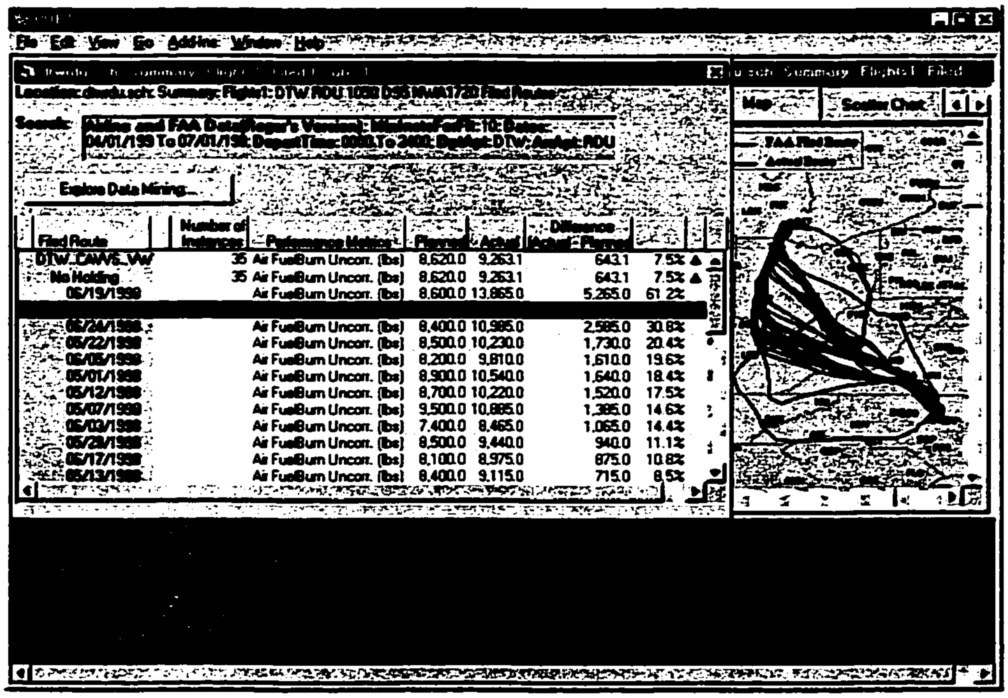
APPENDIX A. SLIDE SHOW SCENARIOS



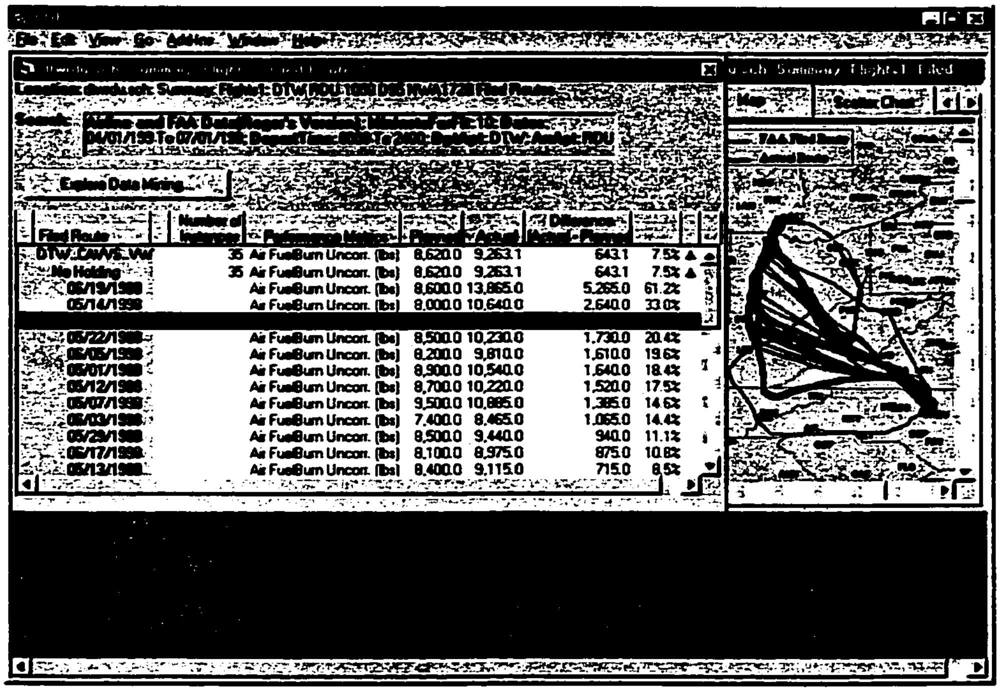
Appendix A.1 ZID: DTW to RDU Slide 1



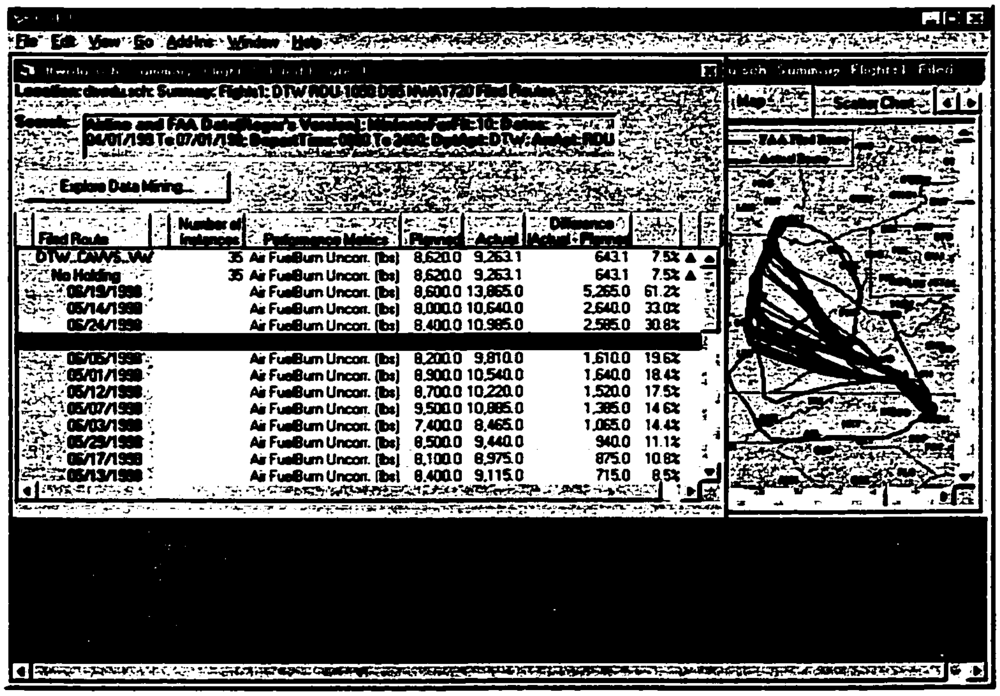
Appendix A.2 ZID: DTW to RDU Slide 2



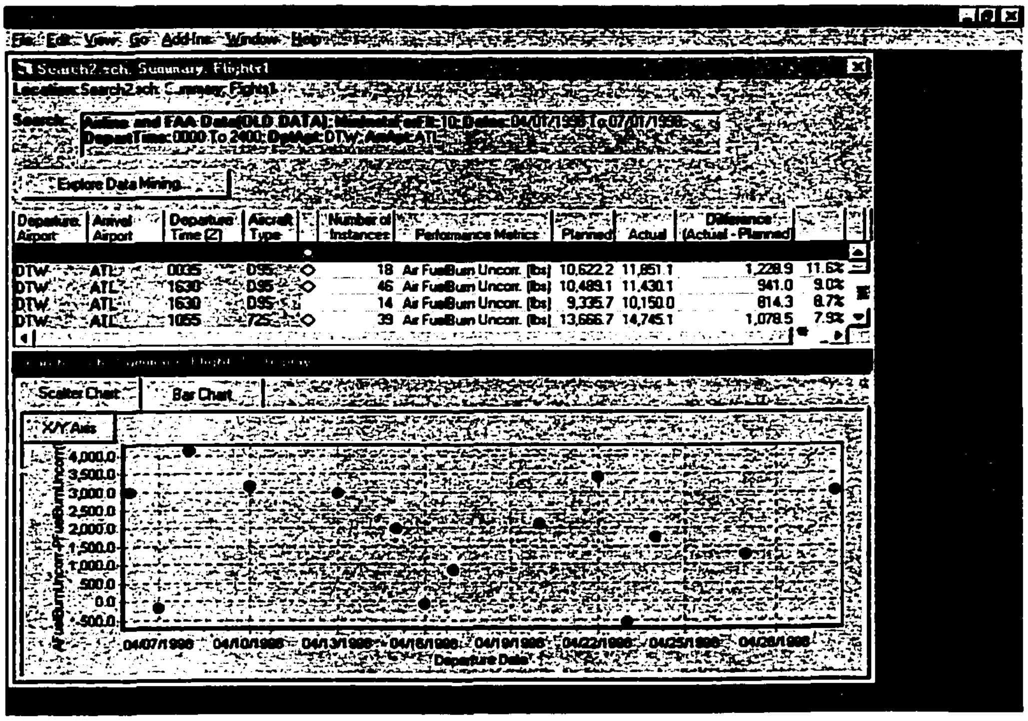
Appendix A.3 ZID: DTW to RDU Slide 3



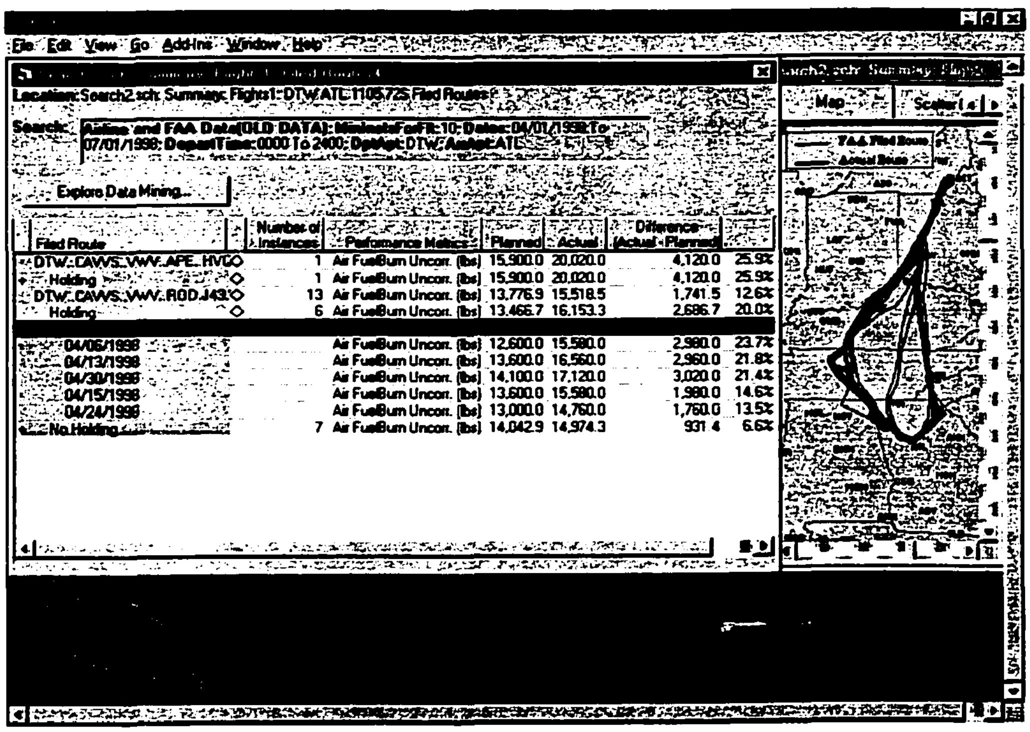
Appendix A.4 ZID: DTW to RDU Slide 4



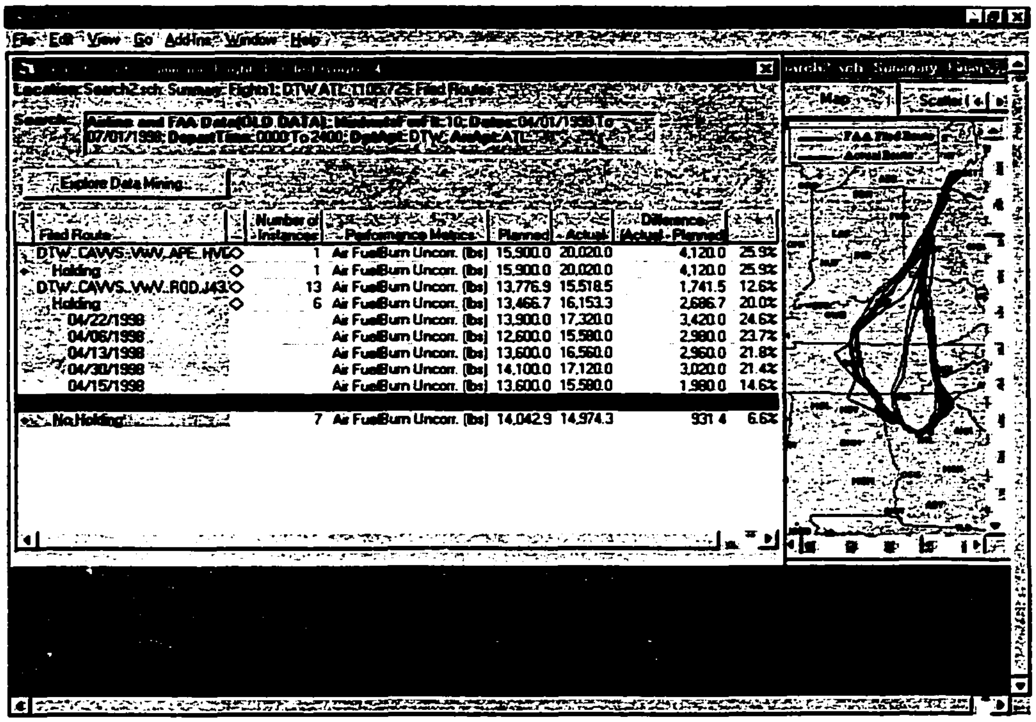
Appendix A.5 ZID: DTW to RDU Slide 5



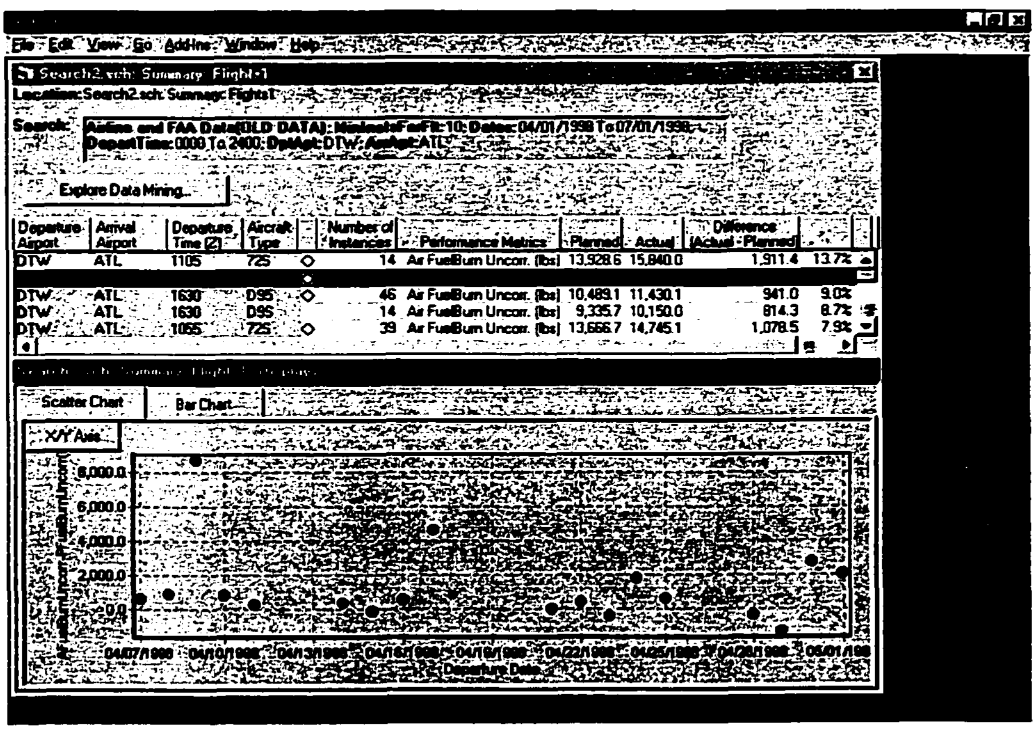
Appendix A.6 ZTL: DTW to ATL Slide 1



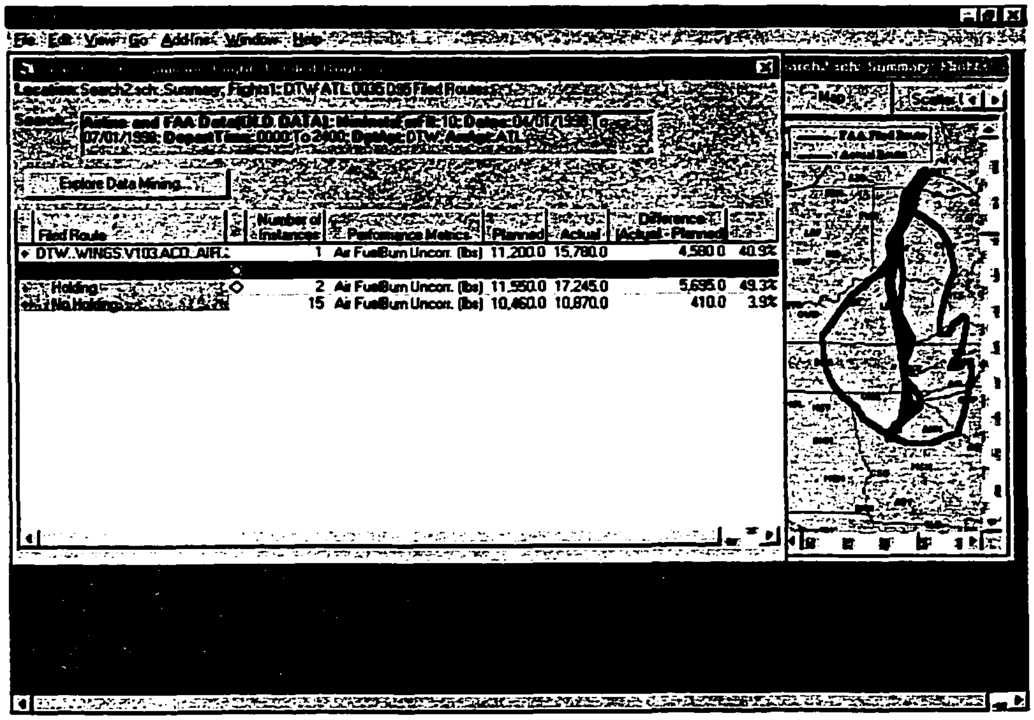
Appendix A.7 ZTL: DTW to ATL Slide 2



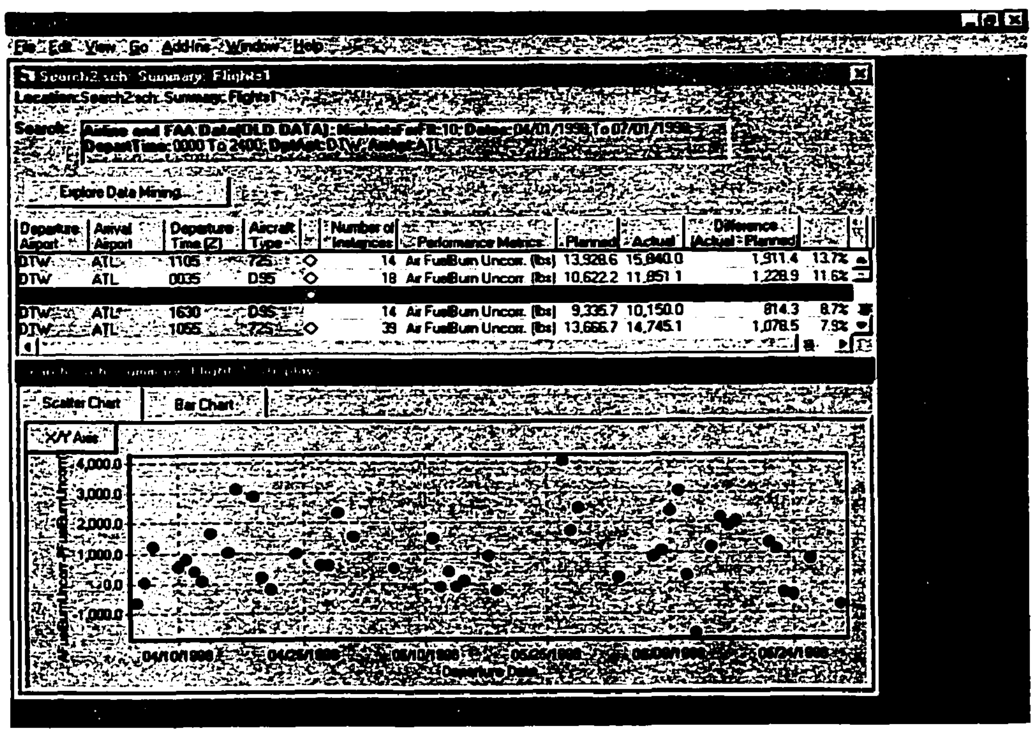
Appendix A.8 ZTL: DTW to ATL Slide 3



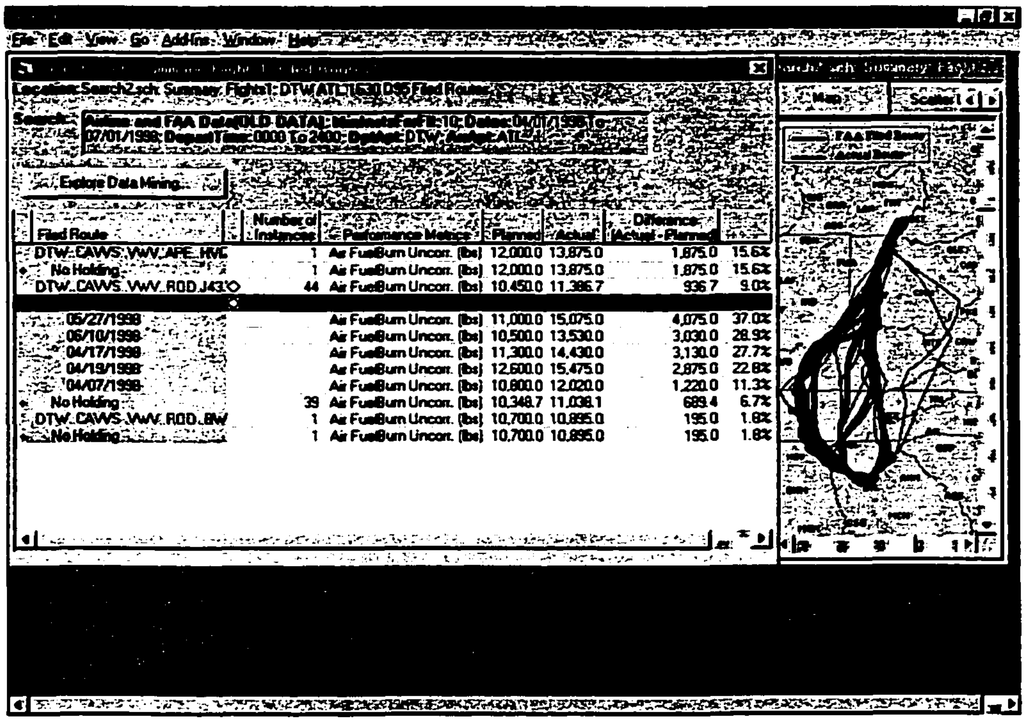
Appendix A.9 ZTL: DTW to ATL Slide 4



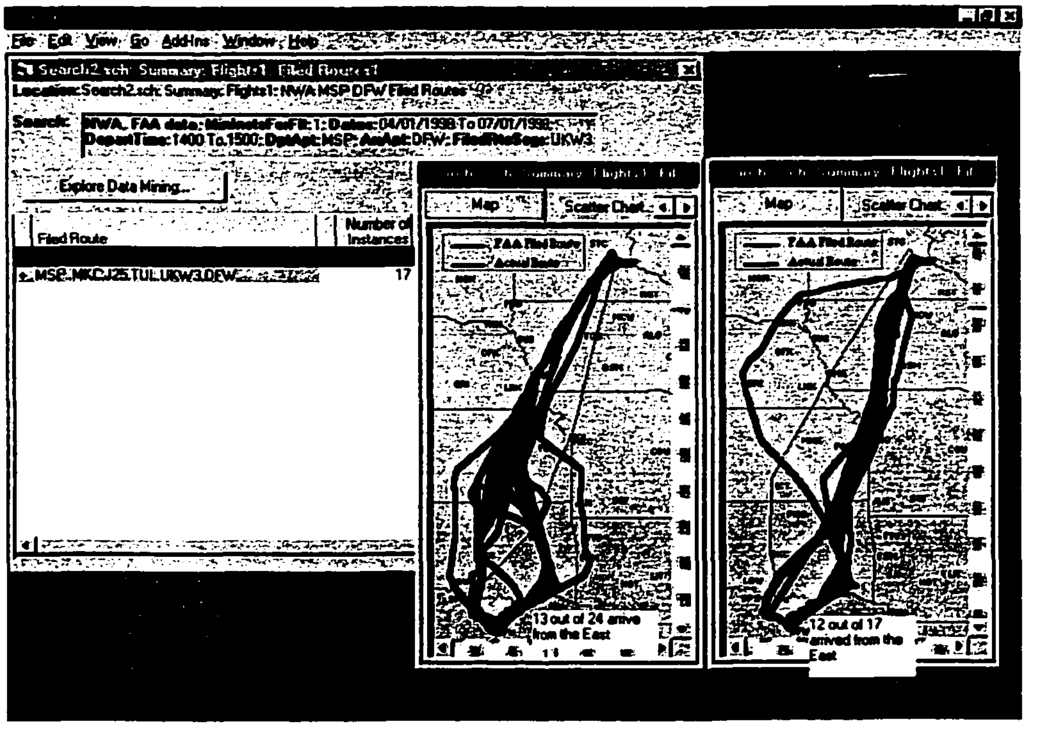
Appendix A.10 ZTL: DTW to ATL Slide 5



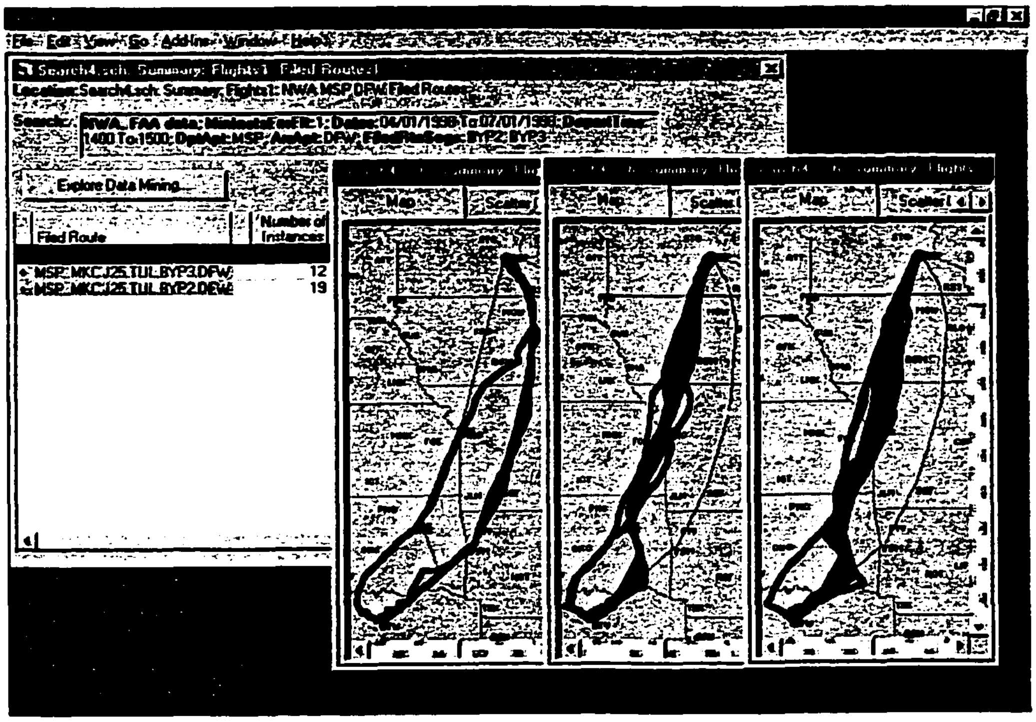
Appendix A.11 ZTL: DTW to ATL Slide 6



