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Traffic Flow Management Tools: Guidance for Use, Integration, and Training: Phase II – Human Factors Assessment of Computer and Web-Based Training for Decision-Support Tools

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16. Abstract

Objective: In this document, we provide a review of representative computer and web-based training materials for Decision Support Tools available for Traffic Flow Management and other air traffic domains. **Background**: Our evaluation relied on our human factors expertise, knowledge of effective user interface design, and the principles of effective learning, memory, and problem solving. Our evaluation also relied on comments and feedback from air traffic controller subject matter experts (SMEs) who reviewed much of the information. **Method**: We reviewed five training modules and evaluated them on several dimensions: Purpose & Objectives, Assessments, Navigation, Content, and Pace & Level of Detail. **Results**: We found both positive and negative aspects to the training materials. The training materials were generally easy to access and use, included good narratives, and often provided written summaries of the main points. The content was generally concise and was presented in a manageable time period. The interactive aspect of the materials was useful in providing some "hands on" experience. However, the navigation structure of the training materials was sometimes cumbersome, often requiring users to return to the beginning of a section rather than to a specific slide. In addition, the use of highlighting to direct the user's attention was sometimes problematic; the colors were inconsistent or the highlighting disappeared before the user made a selection. **Conclusion** & **Applications**: Based on our review, we make several recommendations for future training material development and implementation.

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Executive Summary

In this document, we provide a review of representative computer and web-based training materials for Decision Support Tools that are available for Traffic Flow Management and other air traffic domains. Our evaluation relied on our human factors expertise, our knowledge of effective user interface design, and the principles of effective learning, memory, and problem solving. Our evaluation also relied on comments and feedback from air traffic controller subject matter experts (SMEs) who reviewed much of the information.

We found many positive aspects to the training materials we reviewed. The electronic Learning Management System and Computer-Based Instruction formats were easy to access and use. The slides included good narratives and provided written summaries of the main points provided in the narration. The content was generally concise and was presented in a manageable time period (about 1 hour or less). The interactive aspect of the materials was very useful in providing some "hands on" experience. In most cases, the materials also provided assessments during, or at the end of, the course so that users could evaluate their knowledge. The ATC SMEs working with us spoke positively about these training materials overall.

On the negative side, the navigation structure of the training materials was sometimes cumbersome. Navigation often required returning to the main table of contents and selecting a section of material rather than a specific slide. The use of highlighting to direct the users attention to different fields was also sometimes problematic. In some cases, inconsistent colors were used, or the highlighting of an item disappeared before a selection or an entry was made.

Based on our review, we make several recommendations for future training materials. The materials should: 1) clearly state the objectives of the tool and the training materials, 2) provide different training modes or different versions of training for users with different experience/background levels, 3) provide assessments throughout training and at the conclusion of each lesson so that users can evaluate their learning in an on-going manner, 4) allow users to navigate materials, as needed, to set the pace of instruction.

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1. INTRODUCTION

The purpose of project-level agreement Project Number 09.00.00—NextGen Traffic Flow Management (TFM) Tools Assessment for the Traffic Manager—is to develop a better understanding of human behavior when using the types of decision-support tools (DSTs) planned for the TFM domain and other applicable air traffic control (ATC) domains. These DSTs provide users with recommended solutions and "what if" modeling capabilities that allow users to evaluate the likely outcomes of different potential actions. DSTs typically rely on probabilistic information (e.g., weather predictions), which means that their recommendations may be less than 100% reliable. User trust in the tool is therefore a factor.

One of the project objectives is to develop training guidance for DSTs to examine how training associated with recommendation and modeling tools affects human-machine performance and to develop training guidance for these tools.

In Phase I of this project, we reviewed the literature pertaining to DSTs and NextGen Tools. We also conducted a part-task study to investigate the effect of training and tool reliability on the usefulness of a DST (Woroch, Zingale, and Masalonis, 2017). In Phase II of this project, we will review available computer and Web-based training materials for representative DSTs. This review and the results of the part-task study informed a second part-task study that further investigated the effects of training on DST use (Woroch & Zingale, in review).

This document summarizes our review of representative computer and Web-based training[1] for DSTs that assist decision making, provide recommendations, and allow for "what if" modeling capabilities. We considered the navigation structure of the training materials and the extent to which the training was interactive, whether training objectives and assessments were provided, and the level of fidelity of the training materials including the content and pace of information presentation. We emphasized the need for information to be representative of situations encountered in the field and the need to provide users with information and examples as to the conditions in which a DST is expected to be more reliable and less reliable.

2. BACKGROUND

Phase I of this project involved a literature review followed by a part-task study to evaluate the effect of training and reliability on the usefulness of a DST. DSTs are often imperfect because they rely on probabilistic information such as weather predictions to provide recommendations. Therefore, it is important for the DST user to understand when the recommendations are likely to be more or less reliable and to make use of them accordingly.

The Phase I part-task study investigated this in a preliminary way using a novel and simplified departure rerouting task based on the Integrated Departure Route Planning tool (DeLaura, Underhill, Hall, & Rodriguez, 2012; Davison, Reynolds & DeLaura, 2011). In one condition, the tool provided in the part-task study provided reliable information (i.e., recommended optimal solutions). In another condition, it provided less-reliable information (i.e., recommended less optimal solutions). All of the participants received the same training slideshow on how to perform the task. Half of the participants received additional training about the conditions under which the tool would be more reliable or less

[1] We did not review other types of training materials (e.g., classroom presentations) because they were outside the scope of this effort and are not readily available.

reliable, and the other half of the participants did not receive this additional training. Both groups completed the same test scenarios and the same sets of distractor tasks (included to influence workload), and we collected data on their performance to determine the effect of training, tool reliability, and workload.

We are currently completing data analysis for the part-task study. We expect that the results of that study will show that the participants who received additional training on DST reliability used the tool more effectively (and ultimately made better decisions) than the participants who did not receive the additional training. We expect to find that participants who did not receive the additional training about DST reliability relied more on DST recommendations in high-workload conditions, regardless of reliability, than the DST-reliability-trained participants. We reasoned that the participants who did not receive the additional reliability training would be more likely to accept DST recommendations in high-workload conditions because they would have less time to consider and evaluate alternatives on their own and that they would, therefore, perform more poorly on the task in those conditions than those who received the additional reliability training.

The results of the part-task study, in conjunction with the present document, will serve as input to a follow-up study that will focus more specifically on DST training and provide additional input to the development of training guidelines.

3. APPROACH

In this document, we provide a review of representative computer and Web-based training materials available for DSTs that are pertinent to the TFM domain and other air traffic domains. Our evaluation relied on our human factors expertise; our knowledge of effective user interface design; and the principles of effective learning, memory, and problem solving. Our evaluation also relied on comments and feedback from air traffic controller subject matter experts (SMEs) who reviewed much of the information.

We looked specifically at whether a purpose and objectives were provided at the start of each course. This information is essential for establishing the context and setting the expectations for the users so they can approach the information with an understanding of what is most important (Pintrich & Schunk, 2002). We looked for whether self-assessment questions or problem-solving activities were provided after each section and at the end of the course. Assessments are important for keeping the users engaged with the material and to determine whether they are mastering the content and the procedures necessary for completing tasks.

We assessed the user interface, including the navigation scheme implemented, to determine how easy it was for users to pause and return to previous sections to review information, if needed. These capabilities are essential for regulating the flow of information, for reviewing points made in earlier sections, or for making comparisons across sections. We assessed the content by examining whether relevant examples were provided and whether the level of detail and the pace of the presentation were appropriate for users with different levels of background knowledge or experience. We looked at whether the objectives for the examples were provided—the reason "why" a task was being demonstrated, not just the "how to" (e.g., button presses) of executing a task.

We examined the available training materials for DSTs that represented the different support categories identified in our earlier report summarizing NextGen Tools (Masalonis, Zingale, Puzen, Thomas, & Yuditsky, 2016). The support categories pertained to whether the tools: 1) provide data to assist the user's decision-making process but do not provide specific recommendations; 2) provide specific recommendations to achieve a directed result (e.g., minutes of delay to implement to achieve

required spacing); or 3) allow "what if" capabilities so that the user can evaluate different potential options before making a decision.

For each set of DST training materials, we provide comments in the following categories:

- Purpose and objectives

  Do the training materials state a purpose and set objectives at the outset? Providing an overview of the tool and the goals of training allows the users to set expectations and maintain awareness for what type of information will be presented.

- Assessments

  Are questions or problem sets provided? Providing a means by which users can evaluate their knowledge is necessary to ensure that they are meeting course objectives and expectations. Assessments should be provided at intervals throughout training and at the conclusion of training.

- Navigation

  How easy/difficult is it to effectively navigate through the course? Do the materials allow the users to pause, return to previous information, or get to different sections of information when needed to allow them to compare, contrast, and review effectively? If navigating the material is too cumbersome, it is difficult for the users to maintain concentration on content.

- Content

  Is the information provided at an appropriate level for the intended users? If the material is intended for those with little prior knowledge or experience, is information introduced with the appropriate background and context? Are different modules of training provided for users with different levels of background knowledge or experience? Providing different modules based on knowledge level would allow those with less prior knowledge to acquire basic information and those with more prior knowledge to access more challenging topics or problems. This approach helps users build and advance their knowledge at an appropriate rate.

- Pace and level of detail

  Is the flow of information at an appropriate level for intended users? Can the user stop the lesson or narration if the lesson is proceeding too quickly? Are narration topics summarized in text to allow users to scan main points when needed? As with content, the pace of the material should be driven by the intended group of users.

4. TRAINING MATERIALS REVIEWED

4.1 Corridor Integrated Weather System

We reviewed the Corridor Integrated Weather System (CIWS) computer-based training materials, designated as *Part 3 of "What's New in TFMS Release 5"* training. CIWS provides advanced weather analysis and forecasting capabilities to assist mitigation planning for convective weather events in en route airspace. CIWS provides an example of a DST that assists the user with decision making but does not provide specific recommendations.

4.1.1 Purpose and Objectives

More information about the objectives is needed:

- The training included only a general statement regarding the tool's purpose: "Provides weather decision support on the TSD…"
- There were no "Objectives" provided for training at the beginning of the course. Therefore, it was not clear what main points the users should be expected to master.

4.1.2 Assessments

There were no self-test questions or problems provided.

4.1.3 Navigation

The navigation structure was explained at the beginning of the lesson. However, at times it was somewhat confusing and inefficient. It was difficult to go back to previous information and then return to the current page.

