



Airline Memorization Games: Technology Transfer

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**Jimmy Vu
David J. Winokur**

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Center for Advanced Aviation System Development

Abstract

Effective training for air traffic controllers is a critical component of the Federal Aviation Administration's (FAA's) mission of providing a safe and efficient national aerospace system. The Air Traffic Control (ATC) training program must address the training needs of newly hired controllers (students), ongoing refresher and skill enhancement training for Certified Professional Controllers (CPCs), and new technology and procedures training for students and CPCs. The current ATC training practices and methods have not kept pace with advancements in training technology and design. They continue to rely heavily on instructor-led classroom training augmented with basic computer-based instruction and high-fidelity simulation. As a result, training for students and CPCs is costly, inefficient, subjective, and inconsistent. The current training system also does not have the flexibility or adaptability necessary to meet the need for training new technologies which may reduce the expected benefit of acquisitions. The need for improved training will only become more critical as the FAA hires and trains nearly 12,000 controllers over the next 10 years, while continuing with the incremental implementation of the Next Generation Air Transportation System (NextGen).

To position ATC training to better meet current and future needs, The MITRE Corporation's Center for Advanced Aviation System Development and the FAA have been conducting research for a number of years to identify technology improvements and process changes that will enhance the effectiveness, efficiency, availability, and quality of training and provide flexibility to deal with frequently changing automation capabilities and procedures. Using various training prototype platforms, MITRE has evaluated a broad range of training capabilities at en route and terminal facilities and demonstrated the benefits of incorporating advanced training technology into ATC training.

One of the findings of MITRE's training research is that there are significant benefits to be gained by using interactive game technology and design to support student learning and long-term retention of basic ATC facility data such as airline information. This document presents the specifications for a set of airline memorization games designed to teach students the company name, callsign, and three-letter identifier for each airline that traverses their facility. The games are part of a suite of airline training capabilities that were proven to be beneficial through field evaluation at multiple facilities. The information provided in this document is intended to support the transfer of the game technology to the FAA in order to facilitate the acquisition and integration of these beneficial capabilities into the ATC training system.

Keywords: ATC, airline, NextGen, training, prototype, controller, student

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1 Introduction

1.1 Background

Effective training for air traffic controllers is a critical component of the Federal Aviation Administration's (FAA's) mission of providing a safe and efficient national aerospace system. The Air Traffic Control (ATC) training program must address the training needs of newly hired controllers (students), ongoing refresher and skill enhancement training for Certified Professional Controllers (CPCs), and new technology and procedures training for students and CPCs. The current ATC training practices and methods have not kept pace with advancements in training technology and design. They continue to rely heavily on instructor-led classroom training augmented with basic computer-based instruction and high-fidelity simulation. As a result, training for students and CPCs is costly, inefficient, subjective, and inconsistent. The current training system also does not have the flexibility or adaptability necessary to meet the need for training new technologies which may reduce the expected benefit of acquisitions. The need for improved training will only become more critical as the FAA hires and trains nearly 12,000 controllers over the next 10 years, while continuing with the incremental implementation of the Next Generation Air Transportation System (NextGen).

The MITRE Corporation's Center for Advanced Aviation System Development (MITRE/CAASD) and the FAA have been conducting research to identify technology improvements and process changes that will enhance the effectiveness, efficiency, availability, and quality of ATC training and provide flexibility to deal with new and changing automation capabilities and procedures. Specifically, since 2004, MITRE has been exploring the application of advanced training technology to ATC training curriculum and has developed numerous training capabilities on prototype platforms for evaluation and concept validation. Evaluations of a broad range of capabilities, that include automated speech recognition and synthesis, interactive game technology, automated performance assessment and feedback, and Intelligent Training System (ITS) design, have been conducted with students and instructors at the Miami Terminal Radar Approach Control (TRACON), the Potomac Consolidated TRACON (PCT), the Indianapolis Air Route Traffic Control Center (ARTCC), and the FAA Academy. The evaluations have demonstrated the benefits of incorporating advanced training technology into ATC training, including [1, 2, 3, 4]:

- Improved student skill development and operational understanding.
- Improved student preparation for later stages of training (e.g., simulation and On-the-Job Training [OJT]).
- Improved training quality, effectiveness, and efficiency.
- Improved training consistency, standardization, and objective performance assessment.
- Improved training availability.
- Ability for training to support self-paced, independent learning.
- Reduced reliance on human resources.
- Reduced training time.