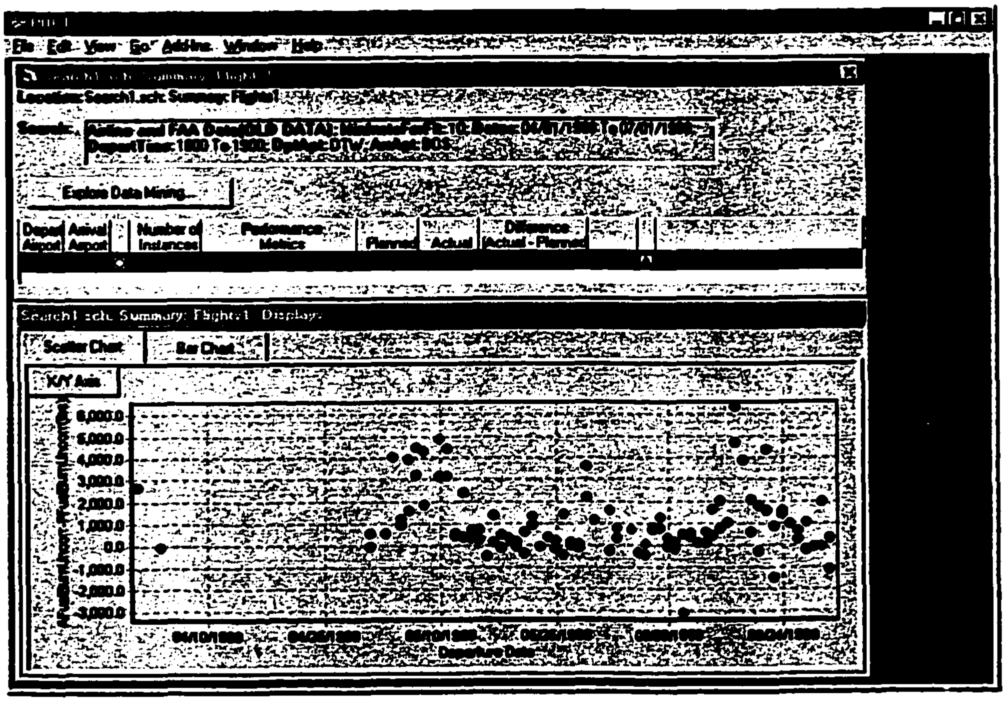
Appendix A.12 ZTL: DTW to ATL Slide 7



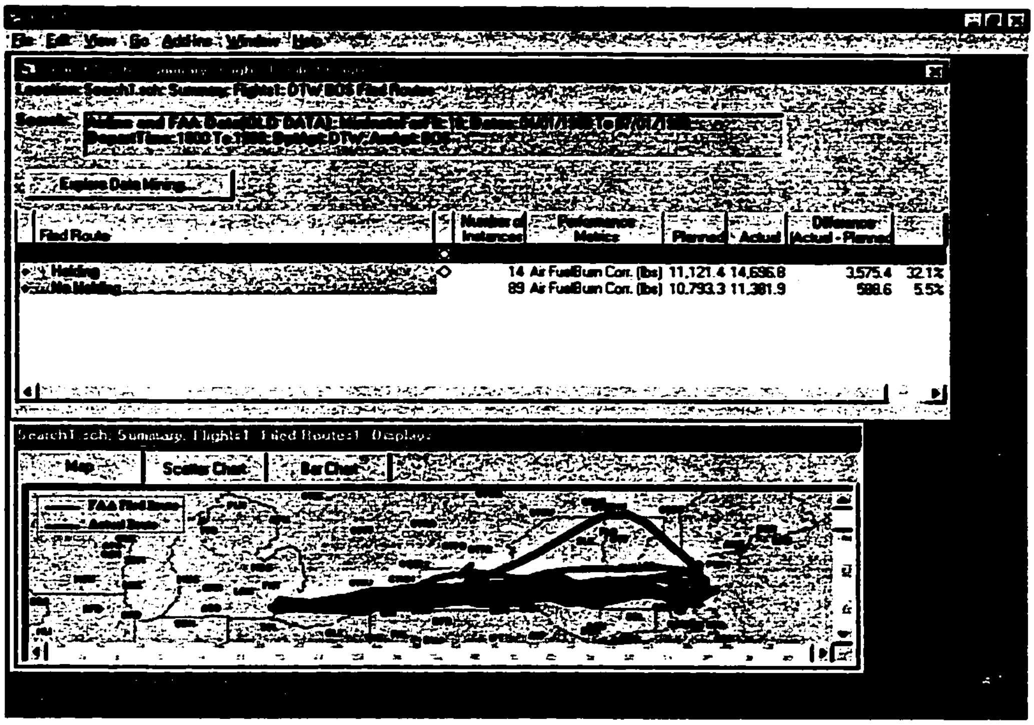
Appendix A.13 ZFW: MSP to DFW Slide 1



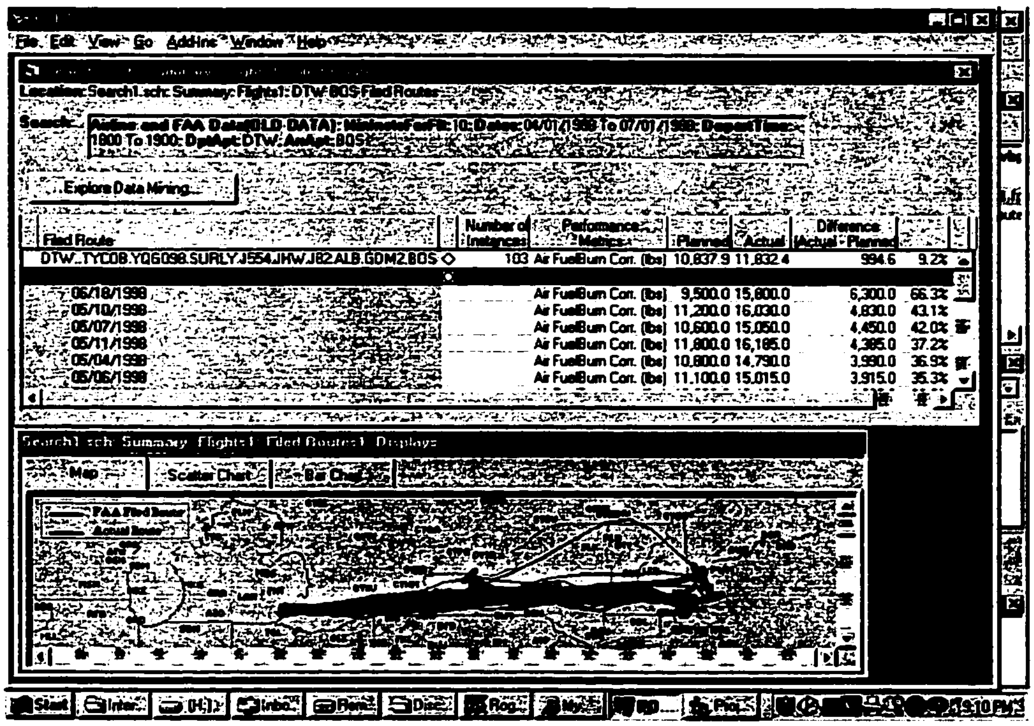
Appendix A.14 ZFW: MSP to DFW Slide 2



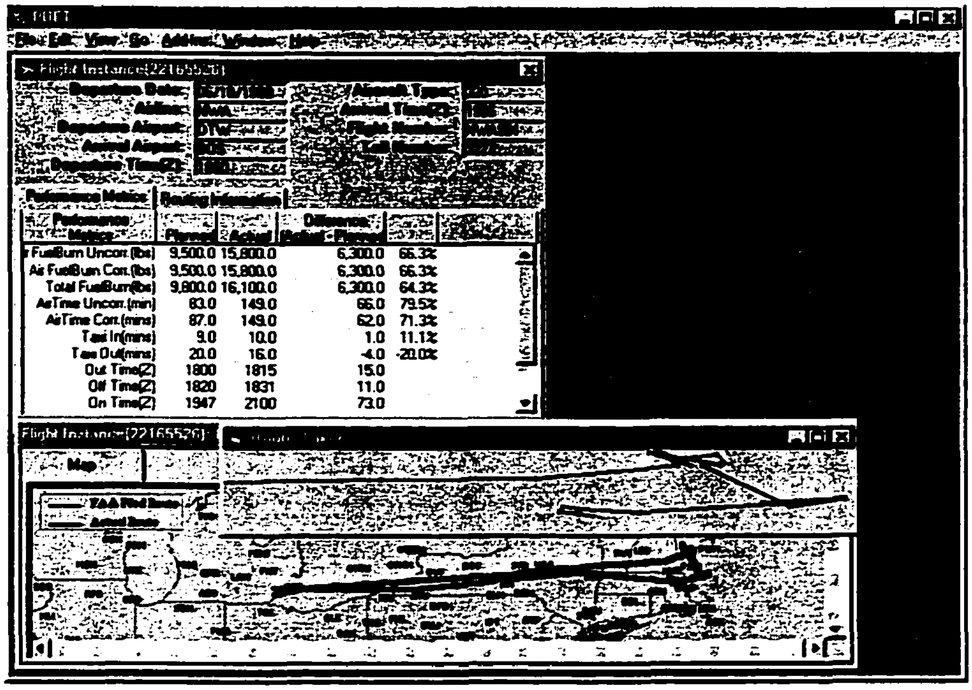
Appendix A.15 ZBW: DTW to BOS Slide 1



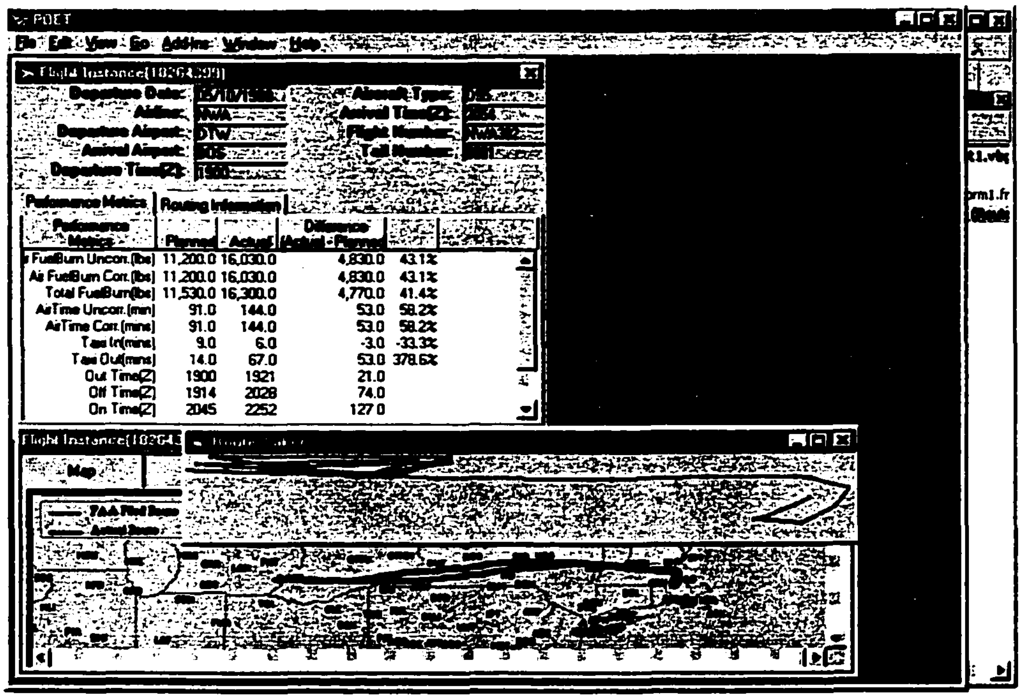
Appendix A.16 ZBW: DTW to BOS Slide 2



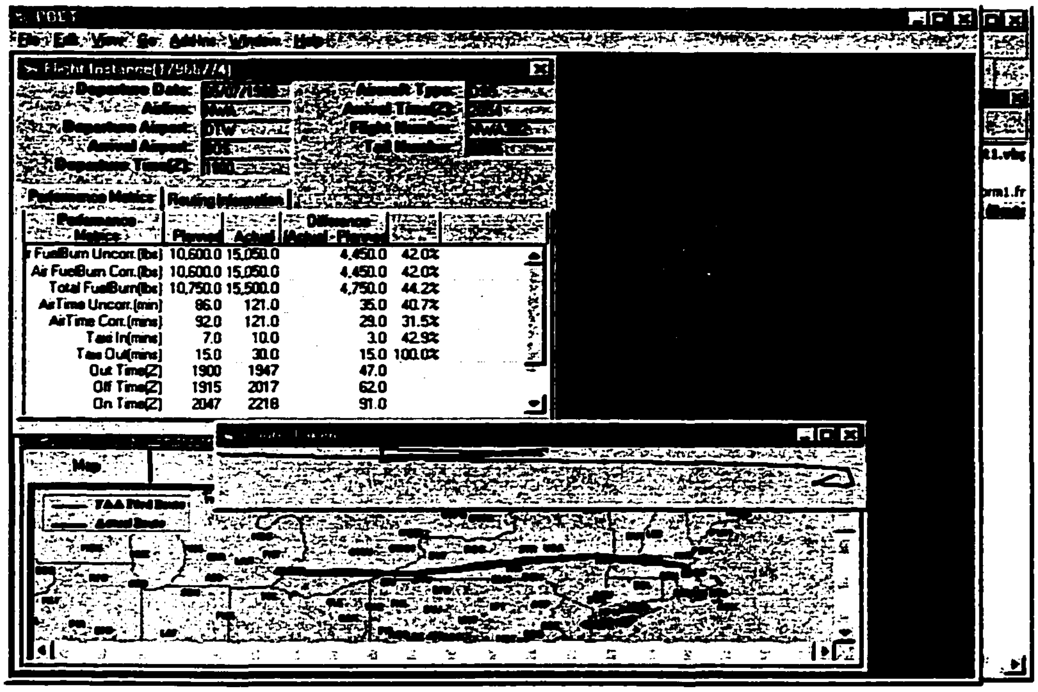
Appendix A.17 ZBW: DTW to BOS Slide 3



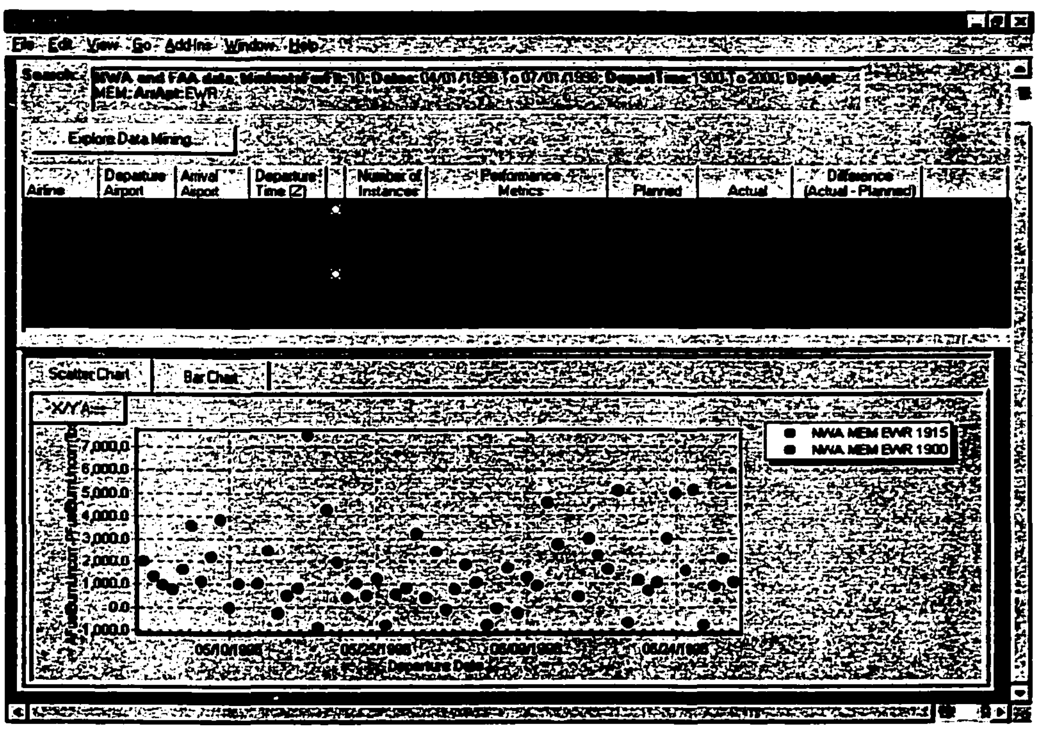
Appendix A.18 ZBW: DTW to BOS Slide 4



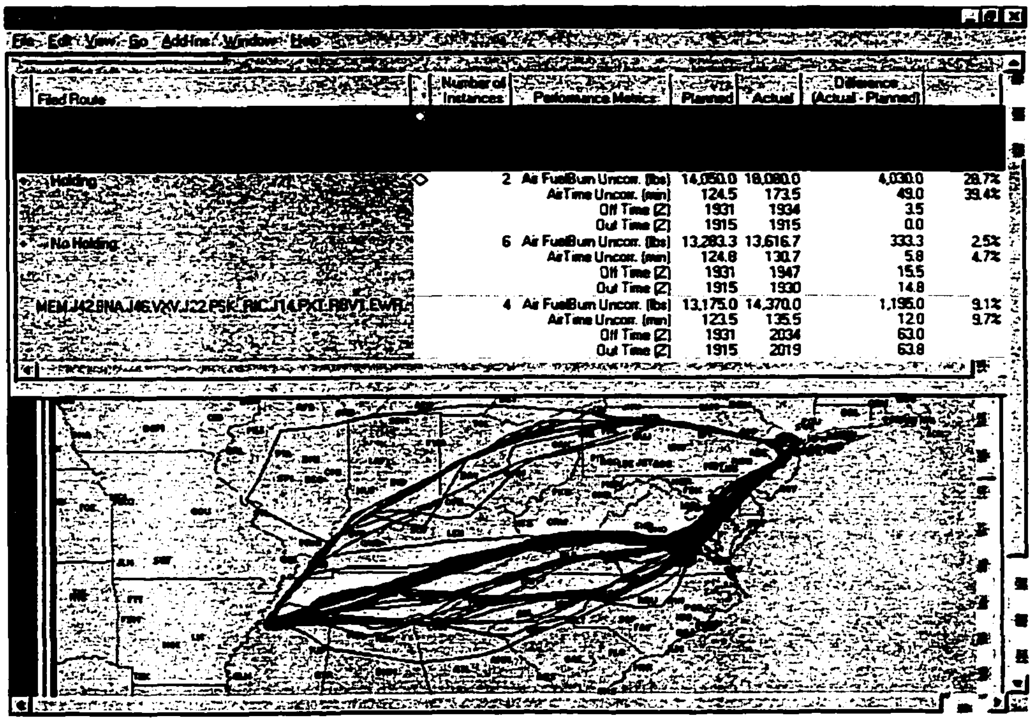
Appendix A.19 ZBW: DTW to BOS Slide 5



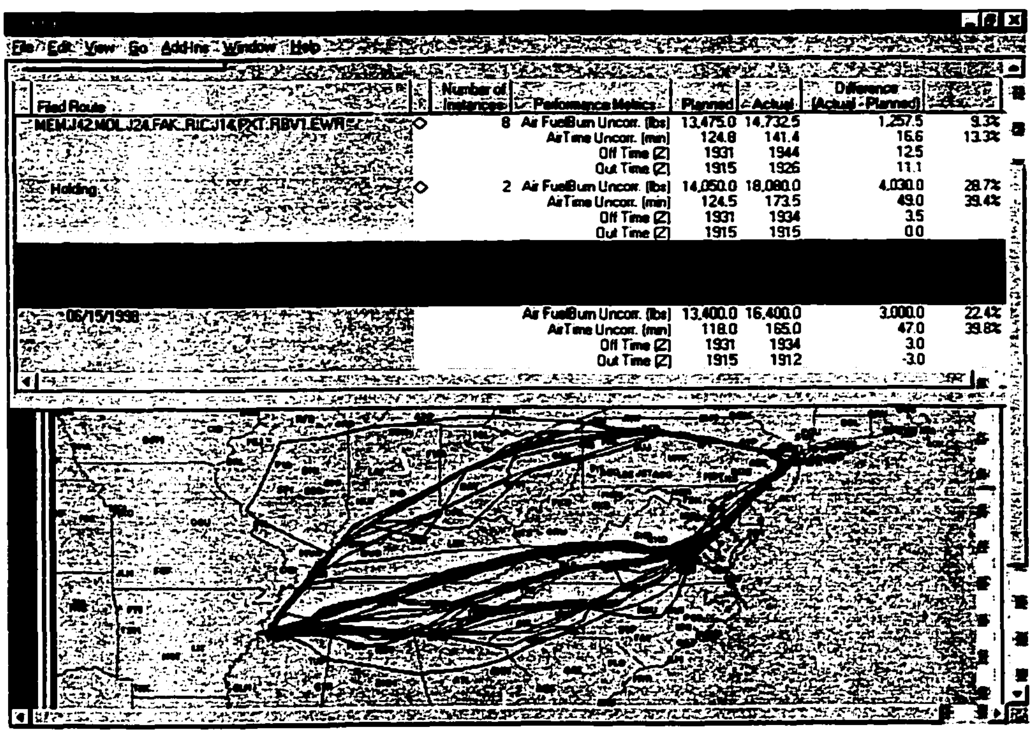
Appendix A.20 ZBW: DTW to BOS Slide 6



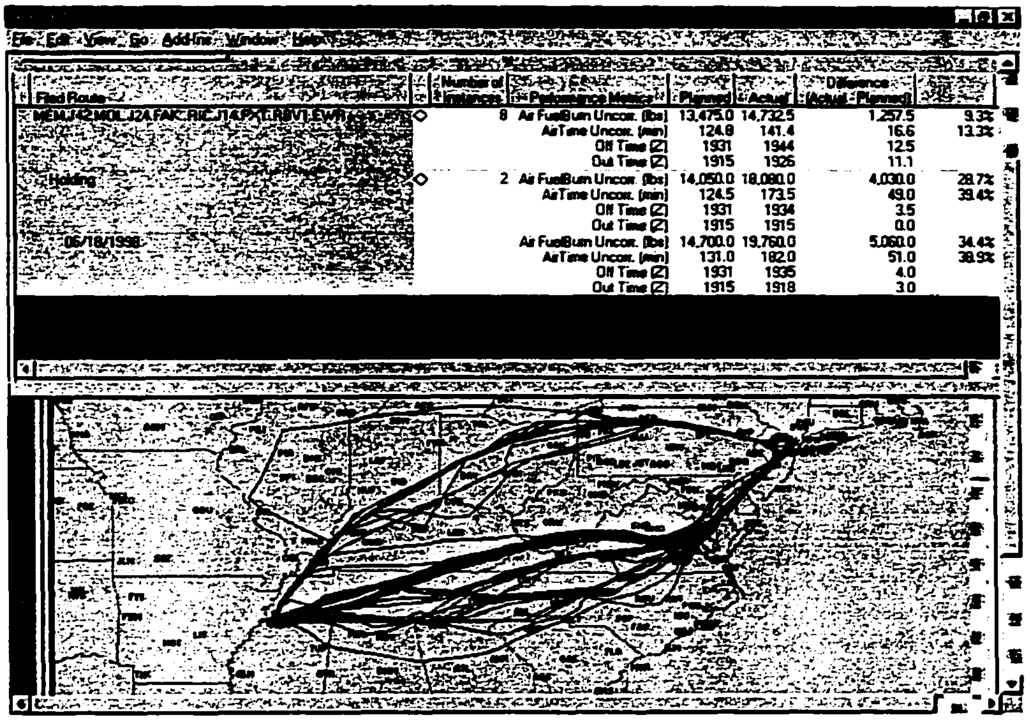
Appendix A.21 ZDC: MEM to EWR Slide 1



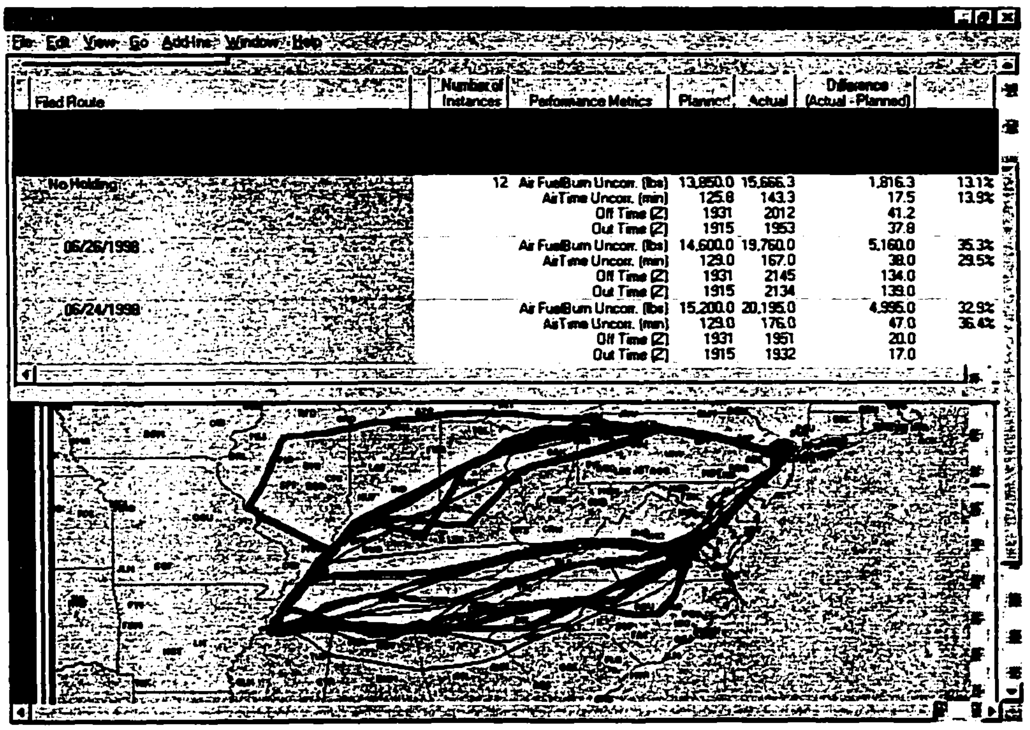
Appendix A.22 ZDC: MEM to EWR Slide 2



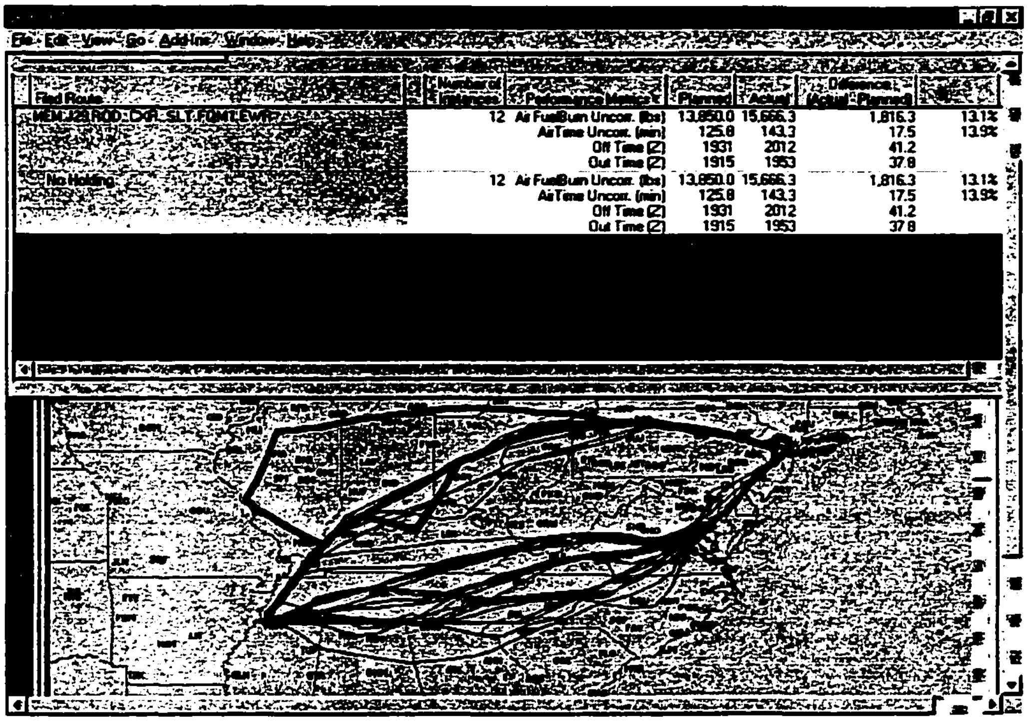
Appendix A.23 ZDC: MEM to EWR Slide 3