- The narration explained the navigation structure, and the navigation tools were provided in a separate text box on the lower right of each slide (see figure 1). The standard location made it easy to locate.

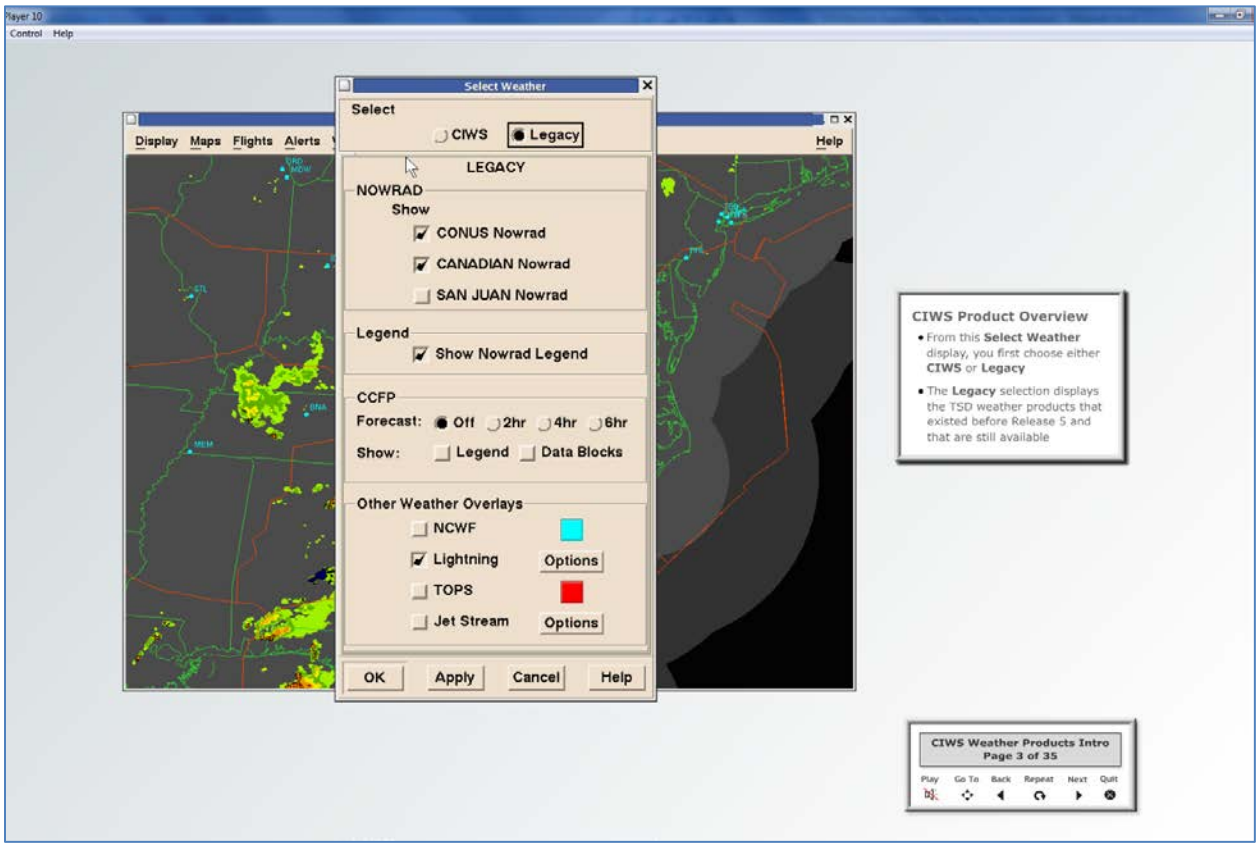

Figure 1. Slide from CIWS computer-based training illustrating the navigation panel (lower right) and narration summary (middle right).

- The "Back" button returned the users to the beginning of the last section, not the immediately preceding slide. It was not possible to use the "Next" button to go back to the current slide without going through all of the previous section in its entirety. This is cumbersome for

anyone who wants to go back to briefly review something from an earlier section or who would like to compare related material across slides.

- The "Next" button did not always function properly. This was presumably a bug. In those instances, it was possible to access the Table of Contents page via the "Go To" button in the Navigation box to find the desired section. However, as with the "Back" button, this required the users to restart at the beginning of the section and view each of the slides again before returning to the current slide.

- The narration describes which options to select to perform certain functions by highlighting them (i.e., surrounding them with a yellow box). However, mousing over the item causes the highlighting to disappear. This can be confusing if the user mouses off of the selection before choosing it. The highlighting should remain until the item is selected.

4.1.4 Content

The examples and demonstrations provided in the training materials would benefit users by providing more context on when to use the tool, which would help maximinize its effectiveness:

- The training was interactive, but it focused more on guiding the users through the steps on how to conduct the tasks (e.g., what buttons to press) than on providing information about the goals of the tasks (e.g., why the task was being performed). The goals of the task should be stated before the demonstration begins so that the users can consider what they would do to achieve the goal. This allows them to determine which steps are intuitive and which require more effort to master.

- It is useful that different weather scenarios are presented, but this would be improved by providing more information about the goals and objectives for each of them. For example, the training would be improved by explaining why the users would want to examine "Growth and Decay Trends" (e.g., what goal is to be achieved) before explaining how to interact with that option.

- Additional information is provided via links in the text box containing the narrative summary. For example, new CIWS features are presented and described when the users select the "CWIS Product Summary" link. However, the users do not always have to view the link information before moving to the next slide. The different types of links (i.e., mandatory versus non-mandatory) should be clearly indicated.

4.1.5 Pace and Level of Detail

The pace and level of detail appeared more appropriate to users with existing background knowledge and may be less effective for those with less experience. The information appears well organized, but is very detailed:

- Overall, plenty of weather information and information about the tool's capabilities was provided. It is not clear what background knowledge is expected of the users.

- It is useful that most of the narration topics are summarized in the text box on the right side of the slide (see figure 1). This allows users to reference the information as needed.

- It is very useful that this set of training materials provides opportunities for the users to experiment with different options on some of the slides such as turning on and off different precipitation levels to determine what each level displays. The different options were explained

in sufficient detail and with a manageable pace for users with different background knowledge levels to understand.

4.2 Time Based Flow Management

Time Based Flow Management (TBFM) is a metering tool that spaces aircraft to meet a scheduled time of arrival (STA) at an airspace boundary or airport. The delay required to meet an STA is distributed among en route sectors and the Terminal RADAR Approach Control (TRACON) to reduce the impact on any one controller. The automation may recommend solutions in the form of speed advisories that the controllers can choose to implement. Alternatively, they may select another means to implement the required delay. TBFM training is divided by operational function, and we reviewed each of the modules available for en route and terminal controllers and for traffic managers.

4.2.1 Purpose and Objectives

The overall purpose of the tool is described at the start of the training package. The training begins with a video of high-level management and union representatives explaining why use of the tool is important and how its functions tie in to the view of the future. A summary of what will be covered in each lesson (see figure 2) gives the users a general sense of what to expect, and specific objectives are outlined at the beginning of each lesson.

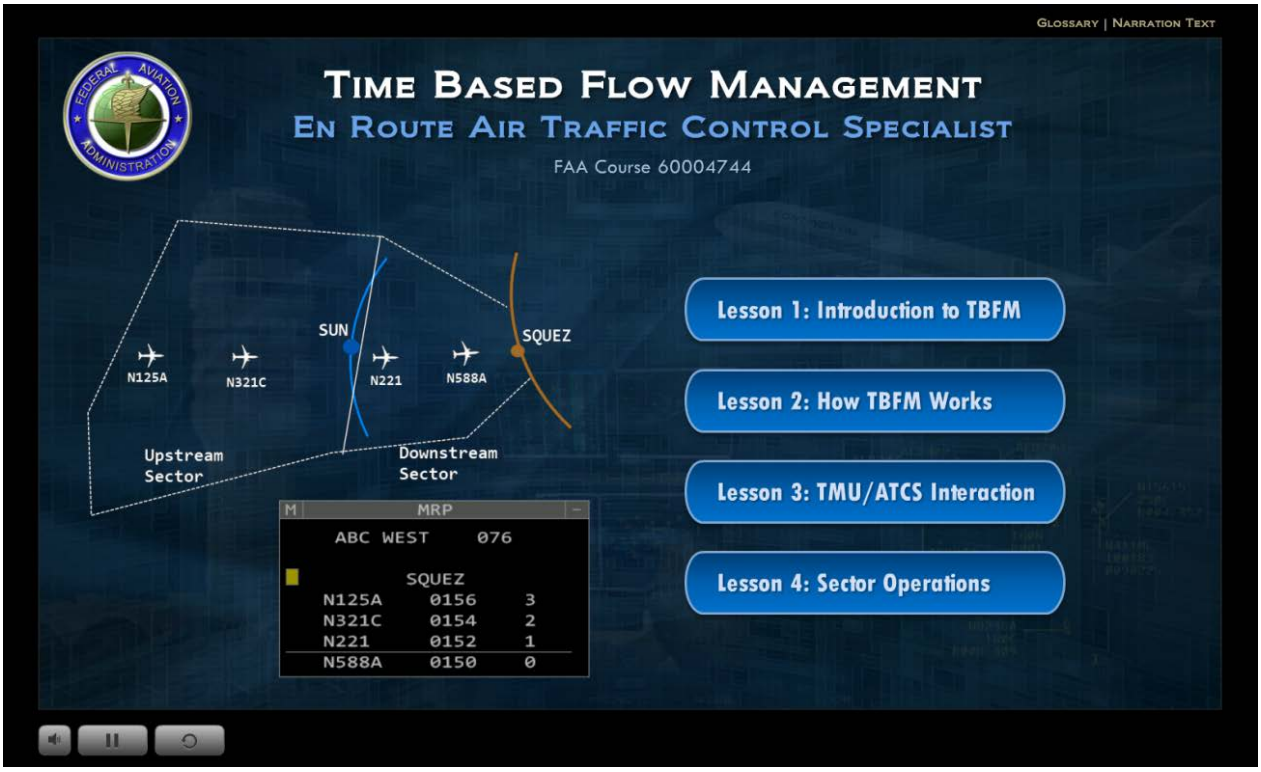

Figure 2. TBFM training begins with an overview of the lessons.

4.2.2 Assessments

An assessment is provided at the end of each lesson. It includes multiple-choice questions and some interactive questions in which the users must execute an action. If an incorrect answer is selected, the audio explains why it is incorrect and allows the user to try again. A score of 70% is required to pass, and additional assessment items on the failed topics are presented if that score is not achieved.