The results of the evaluations, as well as the design and technical requirements for those prototype capabilities that were proven to be beneficial, have been documented by MITRE and delivered to the FAA.

1.2 Information Memorization Using Advanced Training Technologies

One of the findings of MITRE's training research is that there are significant benefits to be gained by using interactive game technology and design to teach elements of the current ATC training curriculum, including basic facility information. Much of the information that is part of initial facility training is taught through a process of self-study and data memorization. While these methods support limited short-term memorization, the use of game technology has proven to be far more successful in supporting long-term retention and "instant recall" of information that students will require throughout their training [5]. In order to demonstrate the benefits of applying game technology and design to portions of the initial facility training curriculum, MITRE developed a set of games that were intended to facilitate the memorization of airline information.

Today, students learn airline information (i.e., the callsign, three-letter identifier, and company name for each airline that traverses their facility) by studying a paper list and repetitively writing down the information. Like much of the information that students must memorize during this stage of training, the airlines are often memorized quickly in order to pass a test and adhere to a training schedule. In addition, students are inclined to move on to the tests as quickly as possible rather than attempt to spend the amount of time necessary to commit the information to long-term memory in part because the current training methods do not support long-term memorization. One of the effects of these shortcomings is that students are not well-prepared for later stage training and must relearn basic information during simulation training and OJT. This is inefficient and can unnecessarily lengthen the time required for these stages of training.

As part of a field evaluation to validate a more effective and appropriate method for teaching airline information, MITRE integrated the games into its ATC training prototype. (Note: For more details about the prototype upon which the games were built, the reader is referred to [6]). The games provided an interactive platform for memorizing the information and were used and evaluated by more than 100 students and instructors from MIA, PCT, and Indianapolis ARTCC (ZID). The evaluations served to validate both the effectiveness of the advanced training technologies as well as the acceptability and usability of the game interface design.

1.3 Document Purpose and Organization

The purpose of this document is to present a detailed description of the airline memorization games that were validated at the various field facilities. This information is intended to support the technology transfer of the game design to the FAA in order to facilitate the acquisition and integration of these beneficial capabilities into the ATC training system. The document contains four sections. Section 1 provides introductory and background information. Section 2 contains an overview of the airline training capabilities. Section 3 presents the high-level requirements for the different airline memorization games as well as the various tools developed to assess student knowledge of the information. Section 4 describes some of the lessons learned as well as design recommendations for implementation.

2 Overview of the Airline Training Capabilities

In order to facilitate the memorization of airline information, MITRE developed a suite of prototype training capabilities. The capabilities are designed to be site-specific and include a set of interactive games that teaches students the company names (aircraft operators), callsigns, and three-letter identifiers of all the airlines that traverse their facility. This section provides an overview of the airline memorization games and also highlights some of the supporting capabilities.

2.1 Airline Memorization Games

2.1.1 Benefits

The airline memorization games employ a teaching model that allows students to interact with the information that they need to learn in a game-like environment. Through the use of the games, students are expected to learn the information better and more effectively than they do today using traditional methods of rote memorization.

One of the advantages of the memorization games over traditional training methods is that they enable students to learn the correct pronunciations for aircraft callsigns. This is particularly important when dealing with some of the foreign airline carriers. The games include a text-to-speech (TTS) system which allows students to hear callsigns spoken aloud. This not only reinforces pronunciation but also provides students with some operational context.

Another benefit of the games is that they provide interactive training capabilities that can be run in a self-supporting mode. The capabilities can be accessed at any time through a simple graphic user interface that enables students to control all of the operations of the system. The games do not require the presence of an instructor and include elements of ITS design that provide automated, objective real-time performance feedback and data. Students can progress through the games at their own pace and play them as many times as necessary to master the training content.

While increasing the level of information retention, the games should enhance the students' performance in later stages of training. For example, by playing the games, students will learn the information thoroughly early on in their training and be better prepared to apply it during simulation and OJT. As a result, instructors can spend their time focusing more on teaching complex concepts and ATC operation rather than ensuring that students know basic airline information.