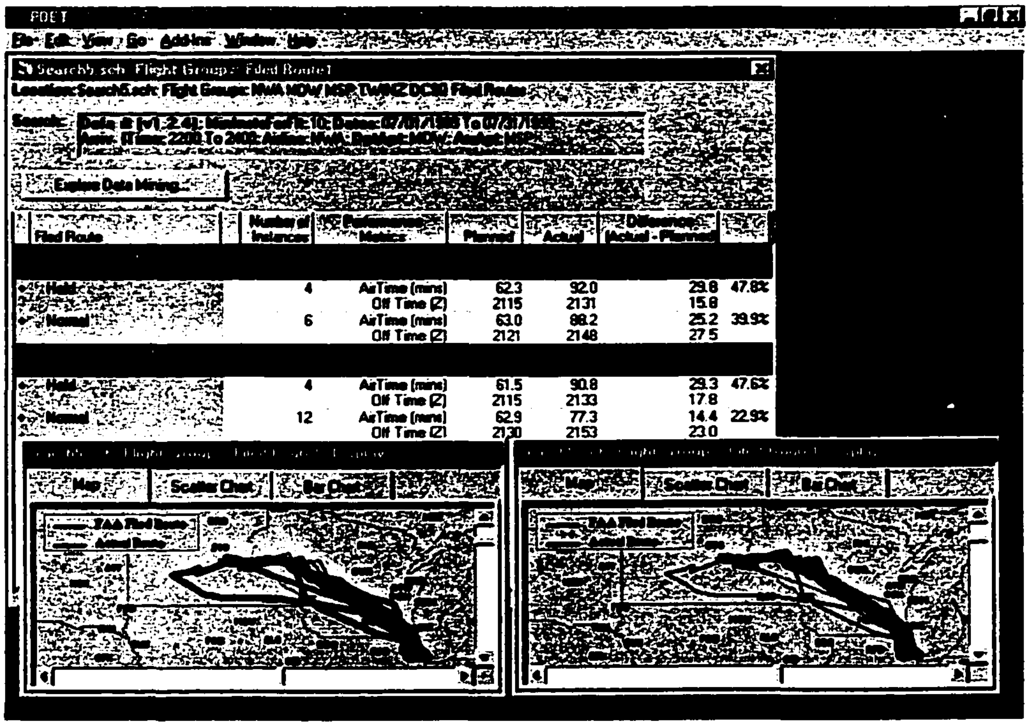
Appendix A.24 ZDC: MEM to EWR Slide 4



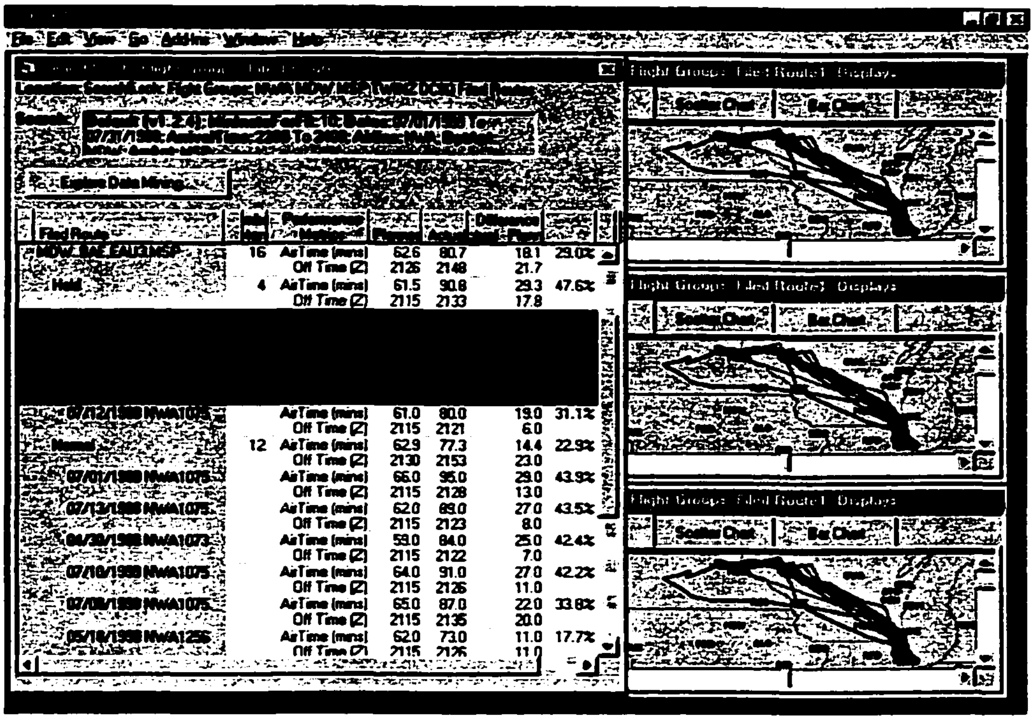
Appendix A.25 ZDC: MEM to EWR Slide 5



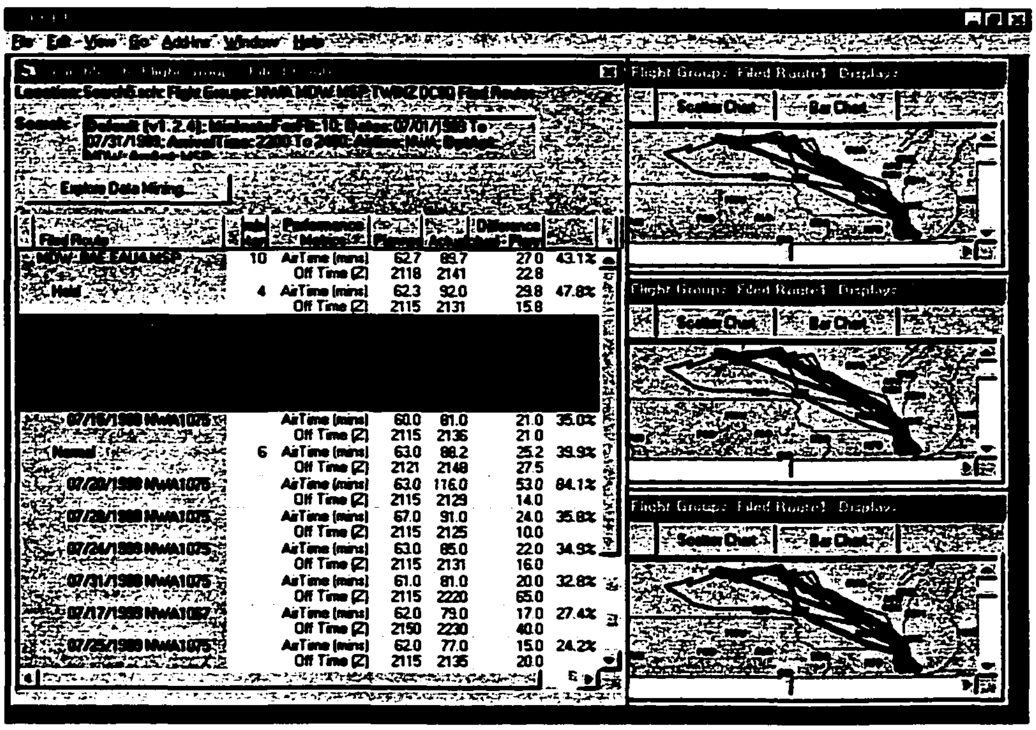
Appendix A.26 ZDC: MEM to EWR Slide 6



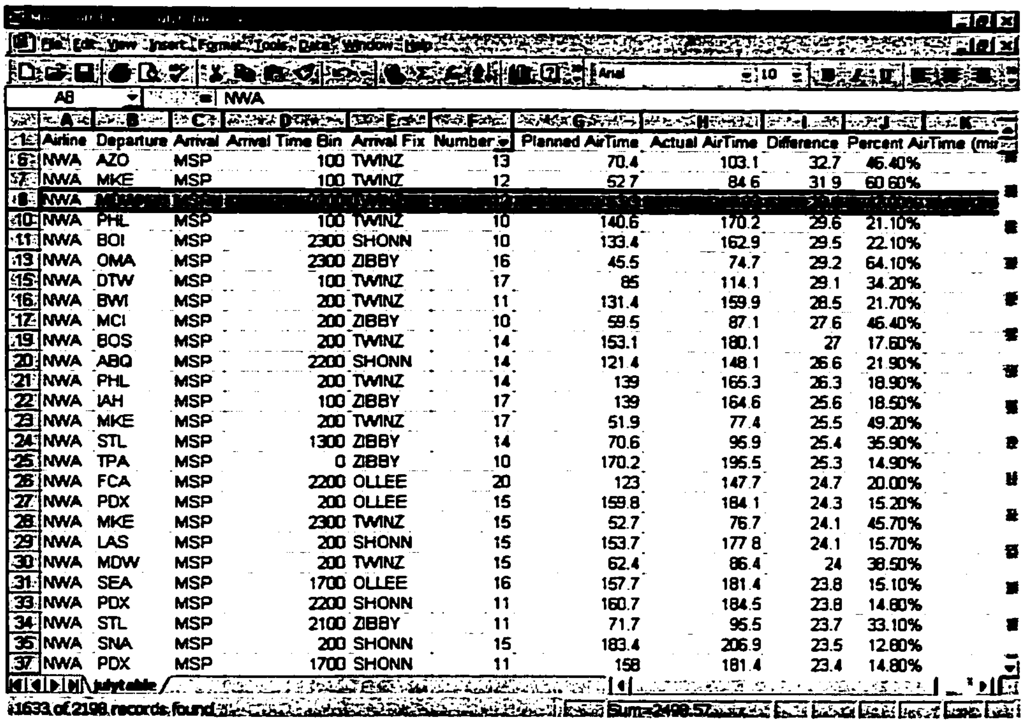
Appendix A.27 ZMP: MDW to MSP Slide 1



Appendix A.28 ZMP: MDW to MSP Slide 2

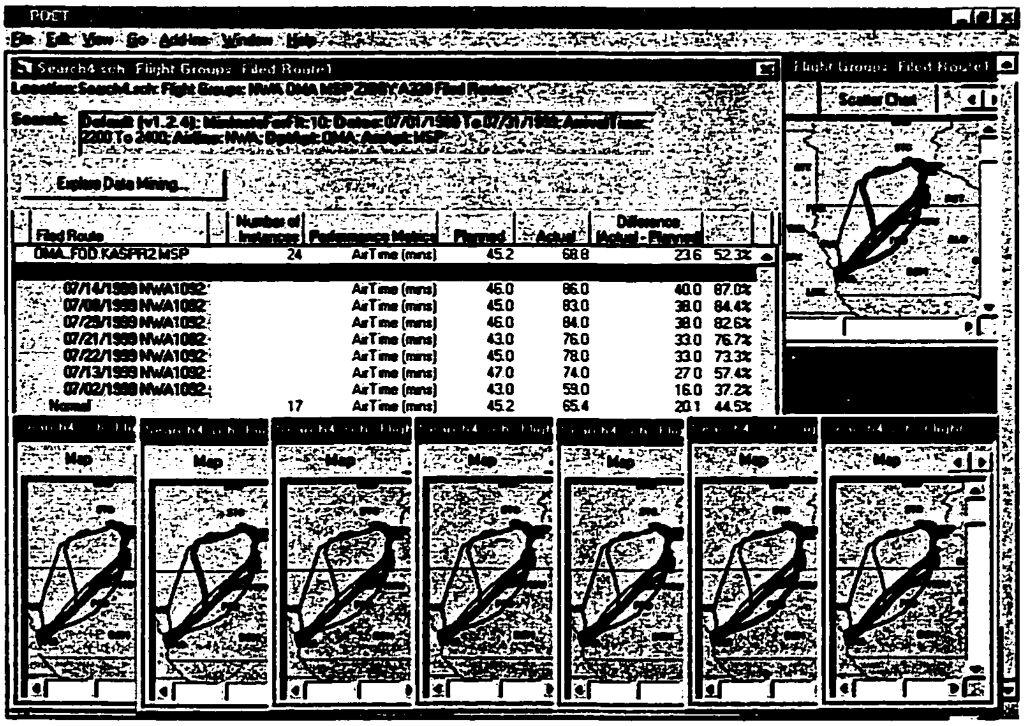


Appendix A.29 ZMP: MDW to MSP Slide 3

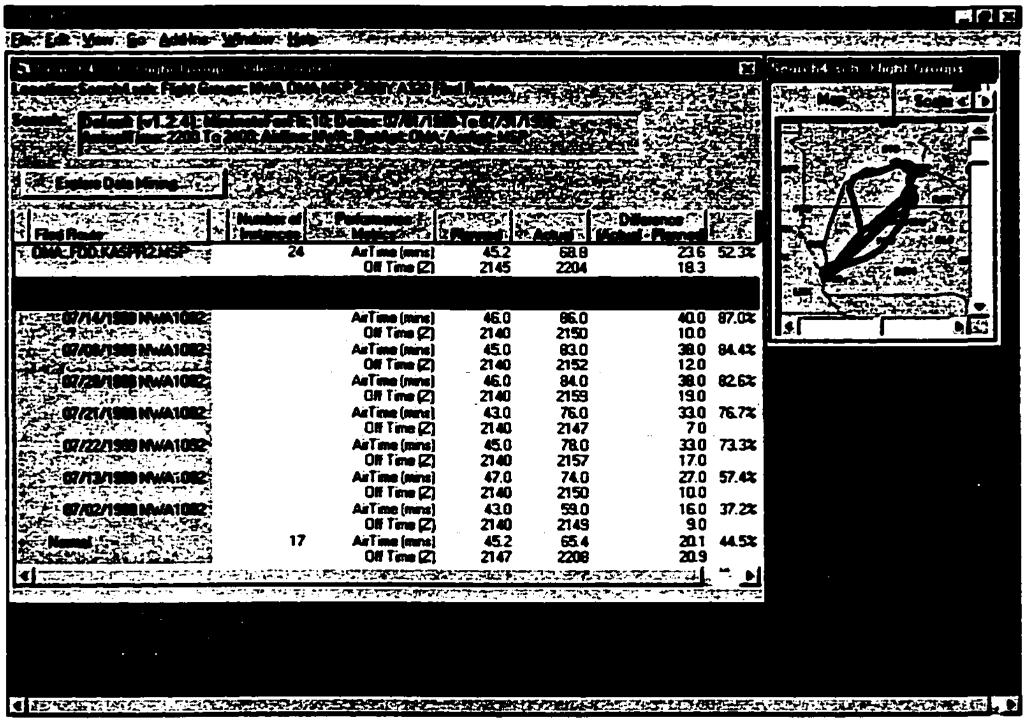


	Airline	Departure	Arrival	Arrival Time Bin	Arrival Fix	Number	Planned AirTime	Actual AirTime	Difference	Percent AirTime
6	NWA	AZO	MSP	100	TWINZ	13	70.4	103.1	32.7	46.40%
7	NWA	MKE	MSP	100	TWINZ	12	52.7	84.6	31.9	60.60%
8	NWA	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	NWA	PHL	MSP	100	TWINZ	10	140.6	170.2	29.6	21.10%
11	NWA	BOI	MSP	2300	SHONN	10	133.4	162.9	29.5	22.10%
13	NWA	OMA	MSP	2300	ZIBBY	16	45.5	74.7	29.2	64.10%
15	NWA	DTW	MSP	100	TWINZ	17	85	114.1	29.1	34.20%