4.2.3 Navigation

Navigation through the lessons is fairly well structured. Users are not allowed to move on until the current page is completed, but they can go back to previous slides or repeat the current slide at any time:

- Easy-to-use controls are provided for navigating through the training or back to previously completed topics.
- A flashing arrow by the "Next" button makes it very clear when users should move on to the next topic.
- The indication used to draw attention or highlight something (i.e., a yellow box) is not always obvious and could be easily confused with other displayed objects (see figure 3). When this occurs, it is difficult to follow on screen what the narration is describing.

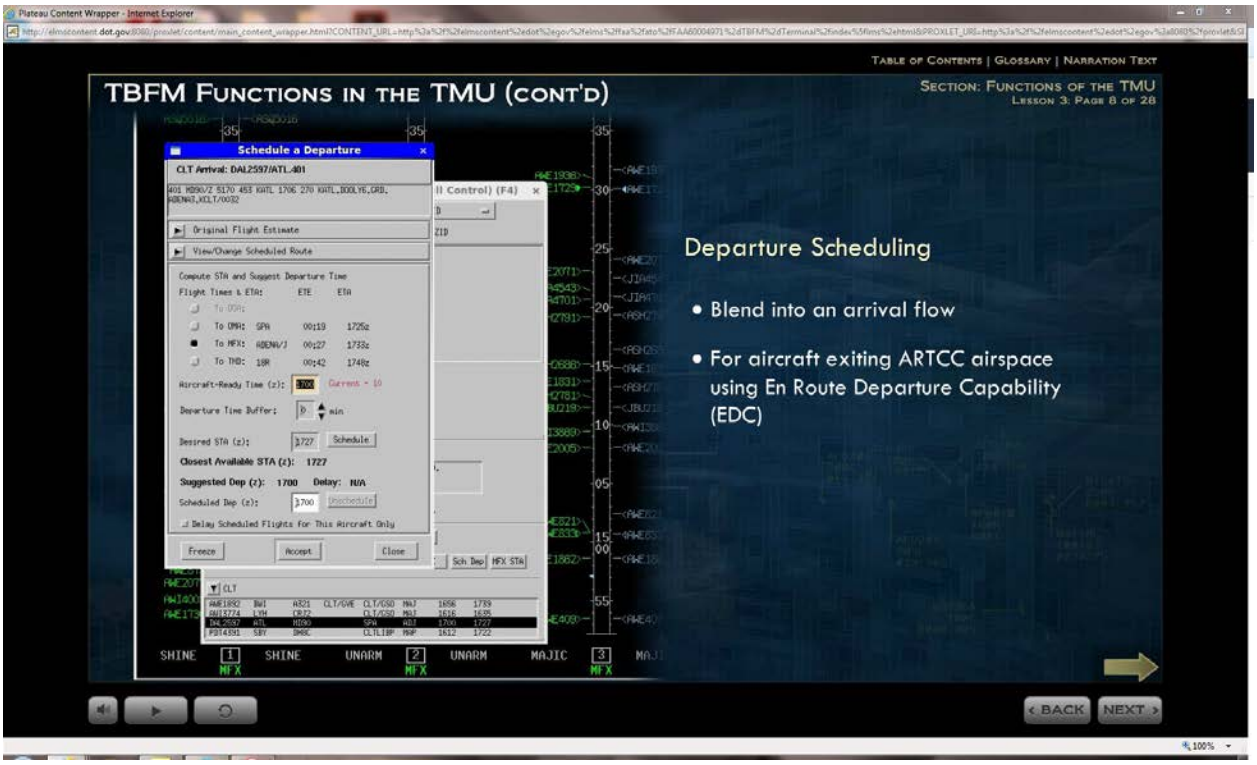

Figure 3. TBFM training slide illustrating the use of highlighting.

4.2.4 Content

The training provides high-level and detailed information on the tool. It explains the general philosophy of what the automation is trying to achieve, the recommendations that it will provide, and the options that will be available to users. It also provides clear direction on the actions that should be taken to accomplish relevant tasks or that should be applied in specific situations:

- The training does a very good job of explaining when, why, and how metering operations may be impacted (see figure 4). Similarly, it describes situations when users may encounter an unusual or unexpected system behavior, and it provides guidance on what to do in such situations. For example, the training explained why a speed advisory may not be provided for a metered flight. This information is very valuable for enhancing users' understanding of the tool and preventing situations in which users are confused by such a situation in the operation.

Figure 4. TBFM training explanation of factors that may impact metering.

- Concrete examples and graphical depictions are used to solidify the understanding of general concepts. The illustration in figure 5 provides a concrete example of how delay is distributed among sectors/facilities and applies specific delay capacities.

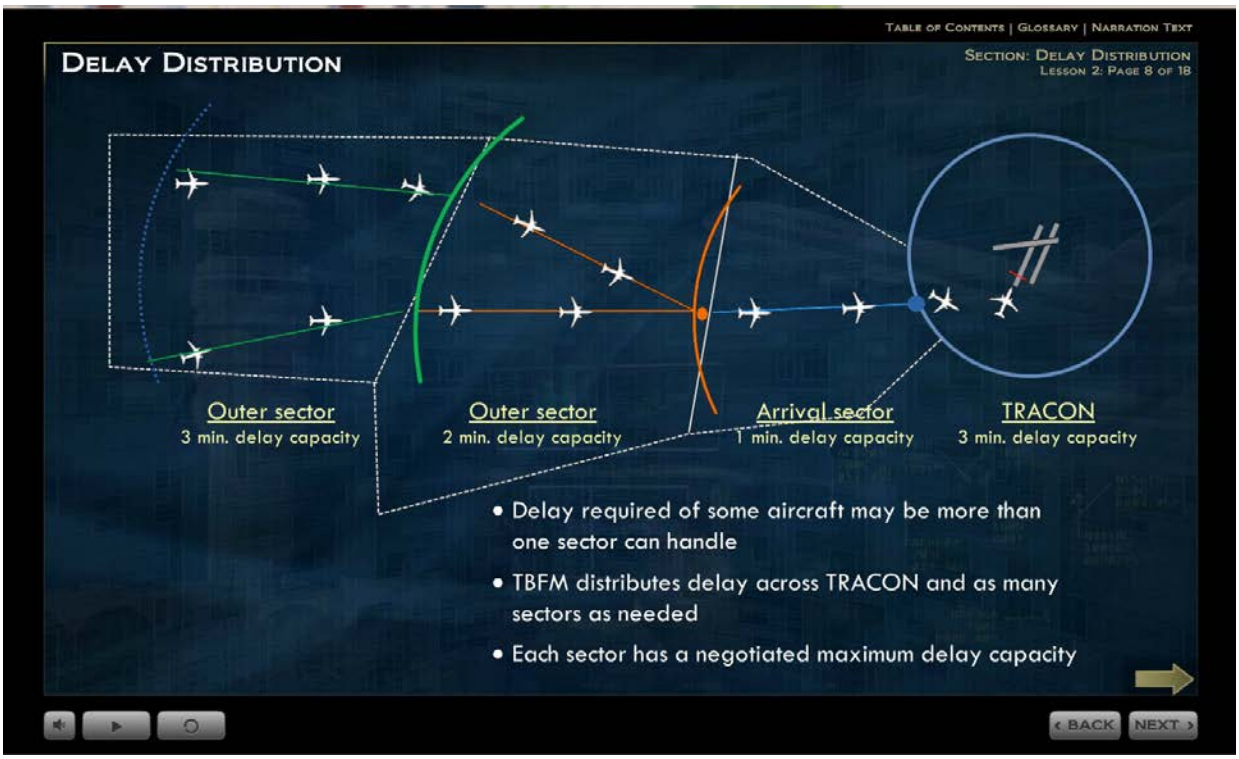

Figure 5. TBFM training use of graphics and concrete examples to solidify high-level concepts.

- Though the training is very good overall, there are a few instances in which it provides high-level information when a more detailed description would be beneficial. An example is the discussion of how traffic managers would use Load Graphs to evaluate when metering should begin or end. The training displays the Load Graph but provides no explanation of what it represents or what the traffic manager would be comparing in the graph. This is part of the en route controller module, not the traffic manager module, and maybe was deemed to be non-critical for that reason.
- The language used by the narrator was sometimes fairly technical and non-conversational. Use of plain language would make the information presented more accessible and a better match to the displayed text, which was simple and to-the-point.

4.2.5 Pace and Level of Detail

Overall, the training proceeded at a very manageable pace. The level of detail increased as the training went on and the user's foundational knowledge on the topic increased.

4.3 Collaborative Trajectory Options Program

The Collaborative Trajectory Options Program (CTOP) computer-based training materials are designated as part of Traffic Flow Management System (TFMS) What's New in TFMS release 9. Its format is similar to that of CWIS. CTOP allows collaboration between the airlines and TFM to reroute aircraft while balancing demand with capacity. The CTOP training materials contain very detailed demonstrations of functionality. It was covered in two parts consisting of mandatory and recommended components. Part 1 covered more basic tool functionality, and Part 2 provided more detailed Command Center and en route Traffic Management functions. The ATC SMEs commented

that it was one of the most useful sets of training materials for an operational tool that they had encountered. The SMEs suggested that it would further enhance training to have users gain some experience using the actual tool itself after completing Part 1 of the training and before moving on to Part 2.

4.3.1 Purpose and Objectives

The overall purpose of the tool and the goals for training are provided, but specific objectives should also be presented for each of the individual units and functions described:

- The overall mission and projected benefits of the tool are provided as is a description of the differences between the previous tool's capabilities and the new functionality (see figure 6). However, given the detailed nature of the training, objectives should also be provided for each unit and individual functions.