2.1.2 Concept of Use

The prototype capability includes five games: Match 3, Match 3 Pro, Fill ID, Fill Callsign, and Pick 2 Review. Although students are not required to play them in a particular order, an implied order of progression is provided. Once students have mastered a game, they can move on to a more challenging one. Students can also go back to previous games if more practice is needed. The games are designed to be played multiple times, and each has an ideal (maximum) score that students can try to achieve. Students are expected to continue playing the games until they have fully committed the information to memory.

The first game, Match 3, is a card matching game that shows students the facility-specific airline information they need to learn and then allows them to interact with it (e.g., by matching the

company name, callsign, and three-letter identifier associated with each airline). Following completion of this game, students should know the airline information to a relatively high degree and be ready to progress to Match 3 Pro. This game, like the other three to follow, is intended to facilitate long-term retention of the airlines by reinforcing what students have learned in Match 3. The primary difference between the first two games is that Match 3 Pro does not show the matches (answers) at the beginning, and it also includes “dummy” cards (i.e., cards that do not match any of the others and prevent students from using the process of elimination when matching the last few sets of cards.) After playing the game, students can move on to Fill ID and Fill Callsign. These games closely resemble the standard tests administered to students and requires them to “fill” in either a three-letter identifier or callsign; however, the information is presented in a game environment. Once students have finished playing the match and fill games, they are expected to play Pick 2 Review. The primary objective of this game is to help students with the airline information that they are having difficulty retaining. Incorporating elements of ITS design, Pick 2 Review uses data captured during prior game play to determine the airlines that students have gotten incorrect the most. Students are then able to practice specifically with this subset of information.

2.2 Airline Knowledge Assessments

After students feel they have mastered the games, they can demonstrate their knowledge of the airline information by taking the electronic tests and “challenge.” The tests are similar to the ones that students typically take today using paper and pencil and require students to type in either the three-letter identifier (“Test ID”) or the callsign (“Test Callsign”) for each airline. One of the key benefits of delivering the test electronically is that the order of the airlines can be randomized. This eliminates the student’s ability to simply memorize a list without knowing the associated information. Students are also provided with an “Aural Challenge.” The challenge is another method of evaluating student retention of the airline information. In the challenge, callsigns are spoken aloud, and students must type in the correct three-letter identifier. In doing so, student performance is assessed in a way that more closely resembles how they would use this information on the job. Both the tests and challenge allow the students’ airline knowledge to be measured more accurately and thoroughly than is done today with traditional methods.

2.3 Support Tools

At any time, students can access a “Stats” page to review their performance (e.g., high scores). In addition, there is a tutorial, which provides a set of interactive instructions on how to play the different games, along with a reference page listing all of the airline information that needs to be learned. These tools act to support the students in their usage of the games.

3 High-Level Functional and Computer-Human Interface Requirements

There are several components that comprise the airline training capabilities, including the memorization games, the tests, and the challenge. The set of capabilities were incorporated into the ATC prototype's web-based framework. They were built using ActionScript (Adobe Flash); however, alternative web platforms such as HTML5 could have also been used. The airline information used to support the games was taken from FAA JO 7340.2B and its periodic change releases. This information was entered into a data file that was used to populate the cards in the games. The audio delivery of the callsigns was created through a commercial off-the-shelf system (COTS) TTS system. The audio was saved into sound files, which were used during gameplay.

This section presents detailed descriptions of all the airline training capabilities. In addition, the data collection requirements are also specified.

3.1 Airline Memorization Games

To begin using MITRE's ATC prototype, students must log into the system. Upon login, they are provided access to a set of customized lessons, including airline training (highlighted in yellow on the left-hand side of Figure 3-1). Once this lesson has been selected, the main menu will be displayed, allowing students to navigate to any of the five games as well as to the tutorial and stats page. (Note: The list of modules associated with a training lesson will be displayed along the top of the screen. The modules associated with the airline training lesson are outlined in red in the figure below and are as follows: Games, Pretest ID, Pretest Callsign, Test ID, Test Callsign, Aural Challenge, and Reference. The Games module will automatically be preselected once the airline training lesson has been selected).