16	NWA	BWI	MSP	200	TWINZ	11	131.4	159.9	28.5	21.70%
17	NWA	MCI	MSP	200	ZIBBY	10	59.5	87.1	27.6	46.40%
19	NWA	BOS	MSP	200	TWINZ	14	153.1	180.1	27	17.60%
20	NWA	ABQ	MSP	2200	SHONN	14	121.4	148.1	26.6	21.90%
21	NWA	PHL	MSP	200	TWINZ	14	139	165.3	26.3	18.90%
22	NWA	IAH	MSP	100	ZIBBY	17	139	164.6	25.6	18.50%
23	NWA	MKE	MSP	200	TWINZ	17	51.9	77.4	25.5	49.20%
24	NWA	STL	MSP	1300	ZIBBY	14	70.6	95.9	25.4	35.90%
25	NWA	TPA	MSP	0	ZIBBY	10	170.2	195.5	25.3	14.90%
26	NWA	FCA	MSP	2200	OLLEE	20	123	147.7	24.7	20.00%
27	NWA	PDX	MSP	200	OLLEE	15	159.8	184.1	24.3	15.20%
28	NWA	MKE	MSP	2300	TWINZ	15	52.7	76.7	24.1	45.70%
29	NWA	LAS	MSP	200	SHONN	15	153.7	177.8	24.1	15.70%
30	NWA	MDW	MSP	200	TWINZ	15	62.4	86.4	24	38.50%
31	NWA	SEA	MSP	1700	OLLEE	16	157.7	181.4	23.8	15.10%
33	NWA	PDX	MSP	2200	SHONN	11	160.7	184.5	23.8	14.80%
34	NWA	STL	MSP	2100	ZIBBY	11	71.7	95.5	23.7	33.10%
35	NWA	SNA	MSP	200	SHONN	15	183.4	206.9	23.5	12.80%
37	NWA	PDX	MSP	1700	SHONN	11	158	181.4	23.4	14.80%