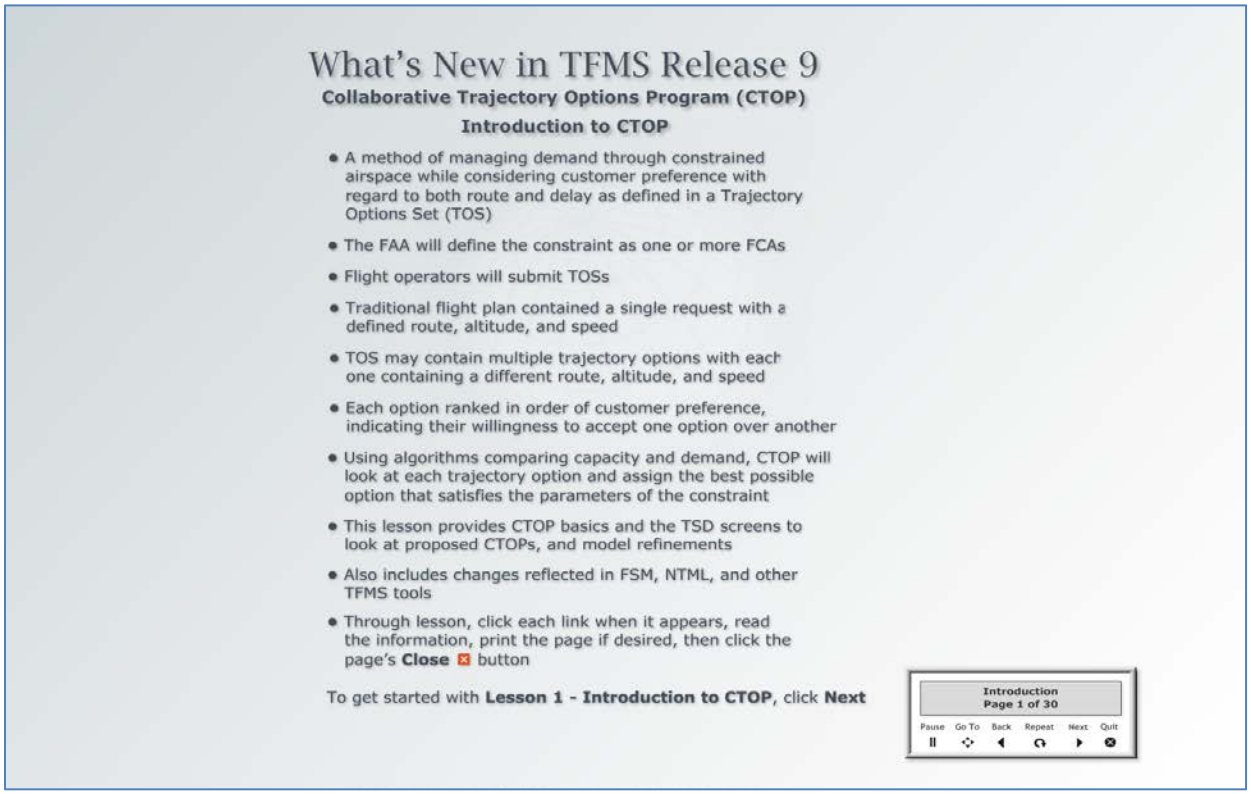

Figure 6. Introductory CTOP training slide.

- The training would benefit by providing an explanation as to how doing the job with the tool differs from doing the job without the tool. This computer-based instruction (CBI) takes a step in the right direction to provide that context, but this theme should be expanded to include different examples.
- Useful lesson summaries were provided at the end of each section and at the end of Parts 1 and 2. However, interim summaries at the end of each subsection would also be useful to aid comprehension and retention of the information.

4.3.2 Assessments

More opportunities to evaluate learning should be included:

- Training would be improved by providing users a way to apply what they learned throughout training (i.e., to provide questions or problem-solving activities to achieve stated objectives at the end of each unit and at the end of the course).
- Similar to the CWIS training, too much emphasis is provided on showing how to execute functions and not enough emphasis on why those functions are being performed. It would be useful to include hands-on exercises to provide users the opportunity to apply problem-solving skills to implement a solution.
- The users should be able to try out what is being demonstrated. It would be useful to provide the users with a non-operational version of the fully functional software so they can try working with different options and apply what they have learned.

4.3.3 Navigation

Some aspects of navigating the training materials were confusing. Some of the navigation problems appeared to be errors/bugs, suggesting that the software needs to undergo more testing before it is released:

- A useful "Go To" function is available for navigating to different sections of the training. However, it does not allow users to navigate to the section they were on prior to selecting the "Go To" option. "Go To" is disabled when that section is selected. Ideally, users should be able to go to the current page the same way they used "Go To" to get to any other page.
- The "Next" button was only made available at the end of a section, but this was not obvious. Users should be able to easily determine whether an option is or is not available.
- There were inconsistent behaviors during the interactive parts of the lesson. Sometimes users were able to select or enter an item other than the correct one indicated by the narration. At other times, users were required to select an option or enter text exactly as specified before the lesson proceeded. The subsequent slides often presented the expected information, which could cause confusion. For example, if the directions said to select "1630" from a drop-down menu, but the user selected "1645", the slides would advance but show "1630" as having been selected.
- During interactive segments, some slides required that users perform a sequence of steps exactly as designated, even though this sequence is not required by the actual tool. In the training materials, if users did not proceed as per the order designated, the slides did not always advance, and there was no indication as to why.
- During interactive segments, color highlighting surrounded the button or option that the narration indicated should be selected. That highlighting disappeared when users moused over the item rather than waiting for the users to select it. The highlighting should remain until the item is selected to clearly indicate the option under discussion.
- Some of the slides contained links that had to be selected before users could proceed. However, other links were not required to be selected before proceeding. The links should behave consistently or be clearly differentiated from one another.

- The use of color to highlight items was inconsistent. On some slides, items highlighted in green were not selectable. Instead, green was used to direct attention to the item. On other slides, the narration described that items highlighted in green should be selected. Color coding must be done consistently. Different colors should be used to differentiate the types of actions expected.
- It was sometimes difficult to find an item being described by the narration even when highlighting was provided because the CTOP screens are visually dense. Additional mechanisms for highlighting and emphasizing (i.e., enlarging the item for a brief time) and a slower pace of narration would be useful. When users are devoting attention to searching for an item, they are less able to attend to the content and may miss important material.
- Navigation/narration should clearly indicate when the users are to select "Next" from the Navigation window or within the CTOP window. The "Next" button in the Navigation window should be highlighted or flashed when it is time to move to the next slide.
- It would be useful to have rewind and fast-forward options available, possibly through a slider bar that would allow users to return or advance as needed to specific areas within each lesson.
- It appeared that on some slides, the interactive elements and the narration could be skipped by selecting the "Next" button, thereby allowing users to skip segments of the lesson.

4.3.4 Content

Content in the CTOP training materials was very dense and may be especially difficult for users with less experience to manage. The flight information window in figure 7 provides a good illustration of how much information is presented on a slide. There should be more description provided and sections of slides highlighted to direct users on what area is being described.

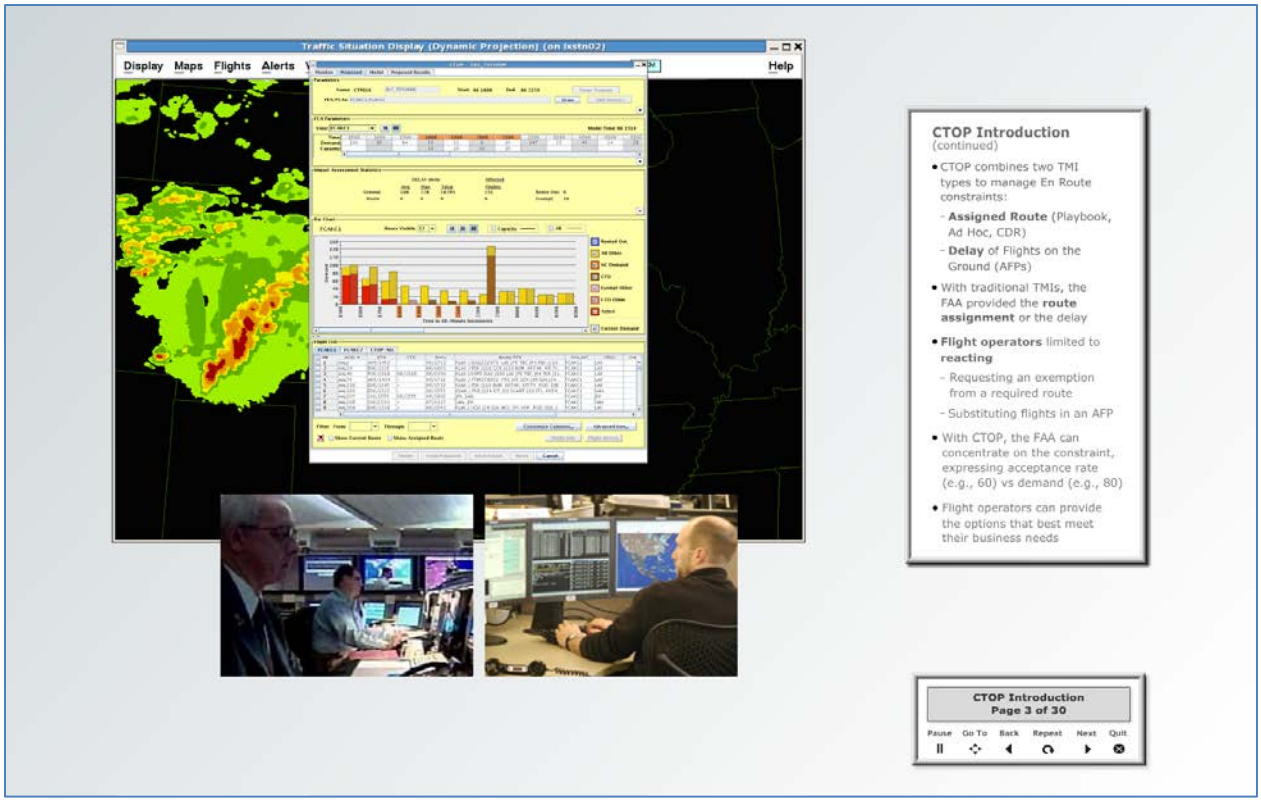

Figure 7. Sample slide from CTOP training illustrating density of content presented.

- One of the ATC SMEs commented that the level of detail and much of the content and demonstrations provided made it more suitable for on-the-job training rather than computer-based training.
- There are segments of training that provide guidance on how the functions may be used in real operations (e.g., entering a parameter value that is different from the default). More of this would be useful. It would also be useful to distinguish procedural (i.e., how to perform the actions) and functional information (i.e., why the actions are performed) so that the users have the appropriate context.
- There are instances in which the training describes new features by pointing out when they are not available to use and why. It would be more effective to provide concrete examples demonstrating the tool's features and clearly explaining under what conditions they are or are not available.
- Information is provided to show how the tool works in conjunction with other available tools (see figure 8 for an example). This is useful for establishing how the tool fits within current operations.