Figure 3-1. The Main Menu

The five games are listed in the order of student progression from top to bottom, and are as follows:

1. Match 3
2. Match 3 Pro
3. Fill ID
4. Fill Callsign
5. Pick 2 Review

The game buttons will highlight when the cursor is moved over them. Selecting a button will launch the respective game. The tutorial and stats buttons are also available for selection. These options are presented in a manner that is intended to convey that they are not part of the series of games (e.g., they are smaller and at the bottom of the page). When any of the buttons are selected, they will be highlighted and a “clicking” sound effect will play. Furthermore, while the student is on the main menu, music will play in order to enhance the game feel.

3.1.1 Match 3

3.1.1.1 Description

At the beginning of Match 3, a set of cards is dealt onto a board. The cards are arranged in columns and there are three cards in each column, consisting of the callsign, three-letter identifier, and company name associated with a particular airline. Students can take as much time as they want to study the information. Once the student indicates that he or she is ready to continue the game, the cards are shuffled and placed randomly onto the board. Then, the student must match the three cards for each airline. Whenever a match is made, points are awarded. In addition, the callsign is read aloud, reinforcing the correct pronunciation. The student must match all of the cards on the board in order to move on to the next one. Upon doing so, a score breakdown is provided, reflecting the student’s performance; e.g., the faster the student finishes a board, the more points he or she will be awarded. If the student makes three incorrect matches, he or she must replay the board. Prior to replaying a board, the student will have the opportunity to study the matches again (if desired). Once the student has matched the cards on all of the boards, the game is over.

3.1.1.2 Specifications

When “Match 3” is selected from the main menu, the game board will be shown with a parameter number of place holders for cards. (Note: During the evaluations, this parameter was set to 15, allowing for five “sets” of matching airline information). A menu will overlay the board offering three options:

- The first option is to start a new game (“New Game”).
- The second option is to resume a saved game (“Resume Game”). (Note: The first time Match 3 is played, this option will be grayed out. It will only be active if a game has been suspended (or saved)).
- The last option is to return to the main menu (“Exit”).

The menu is depicted in Figure 3-2. As with the main menu, when a button is selected, it will be highlighted, and there will be a clicking sound effect.

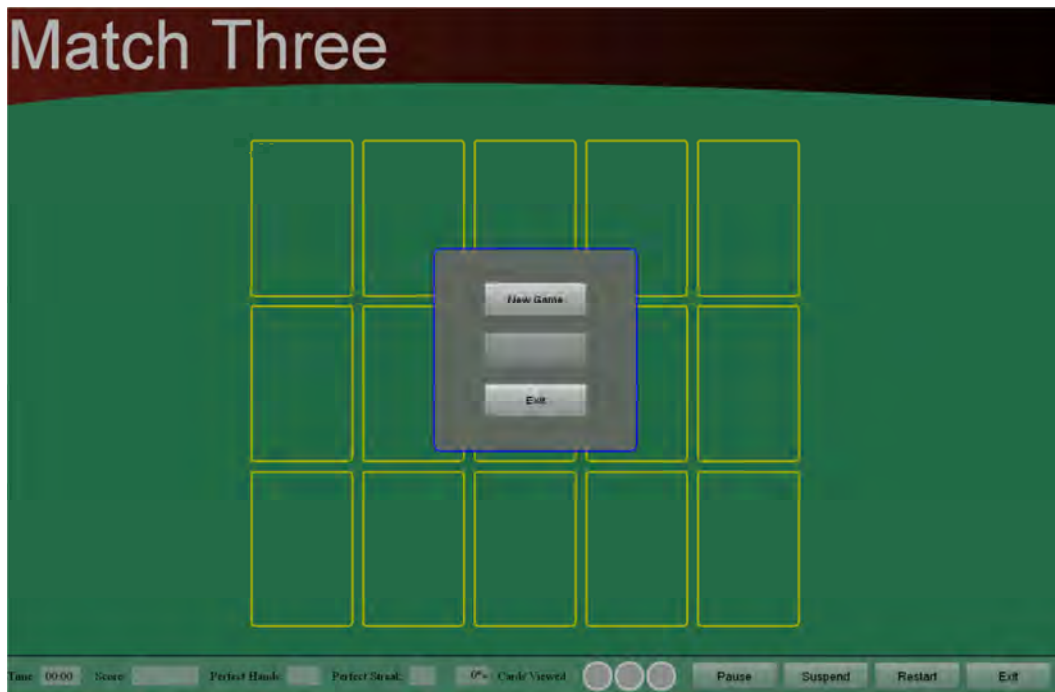


Figure 3-2. Start of Match 3

After “New Game” is selected, the following will occur:

- The three cards associated with an airline will be dealt face up into a column, with callsign in the top row, three-letter identifier in the second row, and company name in the bottom row. Sound effects will accompany the cards as they are being dealt. In addition, animation will be used to make the cards look like they are “flying” onto the board.
 - After the set of cards has been dealt, the callsign will be spoken, and the cards will be flipped over (face down).
 - The next set of three cards will be dealt in the same manner.
- Once five matching sets have been placed onto the board, all of the cards will be turned face up (See Figure 3-3). (Note: The five sets will be randomly selected from the complete set of facility airline information).
- The cards will remain in matching sets until the “Deal Cards” button is selected, indicating the student is ready to play.
 - The “Deal Cards” button is designed to stand out (e.g., the border of the button will blink).
 - The student will not be able to interact with the cards until this button is selected.

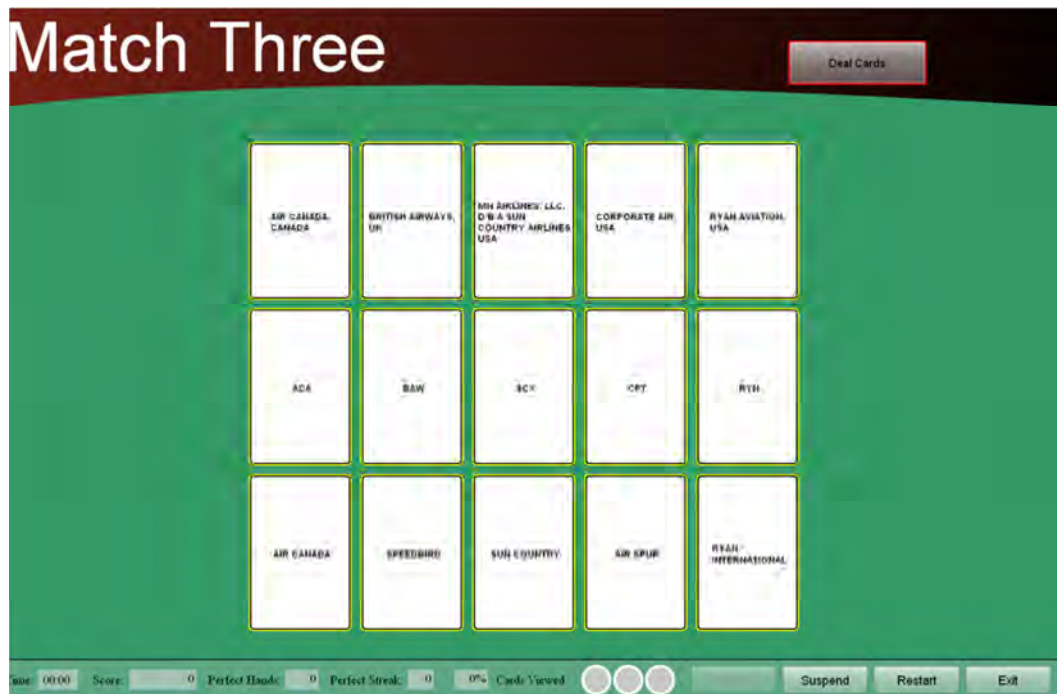


Figure 3-3. Matches Shown

- Upon selection of the “Deal Cards” button, the 15 cards will be removed and then randomly arranged back onto the board, accompanied by a “card dealing” sound effect. Once all of the cards are in place, a timer will start, and the student can begin matching the information sets.

Figure 3-4 shows an example of what a board might look like while a game is in progress.