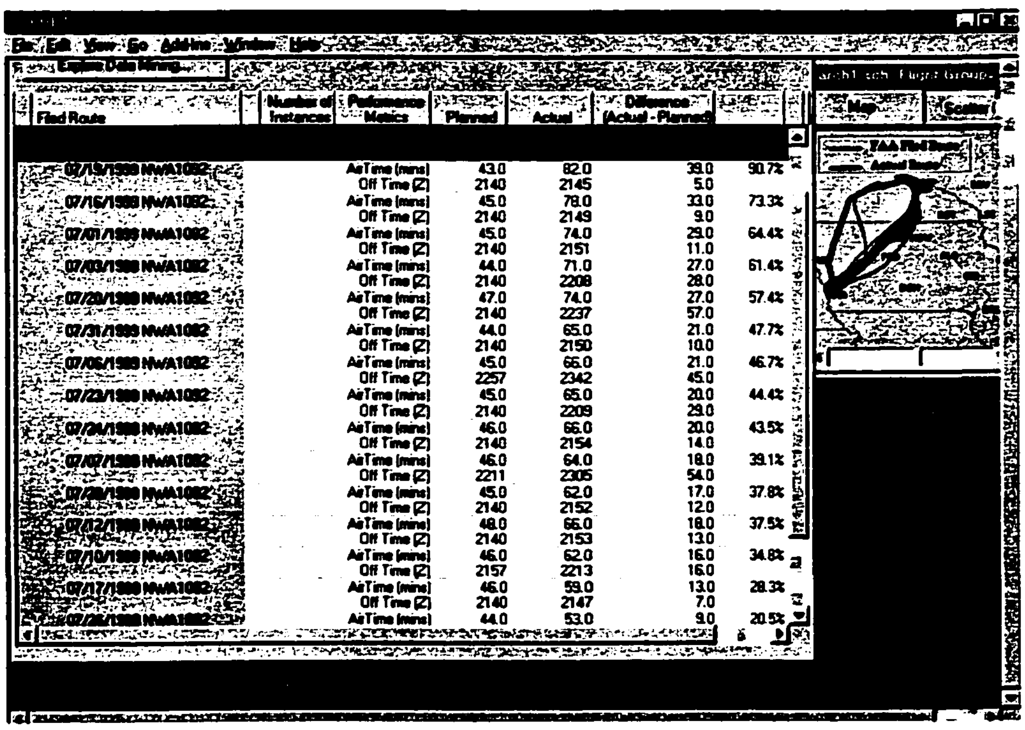
Appendix A.30 ZMP: MDW to MSP Slide 4



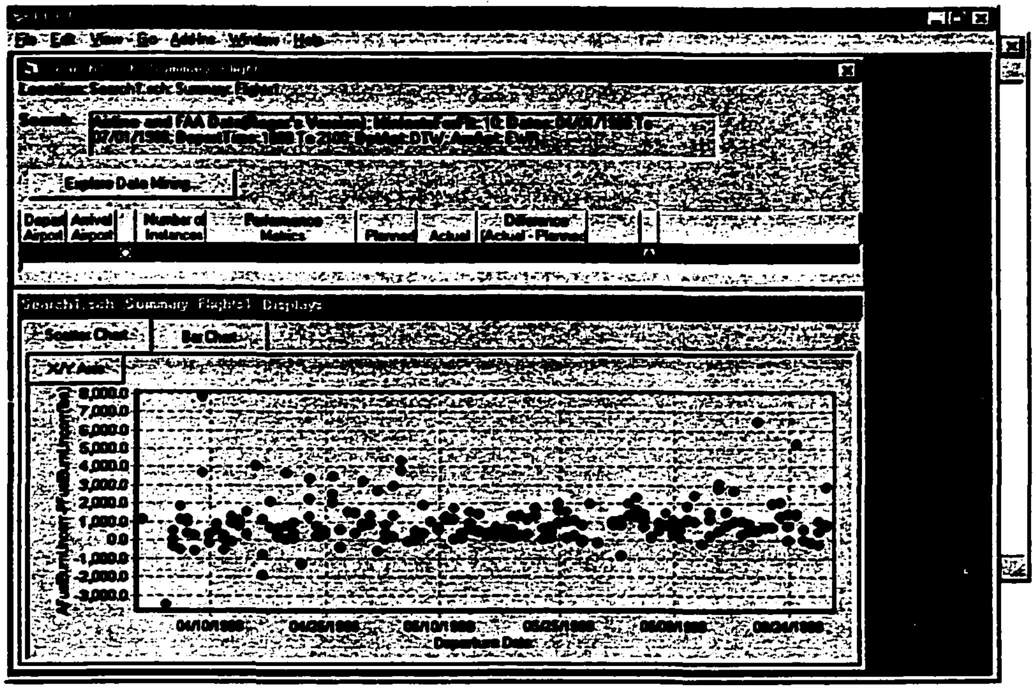
Appendix A.31 ZMP: OMA to MSP Slide 1



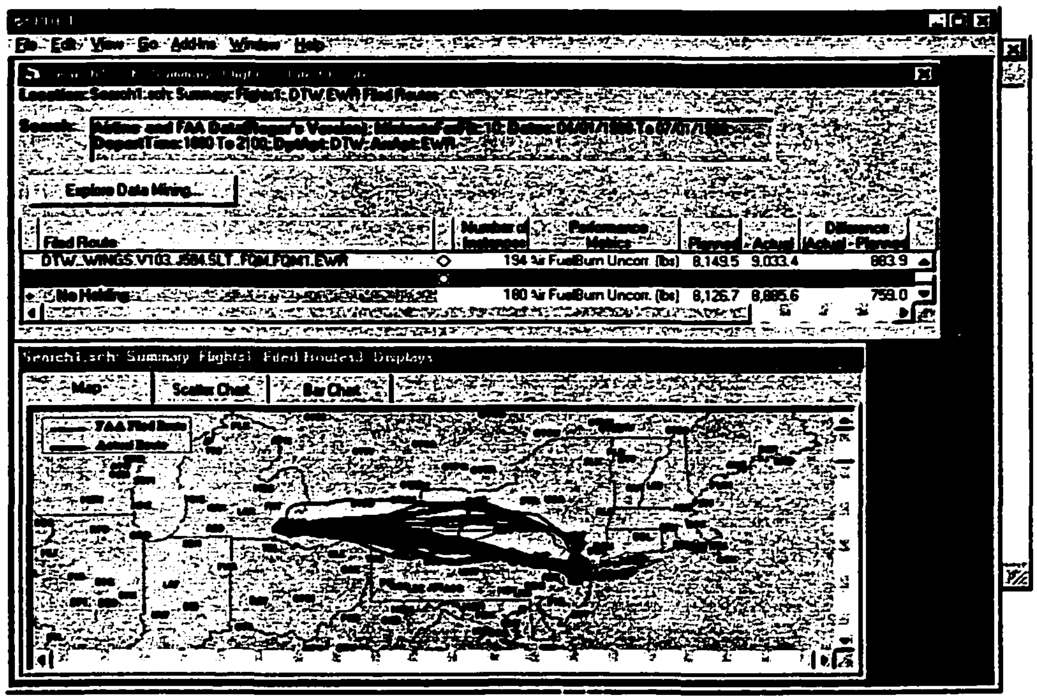
Appendix A.32 ZMP: OMA to MSP Slide 2



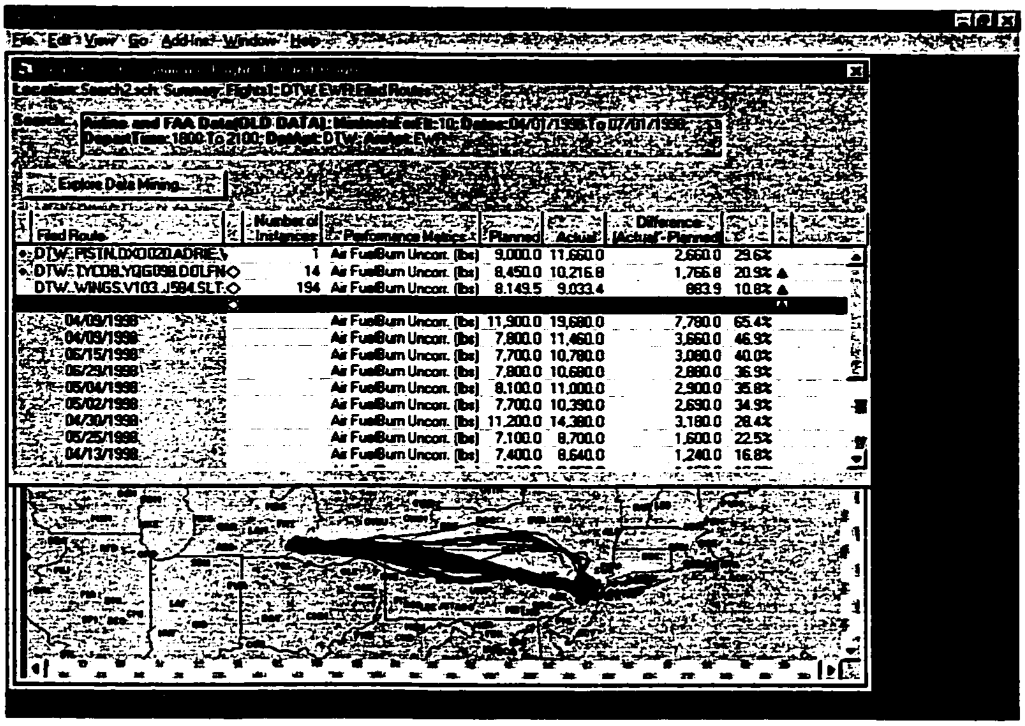
Appendix A.33 ZMP: OMA to MSP Slide 3



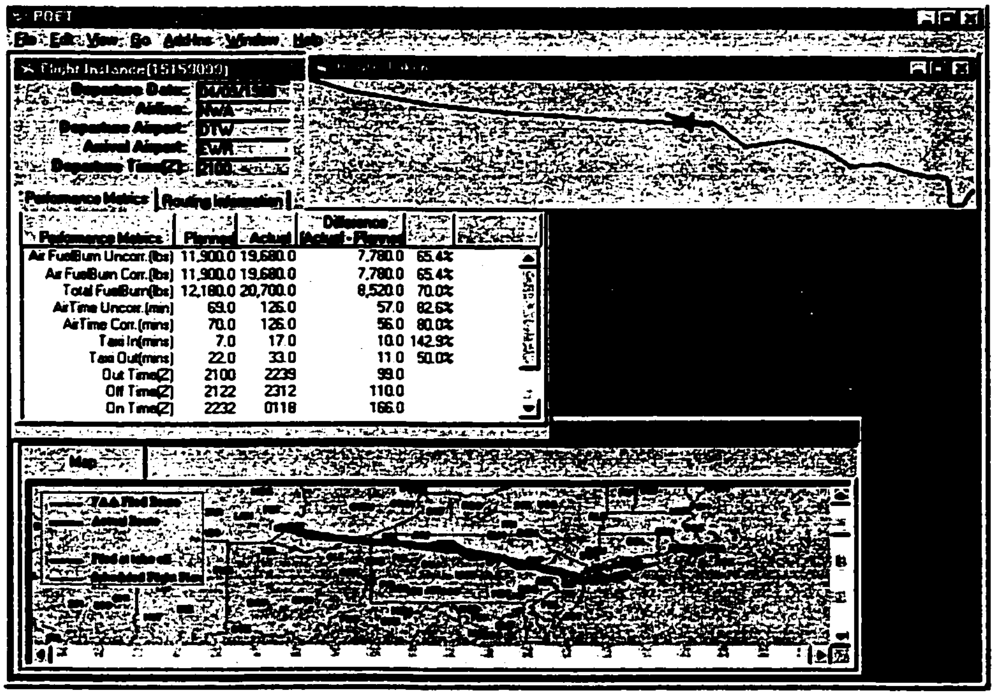
Appendix A.34 ZNY: DTW to EWR Slide 1



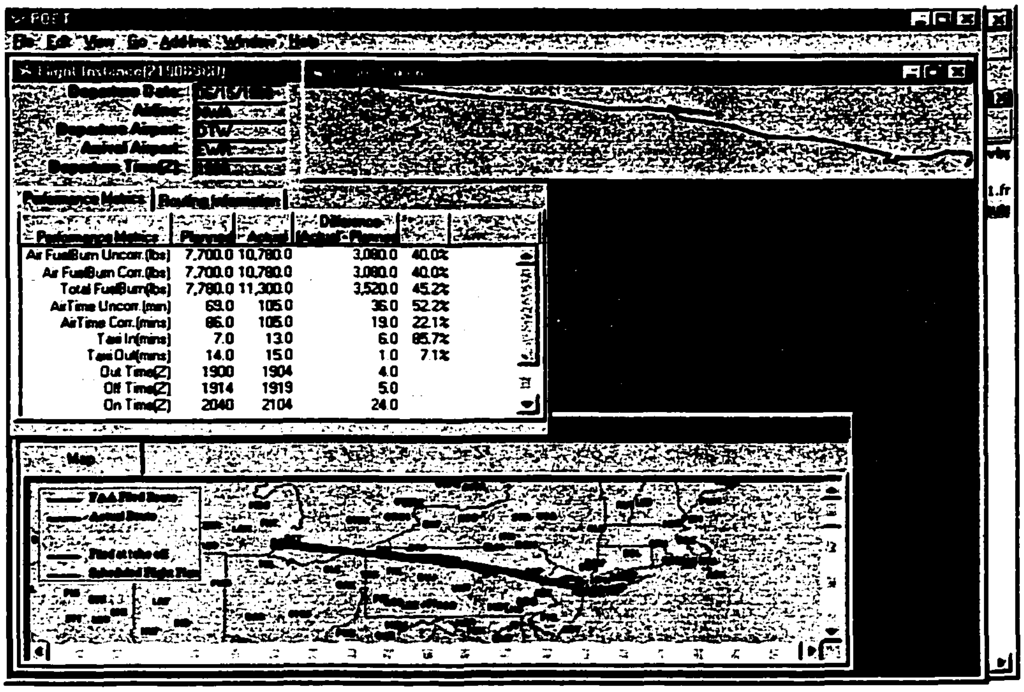
Appendix A.35 ZNY: DTW to EWR Slide 2



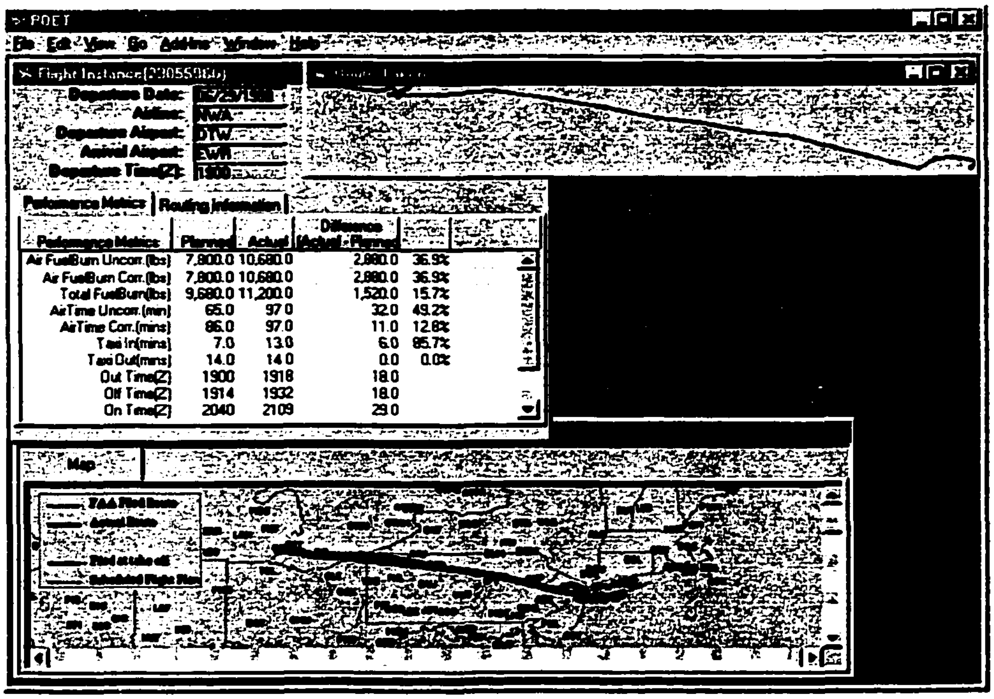
Appendix A.36 ZNY: DTW to EWR Slide 3



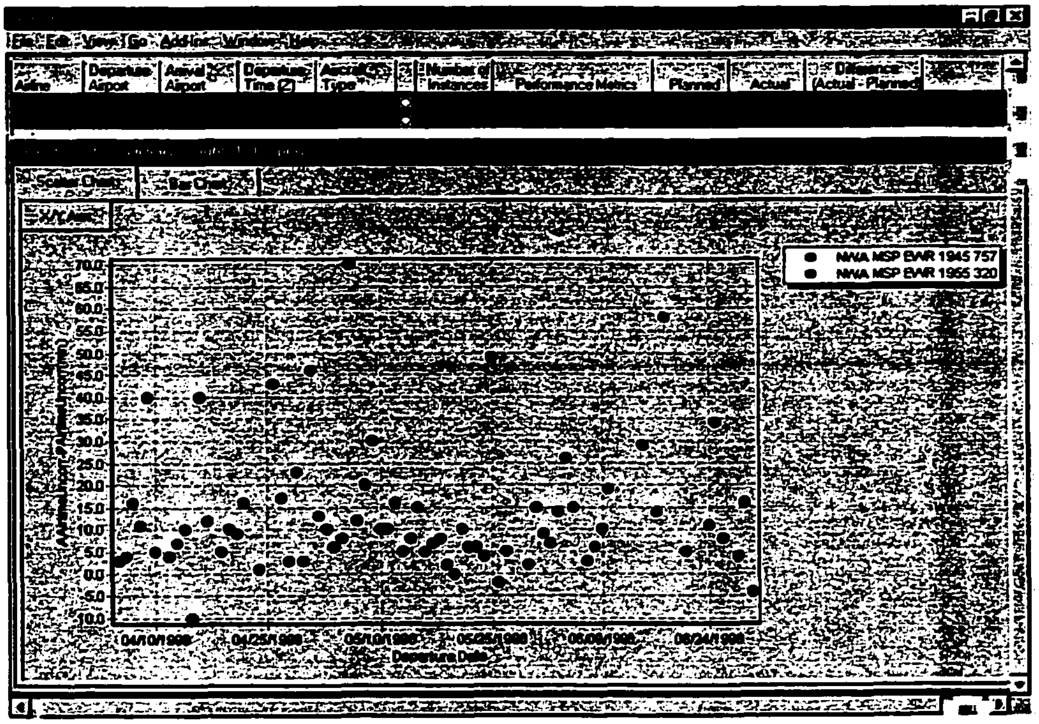
Appendix A.37 ZNY: DTW to EWR Slide 4



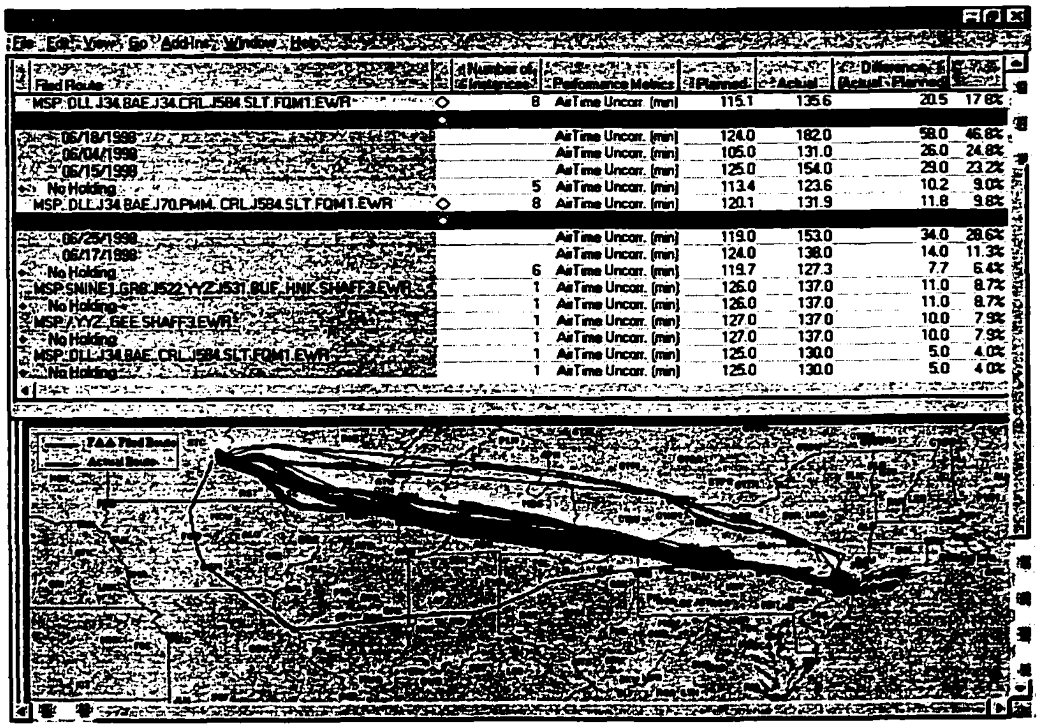
Appendix A.38 ZNY: DTW to EWR Slide 5



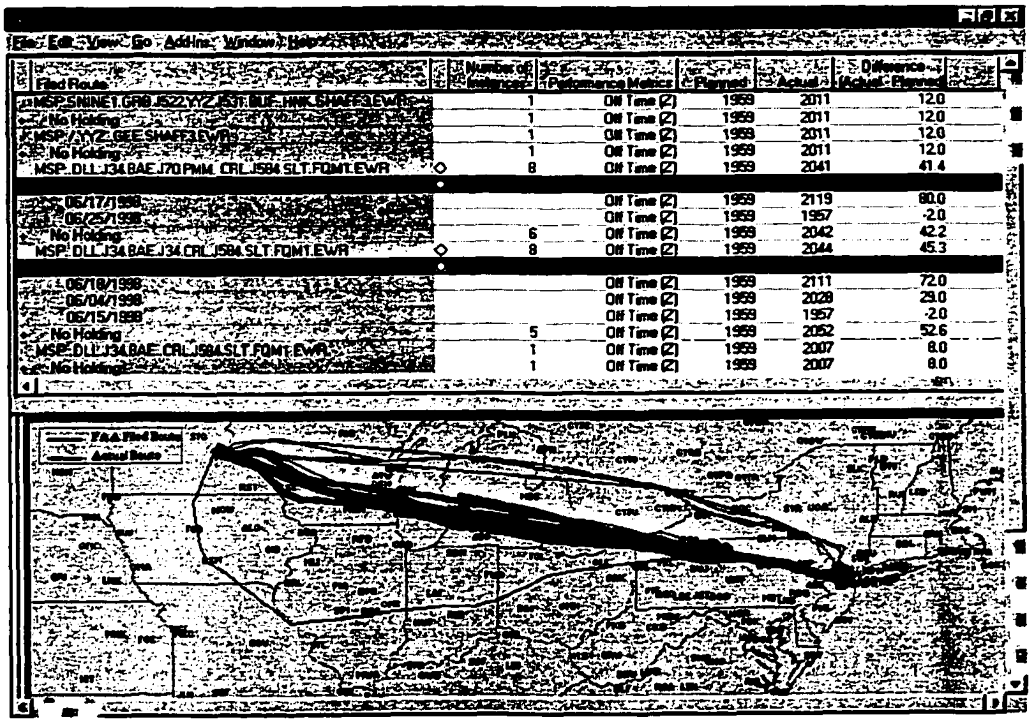
Appendix A.39 ZNY: DTW to EWR Slide 6



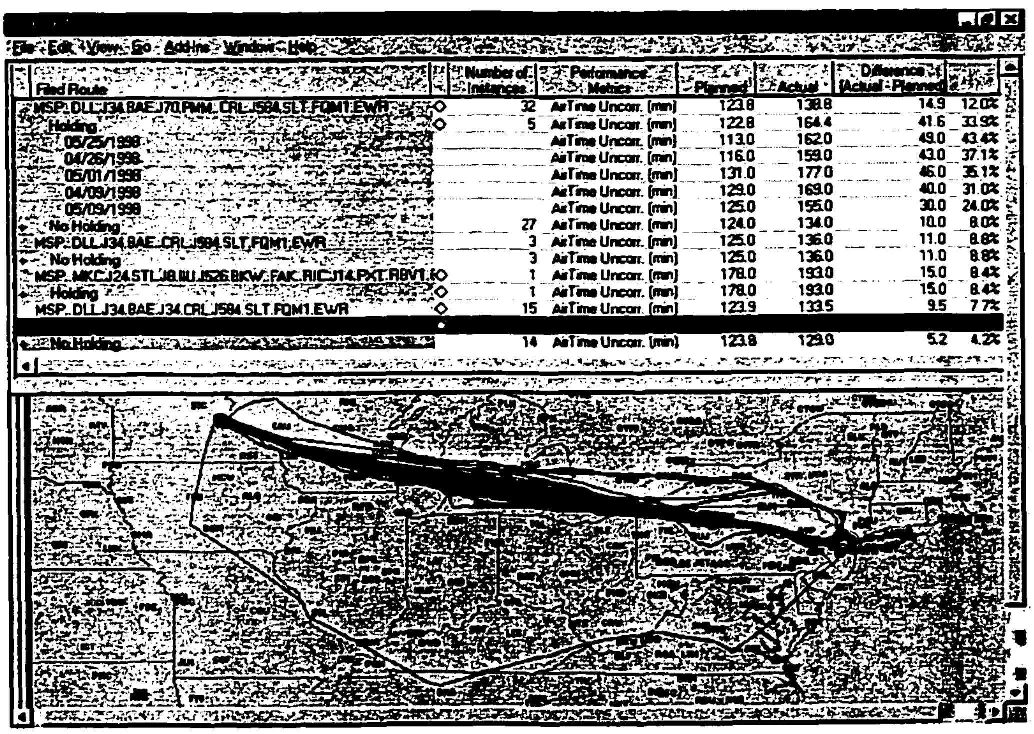
Appendix A.40 ZOB: MSP to EWR Slide 1



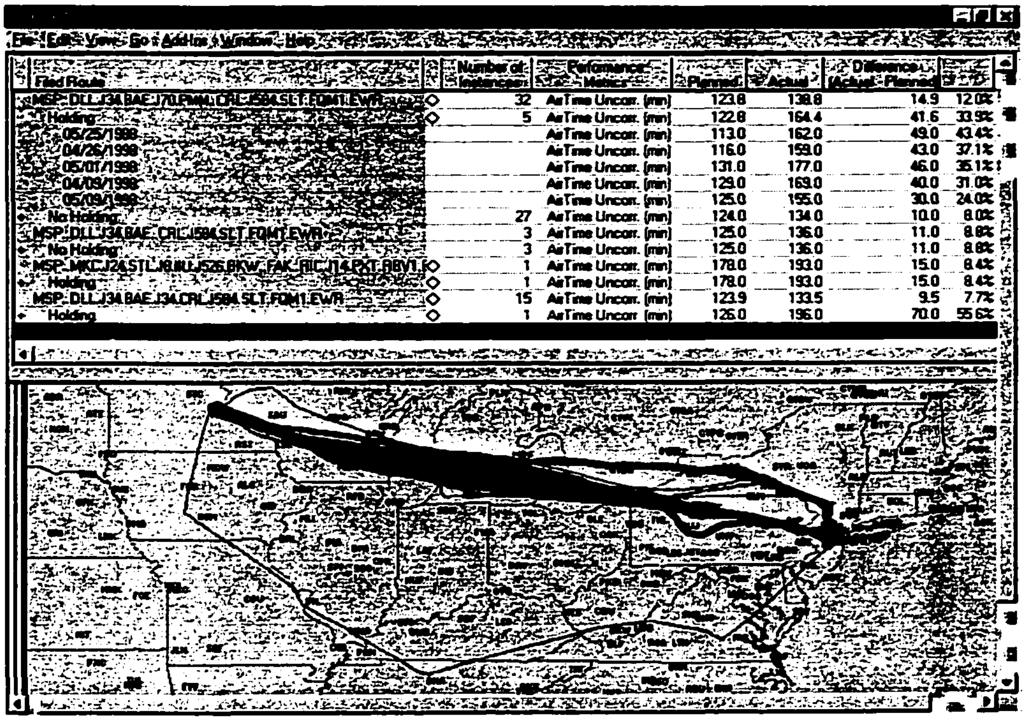
Appendix A.41 ZOB: MSP to EWR Slide 2



Appendix A.42 ZOB: MSP to EWR Slide 3



Appendix A.43 ZOB: MSP to EWR Slide 4



Appendix A.44 ZOB: MSP to EWR Slide 5

APPENDIX B. POET WINDOWS USED IN THE SCENARIOS

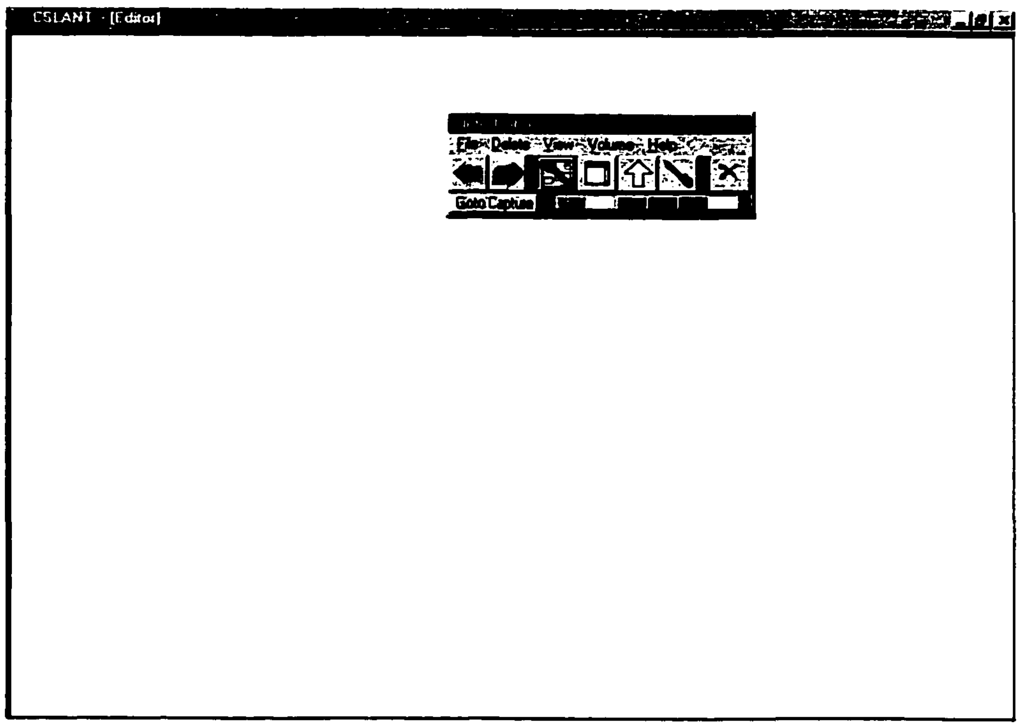