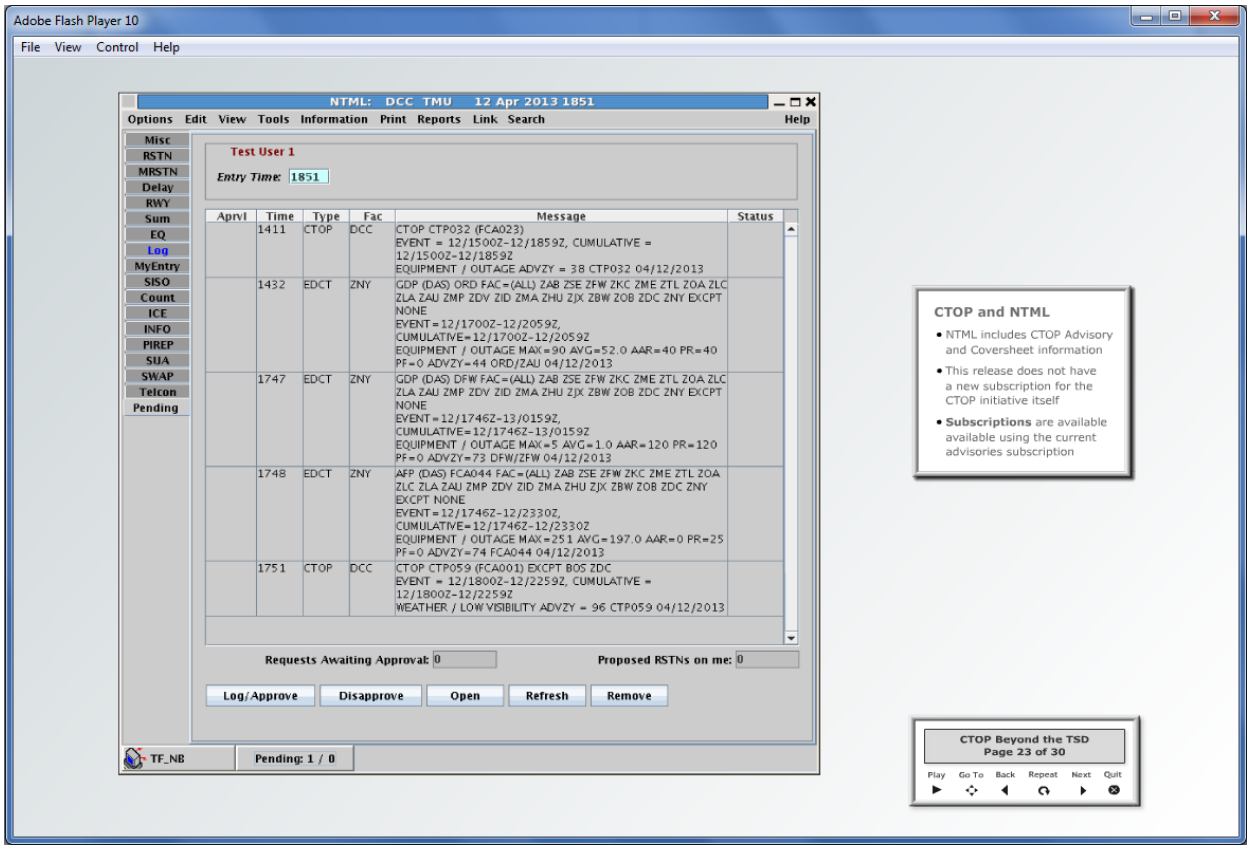

Figure 8. Training describes how CTOPs will be integrated in the National Traffic Management Log.

Many acronyms are presented without definitions. Tool tips should be provided for them. Most of them are defined somewhere in the slides but having the tool tips would be more convenient.

The training materials do not allow users to explore options other than the ones the narration walks them through. There should be opportunities provided to test other functions and features outside of the structured lessons.

Some of the narration gets very detailed, but visual indicators are not always provided to support the description. For example, accompanying the display in figure 9 is a complex explanation of how the user can filter the list of Flow Constrained Areas (FCAs) by unchecking the boxes at the top. It would be beneficial to also illustrate the impact of unchecking those boxes on the list of available options.

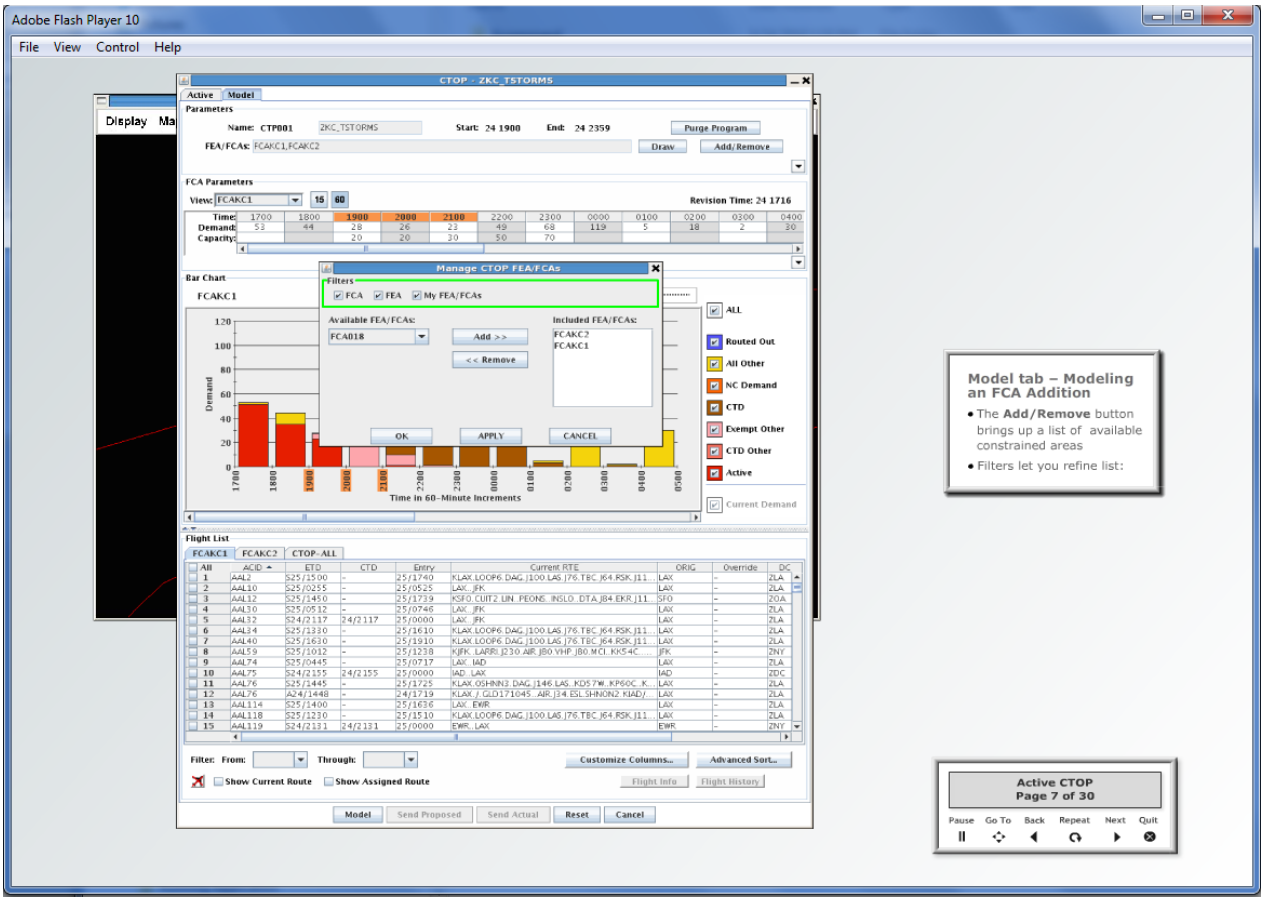

Figure 9. CTOP training slide on filtering the list of available FCAs.

4.3.5 Pace and Level of Detail

The slides sometimes presented too much information or provided narration without supporting visual materials. For example, Figure 10 is one of the final images in a section that described all of the elements listed in the text box on the right. The narration also continued beyond this list to describe some of the interactive components that are available in the tool, but they were not added to the text box.

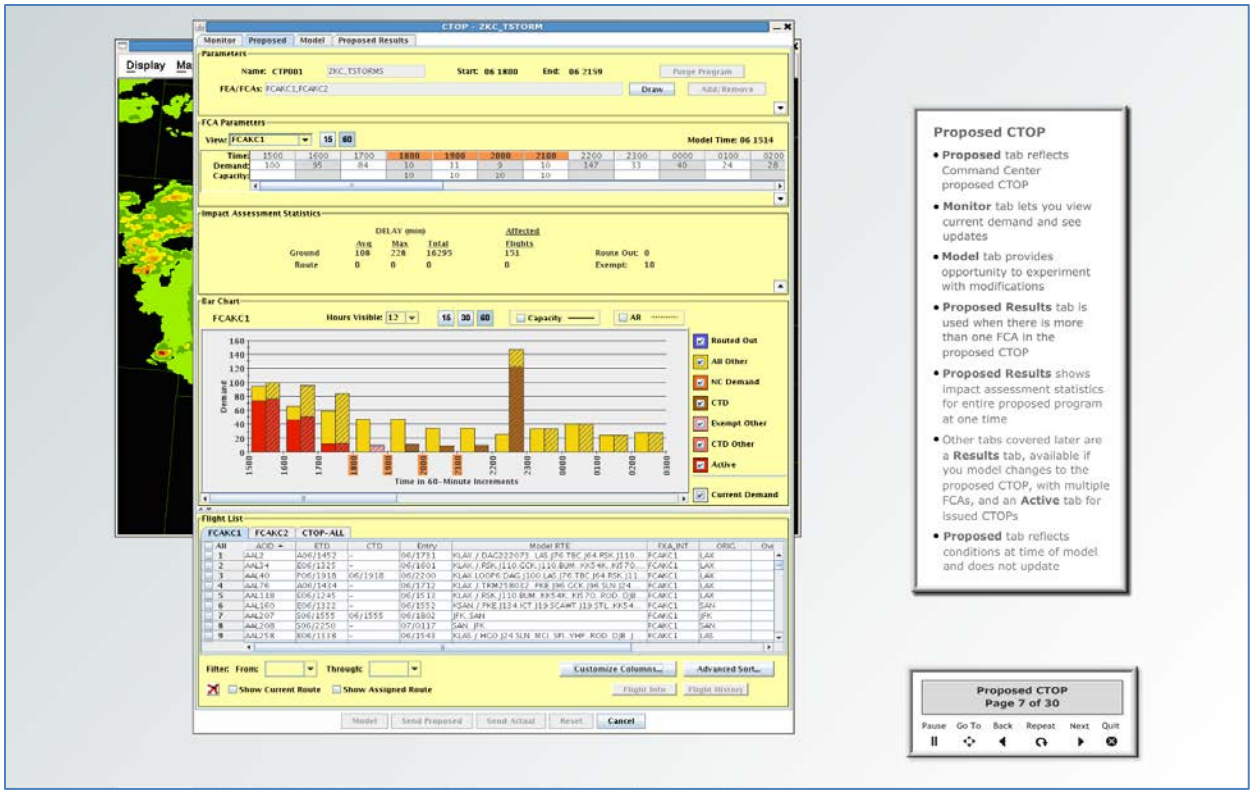

Figure 10. An example of a CTOP training section that covered too many topics. Some, but not all, of those covered are listed in the text box on the right.