Slide	Search Summary	Flight Table	Scatter Chart	Filed Route Table	Flight Route Map	Expanded Filed Route Table	Expanded Filed Route Table with Instance Highlighted	Flight Instance Window	Other
ZNY 1	X	X	X						
ZNY 2	X				X	X			
ZNY 3	X				X	X			
ZNY 4					X			X	
ZNY 5					X			X	
ZNY 6					X			X	
ZOB 1		X	X						
ZOB 2					X	X			
ZOB 3					X	X			
ZOB 4					X		X		
ZOB 5					X	X			
ZID 1	X				X	X			
ZID 2	X				X		X		
ZID 3	X				X		X		
ZID 4	X				X		X		
ZID 5	X				X		X		
ZTL 1	X	X	X						
ZTL 2	X				X		X		
ZTL 3	X				X		X		
ZTL 4	X	X	X						
ZTL 5	X				X	X			
ZTL 6	X	X	X						
ZTL 7	X				X	X			
ZFW 1	X			X	X[1]				
ZFW 2	X			X	X[1]				

ZBW 1	X	X	X						
ZBW 2	X				X	X			
ZBW 3	X				X	X			
ZBW 4					X			X	
ZBW 5					X			X	
ZBW 6					X			X	
ZDC 1	X	X	X						
ZDC 2					X	X			
ZDC 3					X		X		
ZDC 4					X		X		
ZDC 5					X	X			
ZDC 6					X		X		
ZMP1-1	X				X[1]	X			
ZMP1-2	X				X[1]		X		
ZMP1-3	X				X[1]		X		
ZMP1-4									X[2]
ZMP2-1	X				X[1]		X		
ZMP2-2	X				X	X			
ZMP2-3					X	X			

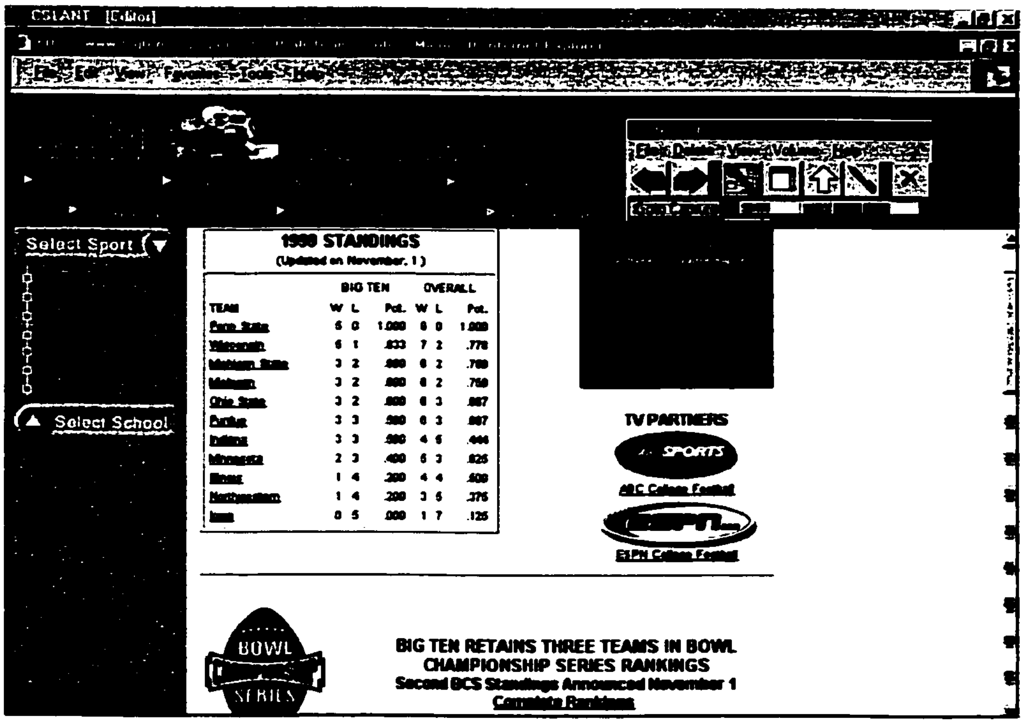
1: The POET screen capture was modified to include several flight instances in one window, which POET 1.0 does not support.

2: A Microsoft Excel spreadsheet screen capture was included in this slide to show the delays sorted by arrival fix, which POET 1.0 does not support.

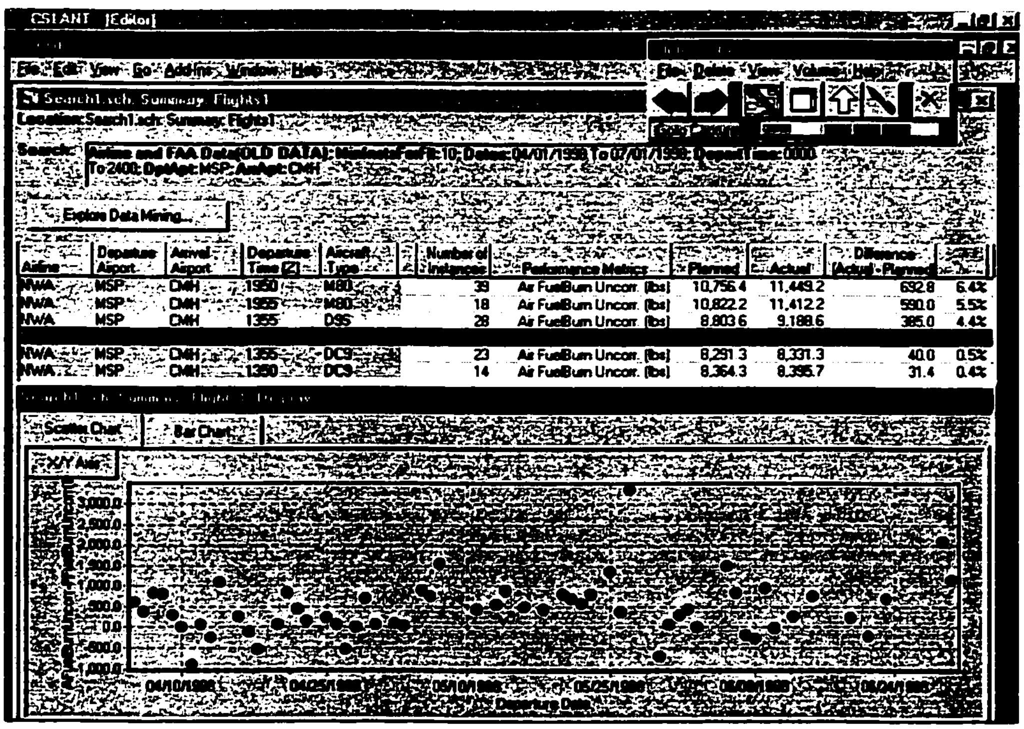
APPENDIX C. THE TRAINING SLIDE SHOW



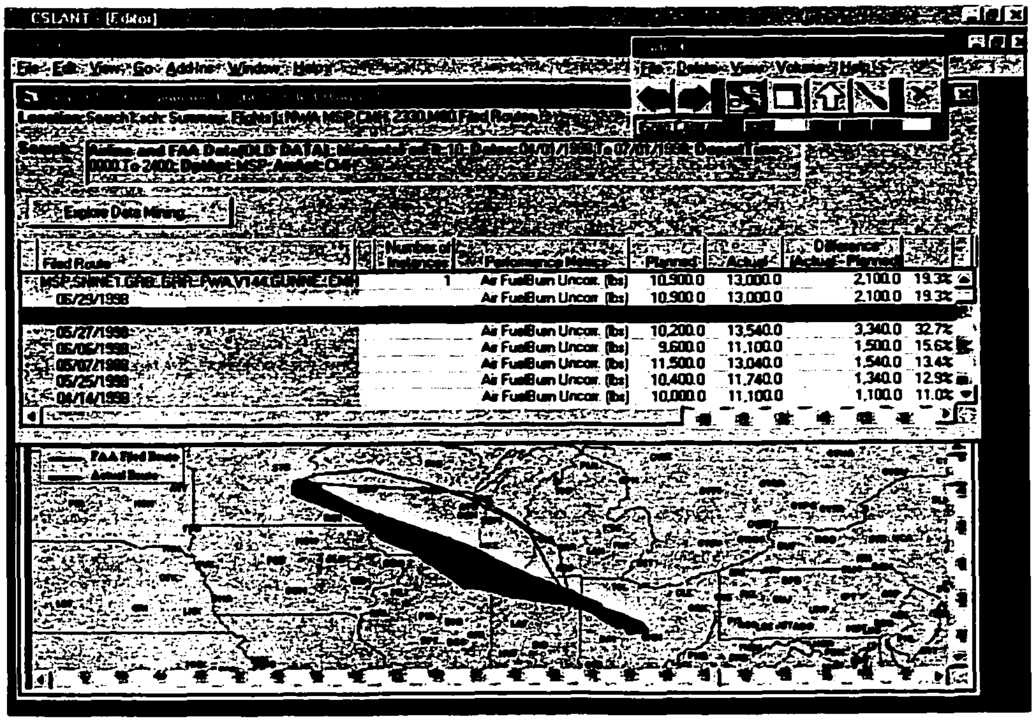
Appendix C.1 Training Slide 1



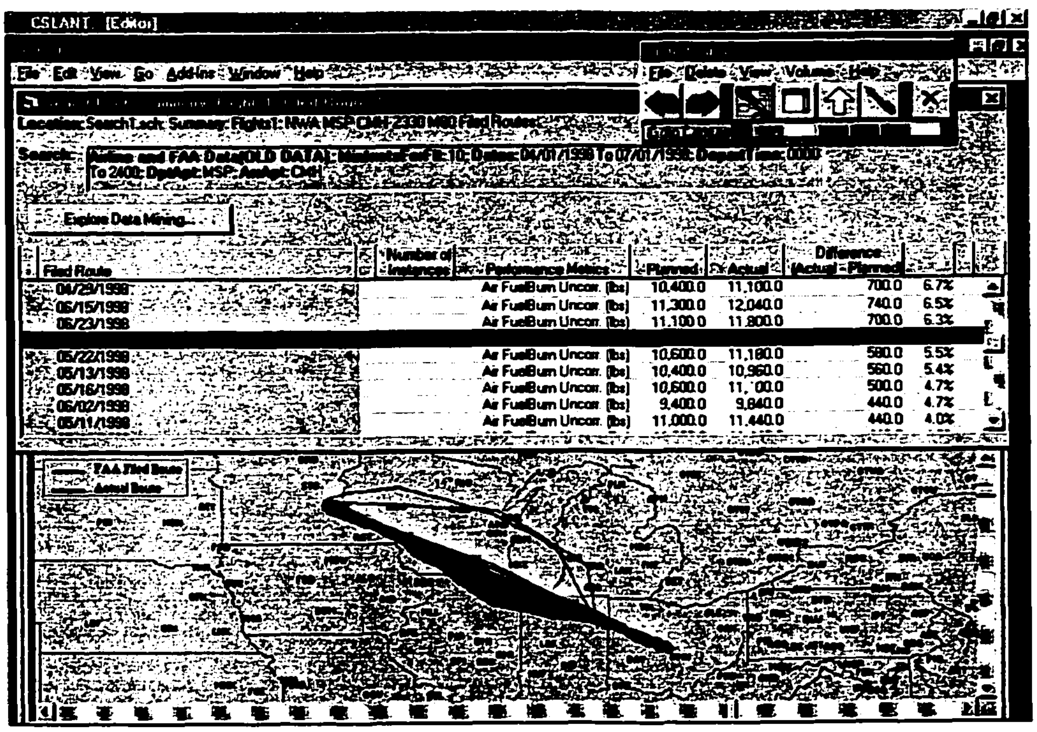
Appendix C.2 Training Slide 2



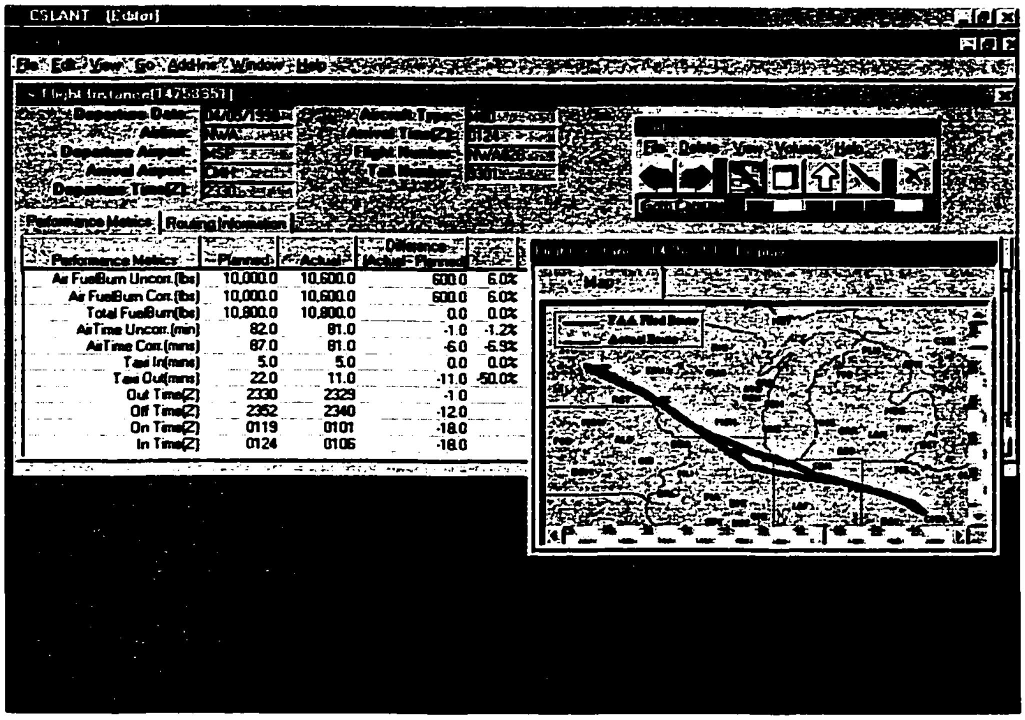
Appendix C.3 Training Slide 3



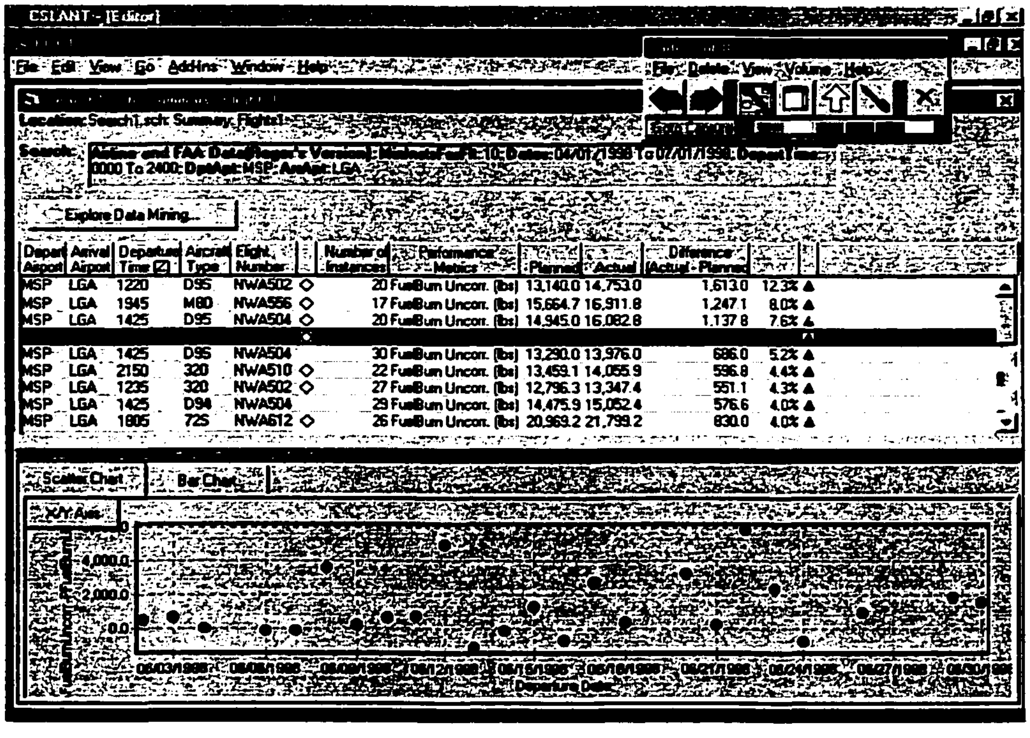
Appendix C.4 Training Slide 4



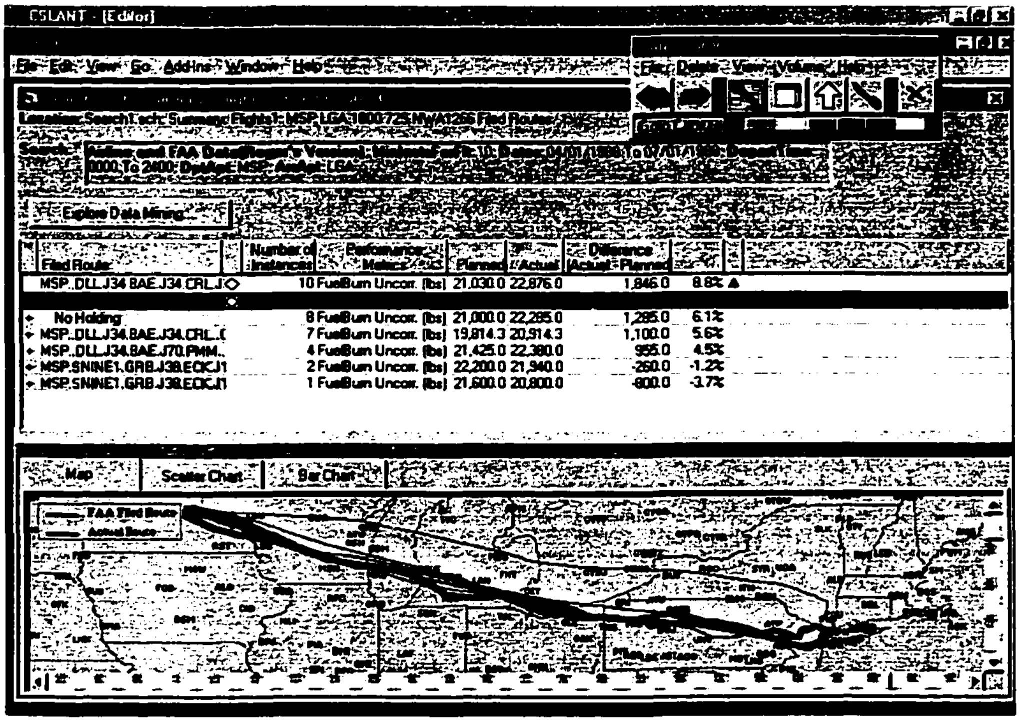
Appendix C.5 Training Slide 5



Appendix C.6 Training Slide 6



Appendix C.7 Training Slide 7



Appendix C.8 Training Slide 8

APPENDIX D. DISPATHCHERS MENTIONING BASIC FLIGHT CLASSIFYING DATA

	DT1	DT2	DVp1	DVp2
ZNY				
City pair	✗	✓	✓	✗
Time of day	✗	✗	✗	✗
Time of year	✗	✗	✓	✗
Number of flights involved	✗	✗	✓	✗
ZOB				
City pair	✓	✗	✗	✓
Time of day	✗	✗	✗	✓
Time of year	✗	✗	✗	✓
Number of flights involved	✗	✗	✗	✓
ZID				
City pair	✗	✗	✗	✓
Time of day	✗	✗	✗	✗
Time of year	✗	✗	✗	✗
Number of flights involved	✗	✗	✗	✗
ZTL				
City pair	✗	✗	✗	✗
Time of day	✗	✗	✗	✗
Time of year	✗	✗	✗	✗
Number of flights involved	✗	✗	✗	✗
ZFW				
City pair	✓	✗	✗	✓
Time of day	✗	✗	✗	✓
Time of year	✗	✗	✗	✓
Number of flights involved	✗	✗	✗	✓
ZBW				
City pair	✗	✗	✓	✓
Time of day	✗	✗	✓	✗
Time of year	✗	✗	✗	✓
Number of flights involved	✓	✗	✗	✗
Number of flights involved	✗	✗	✓	✗
ZMP1				
City pair	✗	✗	✓	✓
Time of day	✗	✓	✗	✗

	DT1	DT2	DVp1	DVp2
ZDC				
City pair	✔	✔	✔	✔
Time of day	✘	✘	✔	✘
Time of year	✘	✘	✔	✘
Number of flights involved	✘	✘	✔	✘
ZMP1				
City pair	✘	✘	✔	✔
Time of day	✘	✔	✘	✘
Time of year	✘	✘	✘	✘
Number of flights involved	✘	✘	✘	✘
ZMP2				
City pair	✘	✘	✘	✔
Time of day	✘	✘	✘	✘
Time of year	✘	✘	✘	✘
Number of flights involved	✘	✘	✘	✘

APPENDIX E. DISPATHCHER QUESTIONS

ZNY Scenario – DTW to EWR	
Text Mode Pair #1	***Code***
1. Is filing through ZBW the answer to avoid holds?	C
2. Is the traffic balanced coming into this center's airspace from 3 neighboring centers?	C
3. Would a reroute be an option for flights looking at holding close to DTW?	C
Text Mode Pair #2	***Code***
1. Could we get a reroute one of the northern alternate routes to avoid holding close to DTW?	C
Voice and Pointing Mode Pair #1	***Code***
1. Why were these flights held?	A
2. Why were they held so far from the [destination] airport?	A
3. Could we have filed a different route to the north or south to void this? [a number of holds and some vectoring]	C
4. Was it weather, ATC congestion, or an aircraft incident at the airport?	B
5. Couldn't you hold us on the ground rather than shortly after departure?	C
6. Couldn't we have been given a different routing [to avoid this instance of holding]?	C
Voice and Pointing Mode Pair #2	***Code***
No direct questions asked	-

ZOB Scenario – MSP to EWR	
Text Mode Pair #1	***Code***
1. Would a departure delay be better?	C
2. Is the holding at SLT due to sector saturation? If so, would alternative flight planning be in order?	B
3. Could we hold closer to DTW rather than SLT to give NWA a better scenario for planning in the event the remaining fuel onboard becomes an issue?	C
Text Mode Pair #2	***Code***
1. Why are so many over filed air-time?	A
2. Routes over crl slt produce holds that are more significant than grb-yyz routes. Would flying a 757 at a higher altitude help the holding situation?	C
3. Flights over grb-yyz seem to get off ground with less delay. Is it better to fly a longer route to reduce ground delays?	C
4. Why is crl slt producing bottleneck? Is traffic coming from other airports (ord-dtw-cvg) producing the problem and can we avoid it?	B
5. Let's consider change of preferred routing to grb-buf or yyz. Maybe we can eliminate the bottleneck over crl slt and reduce ground delays out of msp. What do you think?	C

Voice and Pointing Mode Pair #1	*Code*
No direct questions asked	-
Voice and Pointing Mode Pair #2	*Code*
No direct questions asked	-

ZID Scenario – DTW to RDU	
Text Mode Pair #1	*Code*
1. The majority were diverted to the south – please explain. [Considered equivalent to "would you please explain why?"]	A
Text Mode Pair #2	*Code*
1. Are the most extreme cases due to weather ?	B
2. Are these offloads because of arrivals into DFW?	B
3. Would a lower altitude help?	C
Voice and Pointing Mode Pair #1	*Code*
No direct questions asked	-
Voice and Pointing Mode Pair #2	*Code*
1. Why taken so far south?	A
2. How can we file a route we are more likely to use?	C

ZTL Scenario – DTW to ATL	
Text Mode Pair #1	*Code*
1. Was the reroute predictable before the flight departed?	D
2. Is it traffic saturation?	B
3. Problems with weather?	B
4. Pilot requested?	B
5. Again, what is the reason for the reroutes and was this information known prior to departure?	C
Text Mode Pair #2	*Code*
No direct questions asked	-
Voice and Pointing Mode Pair #1	*Code*
1. This flight suggests we are doing everything right as far as the route is concerned and the predicted fuel burn, and the issue is what can we do for flights at other times of day?	A
2. Are the choke points here and here, or is it strictly a volume issue in Atlanta?	C
Voice and Pointing Mode Pair #2	*Code*
No direct questions asked	-

ZFW Scenario – MSP to DFW	
Text Mode Pair #1	*Code*
No direct questions asked	-
Text Mode Pair #2	*Code*
Are flights getting rerouted because of Center transitions ?	B
Voice and Pointing Mode Pair #1	*Code*
No direct questions asked	-
Voice and Pointing Mode Pair #2	*Code*
1. It looks like Kansas is the pointer where flights get moved to the east. Why is that?	A

ZBW Scenario – DTW to BOS	
Text Mode Pair #1	*Code*
1. What is the reason for the gap in data ? [In the scatter chart]	D
2. For the most part a 9.2% increase in burn for 103 flights will add up. How can we bring this number down?	A
3. What is the reason this flight took such an extensive reroute? [This was one instance.]	A
4. It seems as if there is to much deviation from filed route on good number of flights. What is the reason for this?	A
5. It appears that there are a few different holding fixes. Why the difference?	A
6. I have noticed that this aircraft has been put into a hold at 2 different locations. What is the reason for this?	A
7. Are we checking to see if aircraft are over water equipped?	D
8. Long ground time. What caused this? [For this instance.]	A
9. Could a ground stop have avoided the hold? [For this instance.]	C
Text Mode Pair #2	*Code*
No direct questions asked	-
Voice and Pointing Mode Pair #1	*Code*
No direct questions asked	-
Voice and Pointing Mode Pair #2	*Code*
No direct questions asked	-

ZDC Scenario – MEM to EWR	
Text Mode Pair #1	*Code*
1. Would it be possible to move some of the traffic to a more northerly route and out of the DCA area?	C
2. Some flights had several thousand pounds over burn. Was that really necessary?	A
Text Mode Pair #2	*Code*
1. Is it traffic levels or ATC staffing levels that cause traffic from the south to have less holds?	B
2. Can we plan for the holding? (i.e. plan around it based on the time of day and traffic on that day)	C
3. Is there any airspace available around the DCA area where holding occurs?	D
4. Is the holding due to handoff problems?	B
Voice and Pointing Mode Pair #1	*Code*
No direct questions asked	-
Voice and Pointing Mode Pair #2	*Code*
No direct questions asked	-

ZMP Scenario – MDW to MSP	
Text Mode Pair #1	***Code***
1. Why is it that flights departing closer to scheduled departure time have longer delays?	**A**
2. Would a different time mean less delays?	**C**
Text Mode Pair #2	***Code***
1. Is this a specific sector in MSP Center airspace where there are so many off-loadings to the north?	**B**
2. Is sector staffing or combined traffic an issue?	**B**
3. Would a more southerly route help your sector controllers?	**C**
Voice and Pointing Mode Pair #1	***Code***
No direct questions asked	-
Voice and Pointing Mode Pair #2	***Code***
No direct questions asked	-

ZMP Scenario – OMA to MSP	
Text Mode Pair #1	***Code***
No direct questions asked	-
Text Mode Pair #2	***Code***
No direct questions asked	-
Voice and Pointing Mode Pair #1	***Code***
No direct questions asked	-
Voice and Pointing Mode Pair #2	***Code***
No direct questions asked	-

APPENDIX F. IDEAS FOR IMPROVING PERFORMANCE

Code	Category	Dispatchers		Traffic Managers	
		T	VP	T	VP
A	New preflight route	11	9	9	10
B	Enroute reroute	2	3	2	0
C	Change schedule	1	1	7	3
D	Ground delay/stop	3	4	1	1
E	Same route but miles in trail	0	1	0	0
F	Change Center staffs' workload / traffic volume	2	0	0	0
G	Share information to enable planning (of the fuel burn, filed route, etc.)	3	3	0	1
H	Hold at a different location	1	1	0	1
I	Change altitude	2	2	0	0
J	Fix balancing	0	1	0	0
K	Other	0	1	0	0
Totals:		26	26	19	16

ZNY																						
	A		B		C		D		E		F		G		H		I		J		K	
	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T
Text 1	X	X	X	X							X		X									
Text 2	X	X	X	X																		
VP 1	X		X				X															
VP 2															X							

ZOB																						
	A		B		C		D		E		F		G		H		I		J		K	
	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T
Text 1							X								X	X						
Text 2	X	X															X					
VP 1	X	X				X											X					
VP 2	X	X																				

ZID																						
	A		B		C		D		E		F		G		H		I		J		K	
	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T
Text 1																						
Text 2													X				X					
VP 1		X																				
VP 2	X																					

ZTL																						
	A		B		C		D		E		F		G		H		I		J		K	
	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T
Text 1						X			X				X									
Text 2	X																					
VP 1		X											X								X	
VP 2	X	X			X	X			X				X				X		X			

ZFW																						
	A		B		C		D		E		F		G		H		I		J		K	
	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T
Text 1	X	X																				
Text 2	X	X				X																
VP 1	X	X																				
VP 2	X	X	X											X								

ZBW																						
	A		B		C		D		E		F		G		H		I		J		K	
	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T
Text 1							X															
Text 2						X																
VP 1	X																					
VP 2							X															

ZDC																						
	A		B		C		D		E		F		G		H		I		J		K	
	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T
Text 1	X	X				X																
Text 2	X	X																				
VP 1		X																				
VP 2	X	X							X													

ZMP-1																						
	A		B		C		D		E		F		G		H		I		J		K	
	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T
Text 1	X	X			X	X																
Text 2	X										X											
VP 1		X				X	X	X														
VP 2			X																			

ZMP-2																						
	A		B		C		D		E		F		G		H		I		J		K	
	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T	D	T
Text 1	X	X				X																
Text 2						X		X														
VP 1													X									
VP 2																						

ZNY Scenario – DTW to EWR			
Text Mode Pair #1			
Code	**Dispatcher**	**Code**	**Traffic Manager**
A	1. Is filing through ZBW the answer to avoid holds?	A	(Response) The traffic manager indicates holding is less likely through ZBW and that the approach would be more direct.
F	2. Is the traffic balanced coming into this Center's airspace from 3 neighboring centers?		(Response) "There is a geographical balance." The traffic manager also indicates handoff holds probably due to needing to space in a complex sector.
B	3. Would a reroute be an option for flights looking at holding close to DTW?		(Response) The traffic manager referred the dispatcher to ZBW to answer the question as to whether a reroute would have been possible for this flight instance.
G	4. Knowing when holding is occurring or going to occur would help the airline file routes.		(Response) The traffic manager indicated that backing up occurs almost immediately.
		B	(Suggestion - refinement of reroute idea) Suggests if data indicates holding is likely to be at least 15 minutes it would be better to reroute to the north.

Text Mode Pair #2			
Code	**Dispatcher**	**Code**	**Traffic Manager**
A	1. It does not appear that flights that were filed on an alternate route suffered extensive holding or vectoring. Dispatchers can accommodate this better.	A, B	(Response) The traffic manager agrees with the idea of filing a northern route and also rerouting onto a northern route when holding close to DTW. He indicates rerouting before reaching the ZOB/ZNY border would be preferable.
B	2. Could we get a reroute to one of the northern routes to avoid holding close to DTW?		
			(None city pair specific suggestion) The traffic manager indicated that if the Center understood more about fuel burns it would help them evaluate the impact on the airlines when experimenting with strategies such as tunneling and reroutes.
Voice and Pointing Mode Pair #1			
Code	**Dispatcher**	**Code**	**Traffic Manager**
A	1. Could we have filed a different route to the north or south to void this? [a number of holds and some vectoring]		(Response) The traffic manager answers this question by indicating more information is needed to determine the reason for holding on each day.
D	2. Couldn't you hold us on the ground rather than shortly after departure?		(Response) The traffic manager indicates that the particular hold was probably due to problems getting traffic into EWR.
B	3. Couldn't we have been given a different routing [to avoid this instance of holding]?		(Response) The traffic manager indicates that in this case the holding was so extreme it probably would not have made a significant difference to have flown a northerly route.

Voice and Pointing Mode Pair #2			
Code	**Dispatcher**	**Code**	**Traffic Manager**
H	1. Seems better to hold in Cleveland than the New York Center		(Response) The traffic manager responded that more information would be needed to determine if it is better to hold in Cleveland than the New York Center, in terms of air-time, and that for specific instances it depends on the miles in trail applied as well as the varying skill level of the particular controller taking people out of a hold. (Response) The traffic manager indicated that in the New York Center the holding altitude is lower than in the Cleveland Center so more fuel would be burned in New York airspace when holding.

ZOB Scenario - MSP to EWR			
Text Mode Pair #1			
Code	**Dispatcher**	**Code**	**Traffic Manager**
D	1. Would a departure delay be better?	(ref) H	(Response) "ZNY uses SLT as an out all the time, maybe they can hold closer to the airport."
H	2. Could we hold closer to DTW rather than SLT to give NWA a better scenario for planning in the event the remaining fuel onboard becomes an issue?		
Text Mode Pair #2			
Code	**Dispatcher**	**Code**	**Traffic Manager**
I	1. Routes over crl slt produce holds that are more significant than grb-yyz routes. Would flying a 757 at a higher altitude help the holding situation?	A	(Response) "TYPE AIRCRAFT AND ALTITUDE WILL NOT HAVE AN IMPACT ON YOUR DELAYS HERE. ROUTING OVER YYZ THROUGH ZBW VS ZNY WILL REDUCE YOUR DELAYS. THE QUESTION IS, ARE YOU ILLING TO ACCEPT THE COST OF FILING THIS ROUTE FOR ALL FLIGHTS SURING TIS TIME."
A	2. Flights over grb-yyz seem to get off ground with less delay. Is it better to fly a longer route to reduce ground delays?	A	(Response) "The longer segment will reduce the delay, bcause the flight over GRB does not fly through busy areas until over CRL this may reduce enroute delays."

A	3. Let's consider change of preferred routing to grb-buf or yyz. Maybe we can eliminate the bottleneck over crl slt and reduce ground delays out of msp. What do you think?	A	(Response) "THIS ROUTING WILL REDUCE YOUR ENROUTE DELAYS (CRL-SLT BOTTLENEK), BUT NOT GROUND DELAYS BECAUSE OF THE ARRIVAL RATE AT EWR FOR YOUR PROPOSED ETA, REGARDLESS OF ROUTE."
Voice and Pointing Mode Pair #1			
Code	**Dispatcher**	**Code**	**Traffic Manager**
A	1. If weather isn't the issue, the northerly route looks like it will run into less traffic.	A	(Response) The traffic manager agrees this would be a better route as long as the arrival times are scheduled to avoid international flights approaching New York from the north-east.
I	2. Another solution might be to fly at different altitudes.		The traffic manager does not respond to this suggestion directly.
A	3. A different preferred route on bad weather days might help.	A	(Response) The traffic manager considers the northern route to actually be one that should be the preferred route.
		C	(Suggestion) The traffic manager suggested changing the schedule, in cooperation with the other airlines, to avoid exceeding the airport's capacity excessively and to avoid flight time "padding".
Voice and Pointing Mode Pair #2			
Code	**Dispatcher**	**Code**	**Traffic Manager**
A	1. If we filed on a northern route it might be better.	A	(Response) The traffic manager agreed a northern route through the Toronto and Boston Center should be selectively used each day depending on the runway configuration and Continental Airlines arrival traffic, so that the long holding on the current preferred route could be avoided.