4.4 Reroute Impact Assessment

The Reroute Impact Assessment (RRIA) tool is similar to CTOP in that both tools provide "what if" capabilities to TFM to evaluate the impacts of potential mitigation plans. The training is presented in a style very similar to the CTOP CBIs, but this training was developed in 2010, with a less-refined set of tools. As a result, it has some additional problems, such as too much interactivity that serves no purpose, too many links to additional information, and lack of illustrative examples.

4.4.1 Purpose and Objectives

The training provides an overall purpose and summary but could be enhanced by providing more specific objectives and summaries within each section.

- An overall purpose and objectives are provided for this set of training materials, and the introduction provides a good overview of the tool and its operational relevance.
- Each subsection would benefit from having objectives stated at the beginning and summarized at the end.
- The summary at the end is good but could be improved by reminding users about the operational situations in which they will be able to use the information.

4.4.2 Assessment

No self assessments are provided.

4.4.3 Navigation

The training materials allow the user to navigate using the "Go To" option consistently. However, highlighting is often difficult to notice and removed too quickly for it to be effective.

- There is no pause option available in this training packet. The ability to pause allows users to catch up with the CBI or handle a distraction without losing their place or missing content. Not being able to pause is especially problematic in this training because the information is very dense and often requires additional time to comprehend.
- It is possible for users to use the "Go To" option to navigate to the current slide just as they would go to any other slide. The consistency is useful.
- Some of the highlighting is difficult to notice and, therefore, ineffective. Most highlighting is done in yellow, but when the display background is yellow, highlighting uses a gray color. The gray color on the yellow background is very difficult to notice.
- The highlighting is often removed too quickly before the intended item has been noticed. It would be useful to maintain highlighting so users can consistently locate the item being described.
- There are too many instructions given to click on things, and some of the examples require multiple steps to complete. In many cases, these interactions add little to the learning experience. Instead, they disrupt the flow of the lesson, take up valuable training time, and are sometimes difficult to follow. In figure 11, for example, users are instructed to turn on labels for the ARTCCs when this has no bearing on the feature being taught.

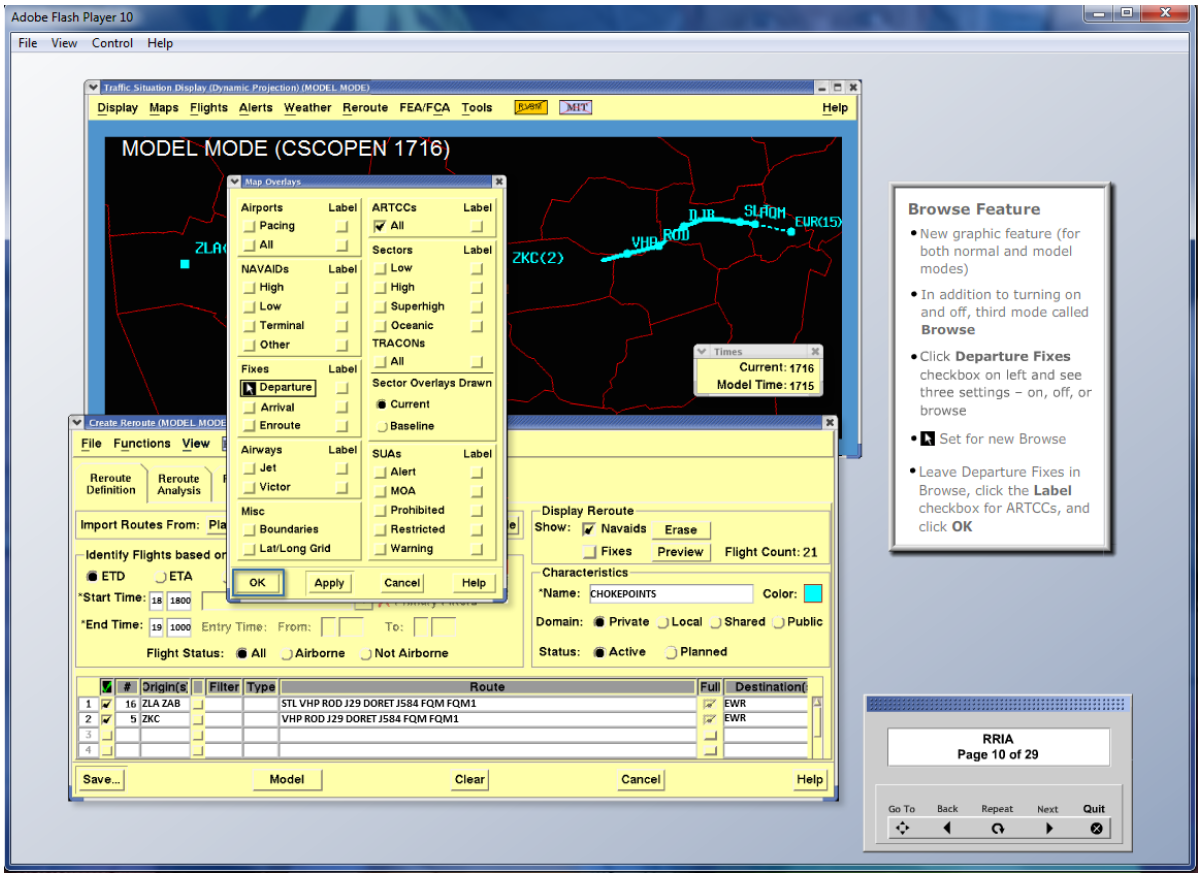

Figure 11. RRIA training example illustrating unnecessary instructions.

- Sometimes users must select a link before being allowed to proceed to the next slide, but at other times they do not have to select the link. Required and optional links should be made distinguishable from one another.
- Sometimes users can enter incorrect information or choose the wrong option, and the slides will still proceed. At other times, the exact entry expected must be made before the slides proceed.
- It is useful that some slides allow users to select different options to learn about what they do. Users can select them in any order, and the other related elements on the display also update accordingly (e.g., see figure 12). The narration provides the description related to the selected item. This is a novel approach for this CBI and the others like it and provides a welcome reprieve from the standard presentation style.

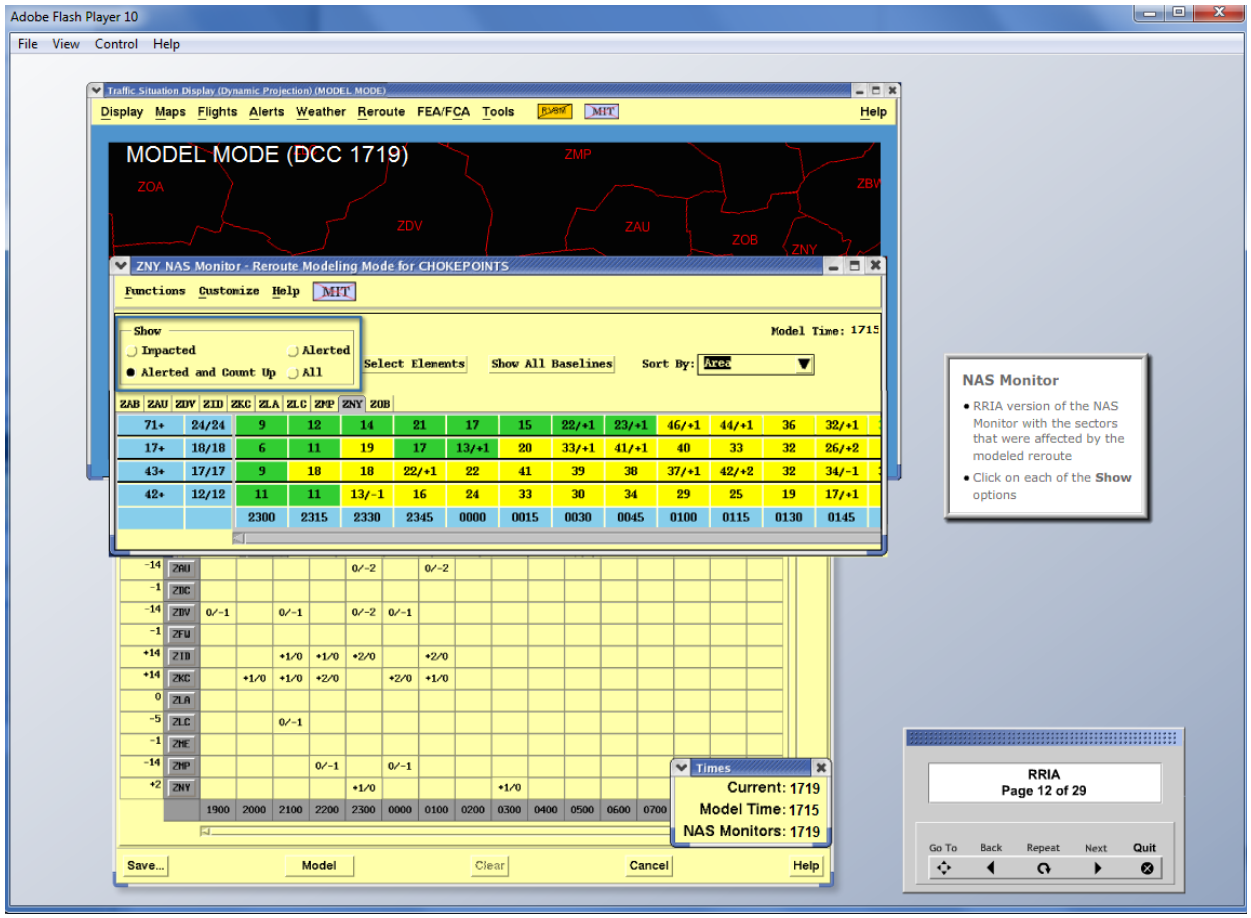

Figure 12. RRIA training example in which the user can guide the training.

- Some unexpected behaviors occur when the script is not followed exactly. The software should be better equipped to handle departures from the script.

4.4.4 Content

The training provides information on when the modeling results may be less useful. However, the information is very detailed and may be difficult for users with less background to understand.

- The training materials provide useful information on new options—tabs, buttons, and checkboxes. However, it is lacking information as to when the tool should be used. It does not describe the benefits of using the tool and why it would make the traffic manager's job easier.

- Useful information on how the algorithm works and when modeling results may no longer be reliable is provided. This is very helpful in assisting users to better understand when the tool will be more or less reliable.

- The information in this set of training materials is dense and would appear to be difficult for someone with less background knowledge to fully understand (see figure 13). As with other training materials, different modes for users with different levels of background knowledge would be useful to allow users to select the appropriate level of information. Breaking up the content into more manageable sections enables easier comprehension.

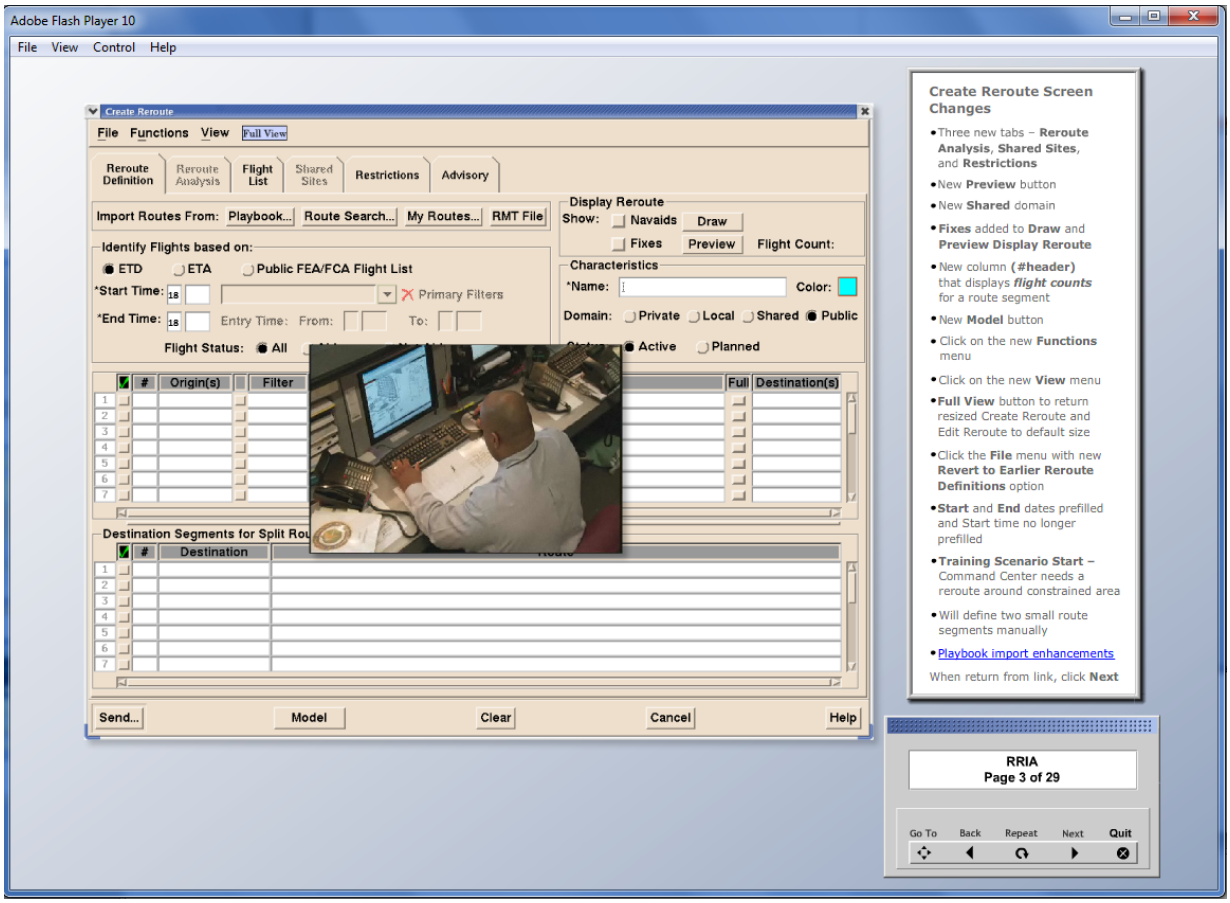

Figure 13. RRIA training example of a detailed topic. All of the elements covered in this one section are listed in the text box on the right.

- There are many instances in which the training presents tools and features, but it does not describe their function or how they are used. For example, users are instructed to expand a menu and view the new options, but the training does not provide any information about what those new options are or how to use them.
- There are too many links to additional information. Many of the topics covered in these linked documents would benefit from an interactive illustration and should be incorporated into the CBI.

4.4.5 Pace and Level of Detail

The pace of the material may be too rapid for users who have less background knowledge.

- The target audience for this training ranges from command-center specialists who are very familiar with the functions being discussed to traffic managers at the field sites who have no experience with these functions. This CBI moves too rapidly through many topics that would not be familiar to the less experienced users.

- It appears that an attempt was made to manage the level of detail by providing more detailed information for some topics in linked documents. However, depending on the knowledge level of the user, this may be counterproductive.

4.5 Integrated Departure Spacing Tool

The Integrated Departure Spacing Tool (IDST) is intended to improve information sharing between the tower, center, and TRACON by allowing the tower controller to conduct electronic coordination of a Call for Release or Approval Request. Coordination was previously conducted exclusively via telephone. IDST primarily streamlines the coordination process but does provide some decision-making support via the timeline display codes that schedule times within which a flight can be placed without conflicting with any existing constraints.

4.5.1 Purpose and Objectives

The course states that it is intended for center and TRACON traffic managers and front line managers who would primarily use the tool for monitoring. They would interact with it less than the tower controllers. However, much of the course content describes how to perform tasks in the tower environment. Center and TRACON personnel can benefit from an understanding of how tower personnel use it, but the details provided in this presentation may be distracting because they are very specific to the tower tasks.

4.5.2 Assessments

It is useful that self-check questions are provided throughout the course, and a 20-question assessment is provided at the end of the course:

- For some assessment questions, it is possible to select an answer correctly because users can execute the steps correctly, not necessarily because they know what is to be accomplished. The question shown in figure 14 provides an example. Rather than requiring users to simply execute steps, the questions should be set up to allow users to make decisions about the actions that need to be taken before the steps are executed (i.e., why they would need to access the Constraint Information Tables).

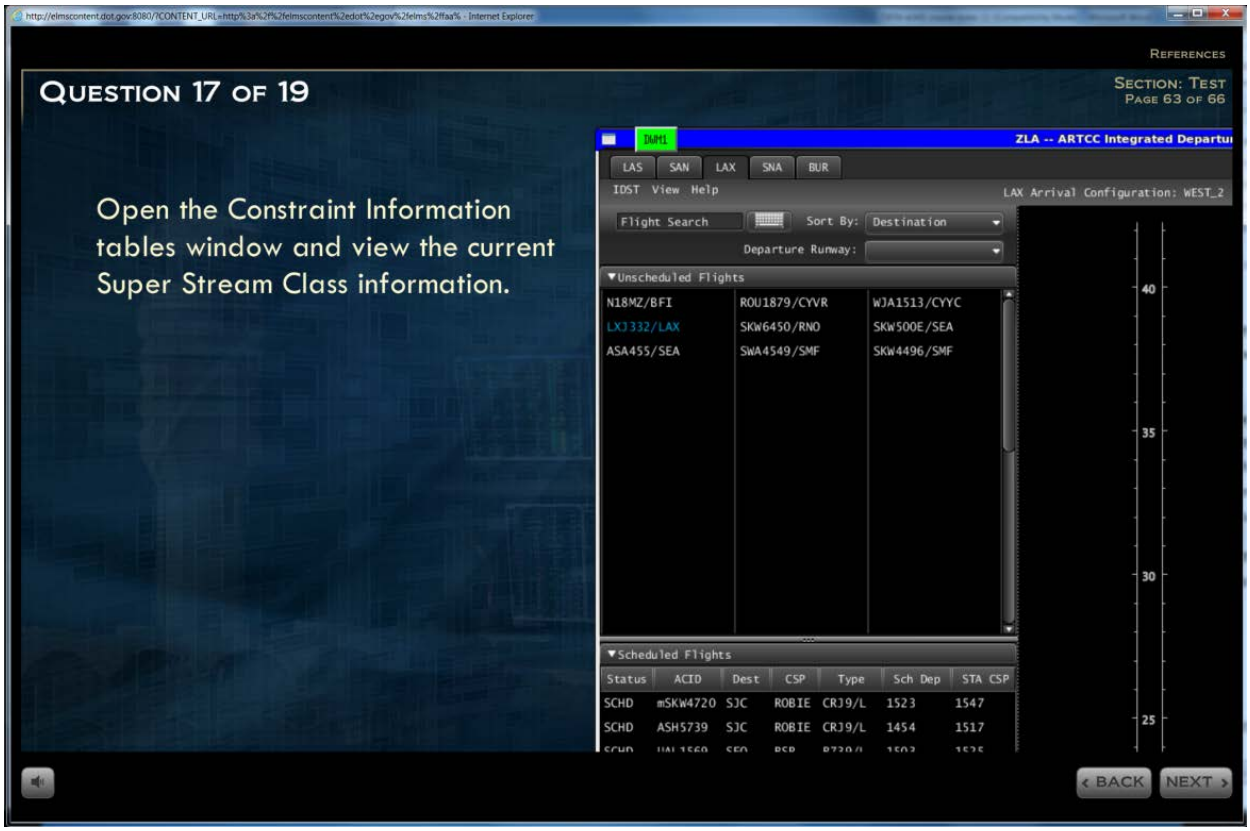

Figure 14. Sample question from IDST end-of-course assessment.

- The end-of-course assessment requires a minimum score of 70% to pass. If users do not achieve at least 70%, they must complete supplementary questions. Those questions appear much more basic that the questions in the original set.

4.5.3 Navigation

The training materials allow users to navigate through the slides as desired once the course is completed.

- The training materials allow users to pause and resume the lesson. However, as with other training materials, if users select the "Back" button, they return to the beginning of the previous section that they must then complete before continuing on.
- It is a useful feature that once the course is completed, users can navigate as desired and go to any slide in whatever order is chosen to review and compare material across sections.
- As with other training materials, it is easy for users to get lost in the details of button presses without necessarily understanding why the steps were being conducted.
- IDST uses several different auditory tones, and these are presented briefly during the training course. It is questionable whether users would be able to differentiate and interpret the different tones from such a short exposure. It would be useful to present them in several places throughout the lesson so users could gain familiarity with them. It would also be useful to ask about the tones in the self-assessment questions.