ZID Scenario – DTW to RDU			
Text Mode Pair #1			
Code	**Dispatcher**	**Code**	**Traffic Manager**
	No performance improving ideas/questions		(Suggestion) The traffic manager's advice was to stay on the APE route because recent re-stratification may help, and while there are altitude restrictions, there is mit over ROD and that route would be longer.
Text Mode Pair #2			
Code	**Dispatcher**	**Code**	**Traffic Manager**
G	1. If you believe this will continue, let me know so we can try and plan for this situation.	(ref)	(Response) The traffic manager wrote, "As far as filing lower altitudes and if you should reroute those flights over ROD VORTAC on a permanent basis, you would be better served to direct those questions to Cleveland Center."
I	2. Would a lower altitude help ?		
Voice and Pointing Mode Pair #1			
Code	**Dispatcher**	**Code**	**Traffic Manager**
	No performance improving ideas/questions	(ref) A	(Suggestion) The traffic manager's advice was to leave it as it is "unless you can help us get more control of the military airspace".
Voice and Pointing Mode Pair #2			
Code	**Dispatcher**	**Code**	**Traffic Manager**
A	1. How can we file a route we are more likely to use?		(Response) The traffic manager responded that ZID concurs with ZOB that the offloading when APE is congested is the best strategy.

ZTL Scenario – DFW to ATL			
Text Mode Pair #1			
Code	**Dispatcher**	**Code**	**Traffic Manager**
D	1. Use of short ground delay for departures would help solve the wasted fuel enroute.	C	(Response) "typically at atl ground delay prgms are not utilized unless wx, & aar rates are low.(ex in the 68 - 72 range or lower.) the normal process is to utilize expanded mit restrictions & perhaps short term ground stops to facillitate traffic flows. most of the time the issue is one of compacted demand where a large quantity of a/c are schedule in a short period of time. these aircraft typically will have to spead out over the whole hour . it is possible that an earlier or later dept time could reduce the amount of holding & fuel burn for you."
G	2. Again, what is the reason for the reroutes and was this information known prior to departure. If this information is know prior to the departure it is paramount that this reroute information be passed to the dispatcher in order to comply with necessary regulations.		(Response) "during this time frame the ne arvl has significant vol & the mw arvl has limited vol. as a general the idea is to try to allow as many as possible flts to fly on their filed route. normally a decision is made in the vicinity of cvg. at this time a decision will be made as to what route works best for vol & tfc flows."
		A	(Suggestion) "most specialist prefer to have the a/c fly his filed route and will normally wait to see if they can allow that to occur. if not the a/c is routed via the nw arrivaf fix. this process may not work well for your operation, but is normally done. the reason most specialist do this is because they dont want to move the a/c unless it is necessary. plese advise if your preference is to be moved on the ground. if so you can expect that to happen most of the time due to the vol over the ne arvl fix."
I	1. Perhaps a lower altitude restriction.		(Response) The traffic manager commented there is an altitude restriction for the ChooChoo arrival, but not Rome, or Macey.

Code	Dispatcher	Code	Traffic Manager
Text Mode Pair #2			
Code	**Dispatcher**	**Code**	**Traffic Manager**
A	1. "Would it be possible keep our flights away from the rome arrival, during hub times at ATL, and avoid some of these delys we are experiencing?"		(Response) "We do tend to favor the Macey arrival fix...by this I mean we will impact the other arrival fixes earlier with increased in-trail or holding allowing the northeast fix to continue inbound...this allows the ATL airport to perform at optimum capacity...Early impact or degradation of the flow over Macey will always result in extended periods of holding, much longer than those over the other 3 fixes. It becomes nearly impossible to recover from holding at Macey and increase the feed rate into ATL...full airport capacity is never realized after this....Therefore, flights are rerouted to allow Macey to run as long as possible at full capacity. We try to do this dynamically versus static same flight reroutes in order to not impact one user any more than another."
Voice and Pointing Mode Pair #1			
Code	**Dispatcher**	**Code**	**Traffic Manager**
K	1. This flight suggests we are doing everything right as far as the route is concerned and the predicted fuel burn, and the issue is what can we do for flights at other times of day?		(Response) The traffic manager commented that 8am, 3pm, and 5pm are rush periods, with more traffic over Macey and Rome, so the filed route is normally not possible during this time, due to fix balancing, but possible during other times.
G	2. We should be advised of changes to the route so we can plan for fuel burns. If we can get information from you that flights will hold here that would be very helpful.	A	(Response) The traffic manager indicated that if the airline filed the Nashville-Rome arrival rate during heavy pushes they would get it and could plan accordingly, but it would be longer than the Macey route [which they sometimes flew]. [Thus, he didn't acknowledge flexibility at the flight instance level, but the flight level for this city pair.]

Voice and Pointing Mode Pair #2			
Code	**Dispatcher**	**Code**	**Traffic Manager**
I	1. Perhaps a lower altitude restriction.		(Response) The traffic manager commented there is an altitude restriction for the ChooChoo arrival, but not Rome, or Macey.
A	2. Perhaps a different preferred route out of DTW, coordinated with Cleveland and Chicago Centers	A	(Response) The traffic manager suggested exploring a route over Charleston, J186, and then J145, because it would not involve as much holding or altitude restrictions.
C	3. Looking at departure times, it look s like we should talk to the airport to see what arrival rate they can handle and consider spacing our departures differently.	C	(Response) The traffic manager responded on slide 2 that the 8 o'clock arrival push into Hartsville was shown and on slide 6 that it was the 2 to 3 o'clock rush period.
D	4. A delay program could have helped to improve spacing.		[The traffic manager did not respond to the idea of a delay program directly.]
G	5. Perhaps you could publish routes that we could file the flights on and plan the fuel burn, and spread them out.	A	(Response) The traffic manager explained when the three currently flown routes from DTW to ATL would be expected to be flown and proposed a new route as worth exploring.
A	6. Perhaps we should file the route most often actually flown		
J	7. Perhaps you could balance them on one arrival fix.		(Response) The traffic manager commented that the holding that took place is to balance workload and the arrival feed. He also explained in more detail the traffic flow into Rome and Macey at different times of the day.

ZFW Scenario – MSP to DFW			
Text Mode Pair #1			
Code	**Dispatcher**	**Code**	**Traffic Manager**
A	1. More often than not our flights are getting rerouted. We need to know if we should file a different route to help planning.	A	(Response) Our recommendation is to file arrivals over the arrival fix (UKW/BYP) that is working the least arrival load at that time. [It isn't clear if he means based on historic or real-time data.]

Code	Dispatcher	Code	Traffic Manager
Text Mode Pair #2			
Code	**Dispatcher**	**Code**	**Traffic Manager**
A	1. Perhaps we should work a new route or file the east arrival.	A, C	(Response) Based on the historical data presented it would appear better to change the filed route to file over BYP rather than UKW. In conducting further analysis it would be useful to also consider which side of the airport the gates for the airline are on; what the taxi-in and airborne fuel burns are for the two cornerpost approaches; and changing the arrival time by 10 or 15 minutes.
Voice and Pointing Mode Pair #1			
Code	**Dispatcher**	**Code**	**Traffic Manager**
A	1. We would prefer a route to Kansas City and then somewhere near Fort Smith for a Dallas arrival		(Response) Fort Smith would be a problem because you will run into heavy traffic coming from the northeast there.
A	Of the generic routes the one to the east over Kansas City to Tulsa would probably be the best for us. [This generic route is not the route most often filed.]	A	(Response) Routes through Tulsa are best, because that allows us to fix balance on the northwest and northeast corners of DFW and thus get you in as soon as possible that way. If we have a choice we will bring you in on the UKW (northwest) side because you park there, but there are times when there is a lot of traffic coming into DFW from the southwest through UKW.
Voice and Pointing Mode Pair #2			
Code	**Dispatcher**	**Code**	**Traffic Manager**
B	1. We should annotate on the flight plan when a flight is fuel critical because of the dogleg from Tulsa to DFW, so that perhaps we could get a more direct route into DFW.		(Response) A more direct route from Tulsa is not possible because that is a departure sector.
A	2. If this is going to happen on a regular basis, perhaps I need to establish that this is the preferred route.	A, (ref) G	(Response) There are problems with the western route because of traffic from the west and a more easterly route would run into traffic problems at Fort Smith. You might trying contacting the Kansas Center each day and try to get the heads up as to which way the switch has been thrown for traffic filed over Tulsa and then file accordingly.

ZBW Scenario – DTW to BOS			
Text Mode Pair #1			
Code	**Dispatcher**	**Code**	**Traffic Manager**
D	1. Could a ground stop have avoided the hold? [For this instance.]		(Response) "based on the data provided if the ground delay was not airline initiated it probably was an faa ground delay program. the lengthy airborn hold may have been a result of a reduced acceptance rate that occurred while the aircraft was enroute" "without all the data in front of me the only thing i can say is based on your data there was a ground delay program in effect which explains the ground and airborn holding. normally when airborn delays exceed 20minutes we will implement a ground stop"
Text Mode Pair #2			
Code	**Dispatcher**	**Code**	**Traffic Manager**
	No performance improving ideas/questions	C	(Response) "Boston is unique because of the meter program filing different routes will not necessarily be beneficial because delay are programed by a computer to make them equitable." "Ground Delay Programs are necessary to avoid overloading airports. The idea is to give the aircraft most of the delay on the ground to avoid costly airborne holding." "There are many holding patterns along a specified route. A possible reason for this holding is airlines usually schedule many flight to arrive at a certain airport at a certain time due to there fix & hub technique."
Voice and Pointing Mode Pair #1			
Code	**Dispatcher**	**Code**	**Traffic Manager**
A	1. Perhaps a different preferred route to the north or south might cause us to run into less traffic problems		(Response) The traffic manager recommended staying on the current filed route because arriving via Scupp or Providence would require crossing departing traffic out of BOS, and the metering that is used should mean the arrivals operate on a first-come, first-served basis anyway.

Voice and Pointing Mode Pair #2			
Code	**Dispatcher**	**Code**	**Traffic Manager**
D	We probably should hold on the ground in these situations where we are experiencing extensive holds.		(Response) My understanding is that the airlines would prefer the holding in the air than on the ground in case the weather has moved on when the flight gets there. "We operate on the basis that if the weather is already there we hold on the ground".

ZDC Scenario – MEM to EWR			
Text Mode Pair #1			
Code	**Dispatcher**	**Code**	**Traffic Manager**
A	1. Would it be possible to move some of the traffic to a more northerly route and out of the DCA area?	A	(Response) It is viable to move traffic through ZOB into ZNY, but a more northerly route through ZDC is not viable because of pref routes or departures out of ZNY.
		C	(Suggestion) Consider changing the departure time or the aircraft type to reduce the number of flights needed.
Text Mode Pair #2			
Code	**Dispatcher**		**Traffic Manager**
A	1. Can we plan for the holding? (i.e. plan around it based on the time of day and traffic on that day)	A	(Response) "One could always expect to hold if your route is files via the northern arrival fixes when the direction of landing is on RWY22 and the southern arrival fixes when the arrival RWY04. Times to expect enroute and arrival fix holding at these fixes is historical data that can be readily accessed from the ATCSCC or the arrival center's TMO."
A	2. Is there airspace available around this obvious bottleneck?		(Response) "unfortunately, HPW/PXT/RBV is the corridor for all arrivals to EWR from ZID/ZTL/ZJX/ZDC/ZMA/ZSA."
		A	(Suggestion) "you might want to check with ZTL to see if they would entertain a more direct route that would perhaps overfly GSO J14 RIC WARRD arvl to EWR."

Voice and Pointing Mode Pair #1			
Code	**Dispatcher**	**Code**	**Traffic Manager**
	No performance improving ideas/questions	A	(Suggestion) "The southern and northern routing [relative to Beckley] would be less likely to hold."
Voice and Pointing Mode Pair #2			
Code	**Dispatcher**	**Code**	**Traffic Manager**
E	1. I wonder if we could slow down the flight and have a smoother transition.		(Response) The traffic manager responded that the route itself was the problem as traffic from that route must be merged with an already established flow and would therefore be held for spacing.
A	2. I wonder if we could get in without a delay by taking a north west approach.		(Response) "Generally, if you come up the east side the chance of coming in with delay are less than if you come in off the west side." [The traffic manager meant the south rather than the east, which was clear because of his synchronized speech and pointing.]
		A	(Suggestion) The traffic manager indicated the best route would be over Liberty to the south of the currently filed route because it would be much easier to merge with other traffic moving up the northeast corridor.
		A	(Suggestion) The traffic manager proposed a new route coming off the currently filed route to join the route through ZOB when runway 4 is in use rather than 22 when the route through the corridor should be used.

<table>
<tr><th colspan="4">ZMR Scenario – MDW to MSP</th></tr>
<tr><td colspan="4">Text Mode Pair #1</td></tr>
<tr><th>Code</th><th>Dispatcher</th><th>Code</th><th>Traffic Manager</th></tr>
<tr><td>C</td><td>1. Would a different schedule mean less delays?</td><td rowspan="2">C</td><td>(Response) "Most likely, but I don't have that data with me."</td></tr>
<tr><td>A</td><td>2. Is it a time problem only and not dependent on the arrival fix?</td><td>(Response) "I would like to see the evening arrival schedule spread out over a 3.5 hour period starting at least .5hr earlier. The airport can only handle 60/hr. Put the problem back to marketing."</td></tr>
<tr><td></td><td></td><td>A</td><td>(Suggestion) Consider filing MDW..ALO.KASPER.MSP This route has reduced traffic. Also, consider MDW..RST.KASPER.MSP.</td></tr>
<tr><td colspan="4">Text Mode Pair #2</td></tr>
<tr><th>Code</th><th>Dispatcher</th><th>Code</th><th>Traffic Manager</th></tr>
<tr><td>F</td><td>1. Is sector staffing or combined traffic an issue?</td><td rowspan="2"></td><td rowspan="2">(Response) " This doesn't look like accurate information. I very rarely see delays of more than 14 minutes in metering and most of these are over 15. I don't experience this without weather or some other unforeseen event." "These must be weather situations. Standard traffic and metering wouldn't create delays of 25-40 minute."</td></tr>
<tr><td>A</td><td>2. Would a more southerly route help your sector controllers?</td></tr>
</table>

Voice and Pointing Mode Pair #1			
Code	**Dispatcher**	**Code**	**Traffic Manager**
D	1. Maybe we should look at a ground delay if its all the time.	D	(Response) The traffic manager agreed ground delays could be used.
		A	(Suggestion) The traffic manager commented that if the airline didn't want to see ground delays another approach would be to offload some of the other Northwest flights arriving at this time from the east coast onto a northern approach
		C	(Suggestion) The traffic manager first commented, "I agree with you this is a problem, but it's a Northwest problem. If you change your schedule by a few minutes you would miss the rush."
			(Suggestion) "Most of the time the flights are taking this busy route over TWINZ. If we offloaded the flights and go up to a northern arrival over Branard or Edward Fields, or a south arrival, we could avoid the busy route at this arrival over TWINZ with fix balancing, because the airport is only busy on this side of the airport at that time of day."
		A	(Suggestion) "These routes at this time of day, and the kind of delays we are seeing here, are a part of marketing - trying to get all the flights here at the same time in a hub and spoke system. If flow control could have more control of these flights and offload at will we could probably take care of these delays."

Voice and Pointing Mode Pair #2			
Code	**Dispatcher**	**Code**	**Traffic Manager**
B	1. Partial suggestions would be to offload some of these to the oclare3 arrival to reduce enroute and holding time.		(Response) The traffic manager responded by stating that if his memory served him correctly the time period involved was one where MSP was experiencing runway construction, which reduced the arrival rate by 10 to 16 an hour.

ZMP Scenario – OMA to MSP			
Text Mode Pair #1			
Code	**Dispatcher**	**Code**	**Traffic Manager**
A	1. Perhaps we need a new preferred route to avoid this rerouting.	A	(Response) "if on a runway 12 config —-the flight could be reouted over rwf to avoid sequencing and yes there would be a delay but it would be minimal because we could make that your only delay"
		C	(Suggestion) "if this flight were probably schedule a little later in the rush the delay would be greatly reduced""
Text Mode Pair #2			
Code	**Dispatcher**	**Code**	**Traffic Manager**
	No performance improving ideas/questions.	C	(Suggestion) "from the data you present thes effected flights are departing during a busy inbound rush on the kaspr arrival. have you considered moving these departure times either ahead or back to miss the major part of the rush."
		D	(Suggestion) "would it be helpful to consider more ground delays at oma during periods we know there is extensive delays. it is currently my understanding that nwa wants us to get the flights off the ground if there are expected delays of 30 minutes or less."
Voice and Pointing Mode Pair #1			
Code	**Dispatcher**	**Code**	**Traffic Manager**
G	1. My contention is that not letting the airline know it needed to change the route earlier lead to a high cost of the extra air time. [He was referring to a single flight instance which was rerouted.]		(Response) The traffic manager agreed this shouldn't happen, but pointed out it was a single instance and there must have been special circumstances, such as a weather event.
Voice and Pointing Mode Pair #2			
Code	**Dispatcher**	**Code**	**Traffic Manager**
	No performance improving ideas/questions.		(Response) The traffic manager commented that the delays were due to volume. She added, "we normally would ground stop aircraft that are going to be held more than 30 minutes, so I suspect some of the delay was for the approach".

APPENDIX G. DISPATCHERS' PROPOSED ROUTE DESCRIPTIONS

Dispatcher	Description of proposed route in comments	Pen/arrow marks for the route	Direct reference
ZNY Text 1	A filing through ZBW to avoid holding on the current route	Yellow pen	
ZNY Text 1	A reroute to avoid holding close to DTW	None	
ZNY Text 2	An alternate route [sometimes used] where there was not holding or vectoring	2 red arrows [on one of the alternate routes]	
ZNY Text 2	A reroute to one of the northern routes to avoid holding at DTW	None	
ZNY V&P 1	A route to the north or south of this area where holding occurs	None	Traced a path through a northerly route while speaking
ZOB Text 2	A longer route than the current route, such as grb-yyz, to reduce ground delays	None	
ZOB V&P 1	This northerly route because it appears to run into less traffic	None	Did not point at the route
ZOB V&P 2	A northern route because it didn't appears to have holding	None	Did not point at the route
ZID V&P 2	A filed route that can be flown without being rerouted consistently	None	Did not point at the route [but he probably didn't have one in mind or was being sarcastic about not being able to fly the filed route.]
ZTL Text 2	A route not involving the rome arrival because of the holding there	None	

ZTL V&P 2	A different preferred route on a lower altitude out of DTW, coordinated with Cleveland and Chicago Centers	None	Traced a route out of DTW to the east [which was not mentioned verbally.]
ZTL V&P 2	The route most often actually flown	None	Traced an average route to the west for the routes actually often flown
ZFW Text 1	A different route because we are normally rerouted	None	
ZFW Text 2	A new route or the east arrival	None	
ZFW V&P 1	Ideally a route through Kansas City to Fort Smith	Yellow pen and 4 black arrows	Drew the route with the pen while speaking
ZFW V&P 1	From the routes currently flown, Kansas City to Tulsa.	Red pen and 5 black arrows	Drew the route with the pen while speaking
ZFW V&P 2	A more direct route than the dogleg from Tulsa to DFW	Red pen [for the approach into DFW]	Drew the change in route with the pen while speaking
ZFW V&P 2	This route we are actually flying after being deviated from Kansas City	None	Traced the route of the average path within the collection of rerouted flight instances
ZBW V&P 1	A different preferred route to the north or south to avoid holding over Gardner	None	Traced a route to the north and to the south quickly, perhaps suggesting they were very approximate
ZDC Text 1	A more northerly route out of the DCA area	None	
ZDC Text 2	A flight plan to avoid predictable holding	None	
ZDC V&P 2	A north west approach on a route currently used with no shown holding, rather than one from the south west	A red arrow	Pointed at the filed northern route, but didn't trace it
ZMP-1 Text 1	A route through a different arrival fix	None	
ZMP-1 Text 2	A southerly route to help sector controllers	None	
ZMP-1 V&P 2	A route through the oclare3 arrival to reduce the enroute	None	Did not point at the oclare4 route,

	and holding time associated with oclare4		**but was busy placing a yellow arrow on the oclare3 route while making this comment**
ZMP-2 Text 1	**A new preferred route to avoid this rerouting**	**None**	