4.5.4 Content

The content is applicable to users from many different domains.

- IDST is a complex tool that has implications for many users across many domains. It is intended to help minimize the need for telephone coordination among tower, center, and TRACON personnel. However, the training indicates that some options still require users to notify others of their decisions and actions by telephone. This presents an additional burden to the users' memory unless clear prompts are provided as to when this is or is not necessary to contact others. This was not clearly explained in the training course.
- The content intended for center and TRACON users is manageable because their use of the tool only involves viewing information (e.g., sorting by airport), not making decisions or modifications.

4.5.5 Level of Detail

The training materials provide much detail and proceed at a rapid pace, which may make it difficult for users with less background knowledge to keep up.

- The details provided for tower use are very fast paced. The course includes very rapid sequences of button selections to demonstrate how tasks are accomplished. User-controlled pacing would better allow users to regulate the content flow, comprehend the information, and retain the information for future use.
- The fast pace makes it more likely that people with less background knowledge would have difficulty acquiring the information they need. As with other training materials, it would be useful to have a basic mode and an advanced mode so that users can access the appropriate level of detail for their needs.
- The training materials illustrated many of the multiple IDST options available. The options include color coding. For someone with less background knowledge, the color code can be confusing (see figure 15). This part of training should be conducted more slowly to present in a more detailed manner what each color option indicates.

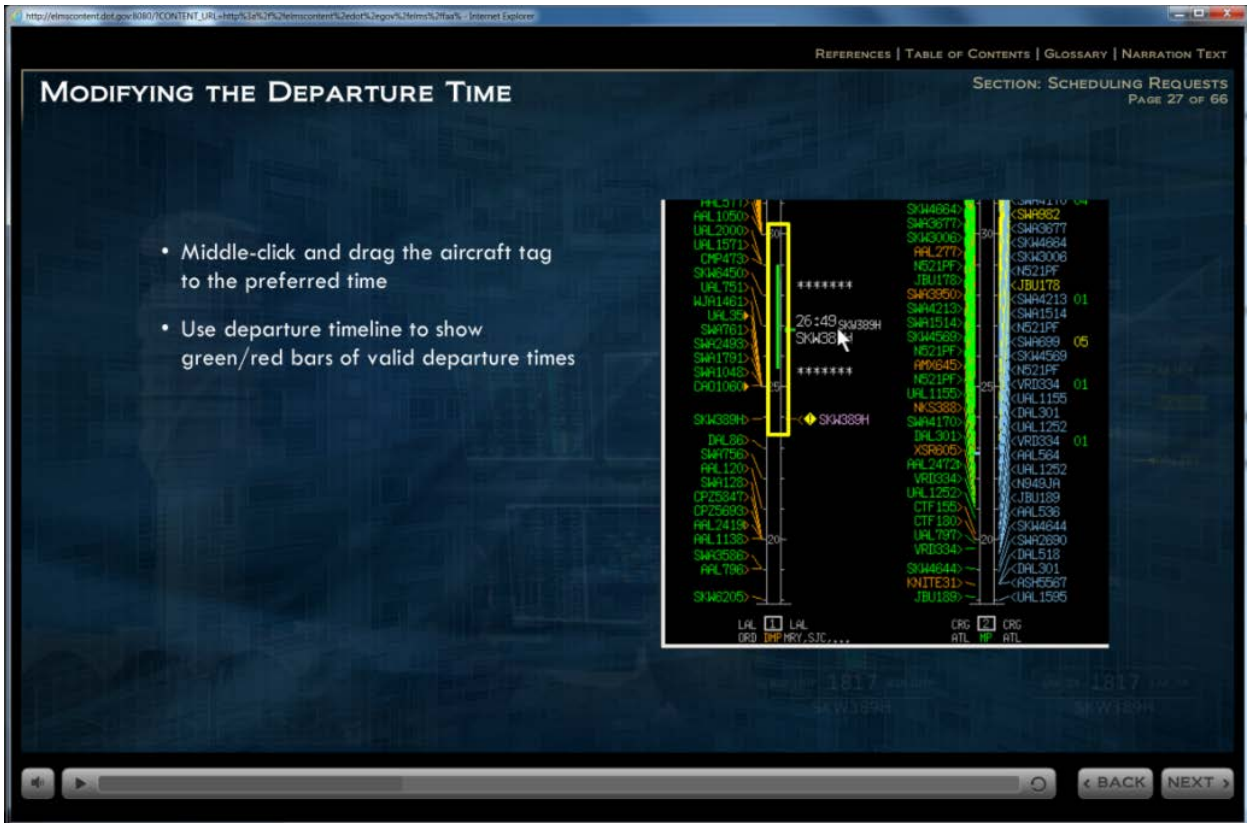

Figure 15. IDST training illustration of detailed content and color coding provided by the tool.

5. SUMMARY

We found many positive and useful aspects to the DST and NextGen training materials we reviewed. The electronic Learning Management System and CBI formats were easy to access and use. The slides included good narratives and provided written summaries of the main points of the narration. Generally, the content was concise and was presented in a manageable time period (approximately 1 hour or less). The interactive aspect of the materials was very useful in providing some hands-on experience with the interface. In most cases, the materials also provided assessments during, or at the end of, the course so that users could evaluate their knowledge. The ATC SMEs working with us spoke positively about these training materials overall.

On the negative side, the navigation structure of the training materials was sometimes cumbersome. Navigation often required returning to the main table of contents and selecting a section rather than a specific slide. This could become time consuming because users then had to proceed from the beginning of the section to get to the desired slide. If users wanted to review the material on a single slide, they would need to start at the very beginning of the section. The use of highlighting to direct the users' attention to different fields was sometimes problematic. In some cases, inconsistent colors were used, or the highlighting of an item disappeared before a selection or an entry was made.

The examples provided in the hands-on portion of training often demonstrated or guided users on how to perform a series of steps (i.e., which buttons to press) without providing a context or explanation for the objective of the task. This made it difficult to follow the procedure being executed, sometimes even for the ATC SMEs.

The material was often complex, detailed, and moved at a rapid pace. This makes it especially difficult for those with less domain knowledge or experience to manage and comprehend effectively. We also found that the training materials did not typically provide enough information about tool reliability and the circumstances under which a tool's recommendation my not be as useful. The part-task we performed in Woroch, Zingale, & Masalonis (2017) found that a training module that focused on the situations that predicted the reliability of a DST improved performance under conditions of high workload, such as those often encountered by TFM personnel.

6. RECOMMENDATIONS

Based on our review of DST and NextGen computer-based and Web-based training materials, we make the following recommendations for future training materials of this kind.

6.1 Clearly State Objectives for Both the Tool and the Training Materials

The training information should first state the purpose of the tool itself and whether it replaces an existing tool or method, or provides a new capability. This will help users establish a framework for the information that follows and allow them to remember related background information.

A list of specific learning goals should then be provided at the start of training and at the beginning of each section. This helps users identify priorities as they proceed through the lesson. The goals should specify what content knowledge is to be mastered and what procedures are required to achieve mastery in completing a task.

For DSTs, it is particularly important to provide information and examples about the conditions under which the tool's results and recommendations are less certain or reliable. This will help users better understand the constraints of the tool and when other solutions may need to be implemented. Training should clearly indicate which factors need to be attended to, and it should provide an indication as to the reliability of the provided solution.

6.2 Provide Different Training Modes or Different Versions of Training for Users With Different Experience/Background Levels

For complex and detailed courses, we recommend providing different learning modes or different versions of training so that users with different levels of background knowledge can get the most out of training. A basic and an advanced mode or version would better allow users to select the appropriate content level for their needs. Someone with less experience or background knowledge would benefit from working through a basic mode to achieve mastery of core concepts before proceeding to more challenging, advanced material. After the users comprehend and understand the core concepts, they are better prepared to proceed to the more challenging information and integrate it into their understanding. Alternatively, someone with more experience or background knowledge would be able to begin with materials that provide a more sophisticated level of detail and offer more complex examples. We suggest that modes be user selectable and that the mode in use be clearly indicated on the interface.

6.3 Provide Assessments Throughout Training and at the Conclusion of Each Lesson

Training materials should provide learning assessments throughout the lesson. At minimum, assessments should be provided at the end of each section and at the end of the course. However, additional question sets should be offered if detailed problems are taught and demonstrated. Users

need sufficient opportunity to solve the problem on their own, both in terms of determining the approach to the problem and in executing the steps required to achieve the goal.

We recommend providing multiple versions of assessments so users can return to information and take quizzes a second or third time without repeating the same question sets. Questions should be inserted following demonstrations so that users have the opportunity to perform a task on their own. The interface should provide feedback as the steps are completed. If a correct selection is made, users move to the next step. If incorrect, the training materials should allow another attempt, and if still incorrect, then feedback and direction should be provided to guide the users. This approach allows users to make the decisions and execute the steps involved with guidance provided, if needed.

We also recommend allowing users sufficient opportunity to test different functions on their own, perhaps by providing supplementary materials for the course that allows them to work on different problem sets until they feel they have sufficiently mastered the material or to refresh their knowledge, as needed.

6.4 Allow Users to Navigate Materials as Needed to Set the Pace of Instruction

We recommend that the navigation structure implemented in the training materials allow users to pause and review information as needed. When paused, the system should ensure that all narration and video also pause. This implementation allows users to control the flow of information and set the pace of the instruction. The system should allow users to return to previous information and then back to the current information quickly and easily. This lets users make comparisons and build connections between related topics or concepts, and helps fill knowledge gaps.

Finally, we suggest that additional training materials or modules be adapted for specific facilities and for representative situations that those facilities encounter. This would take the basic elements of training and adapt them to specific field implementations. This method would best allow users to see where and how the greatest benefits of tool use may be gained and when other approaches to achieving goals may be needed.

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Acronyms

ATC	Air traffic control
CBI	Computer-based instruction
CIWS	Corridor Integrated Weather System
CTOP	Collaborative Trajectory Options Program
DST	Decision Support Tool
FAA	Federal Aviation Administration
FCA	Flow Constrained Area
IDST	Integrated Departure Spacing Tool
RRIA	ReRoute Impact Assessment
SME	Subject matter expert
TBFM	Time Based Flow Management
TFM	Traffic Flow Management
TFMS	Traffic Flow Management System
TRACON	Terminal RADAR Approach Control