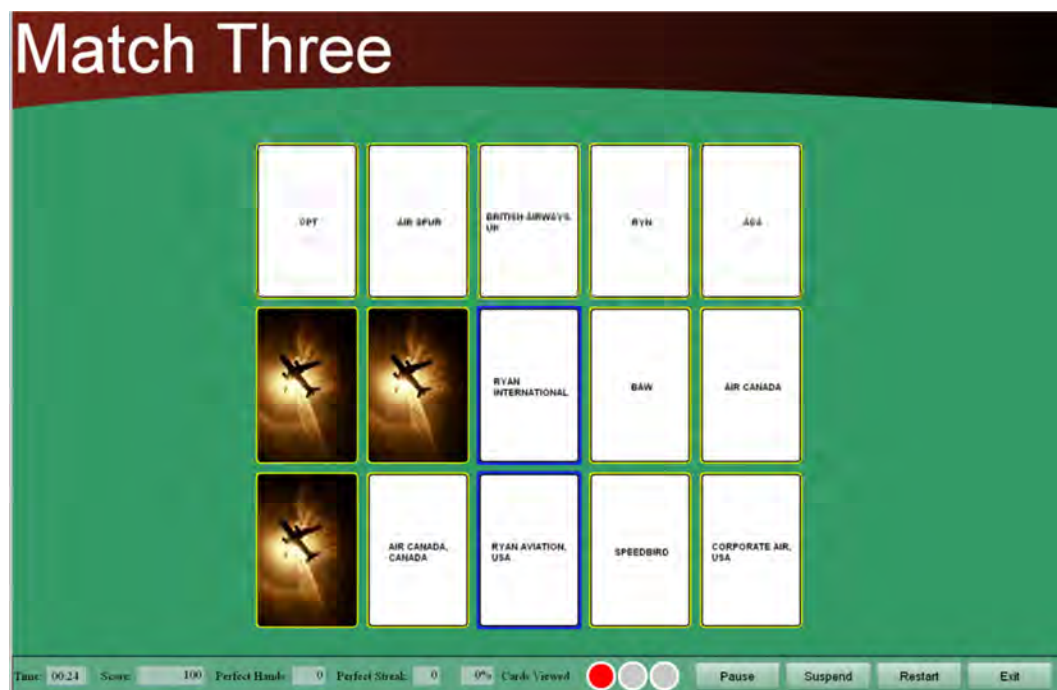


Figure 3-4. Match 3 During Game

The following rules prescribe the game behavior:

- The student will move the cursor and select, or click on, the three cards that constitute a matching set of airline information (i.e., the callsign, three-letter identifier, and company name). When a card is selected, its border will be highlighted. If the student clicks on a card that has already been selected, the card will be unselected. Following each successful match, the callsign will be spoken, and the three matching cards will be flipped over.
- Once the student has matched all five sets, the board is complete, and a new set of 15 cards will be dealt. A pop-up window will appear between sets to show the student's score on the completed board.
- After the student has successfully completed all of the boards, Match 3 will end, and the student will be asked if he or she wants to "Play Again," or "Exit" (leave the game and return to the main menu). The total number of boards the student needs to complete will depend on how many different airlines traverse a given facility. For example, for the evaluations at PCT, there were 21 boards in this game. (Note: When the game goes to the last board and there are not enough new (first time seen) cards to fill the board, then the rest of the board will be randomly filled with cards that the student has already seen. Until that point, the same card will not be shown twice).
- Anytime the student selects three cards (consecutively) that are not part of a matching set, a strike will be assigned. Following three strikes within a board, the student will not be allowed to continue playing the current board and will be provided with the following options: "Try Again" (play the exact same board again), "See Matches" (view the three cards that go together for each airline), or "Exit" (leave the game and return to the main menu). If the student decides to save and exit the game, upon resumption to the game he or she will be given a random selection of cards that **have not** been dealt from the "deck" of cards. (Note: Strikes that are accumulated will not be carried over from one board to the next; for example, if the student completes a board with two strikes, when the next set is dealt, the strike counter will be reset to 0).
 - If "See Matches" is selected, all of the cards will be removed from the board, and then redealt into their original columns. While the matches are shown, the "Deal Cards" (blinking) will appear above the cards. This button will then reshuffle the same cards and begin play when the student selects it.
- During the game, the student may choose to stop playing by selecting the "Pause" button. When this button is selected, the cards in play will be removed, and the message, "Paused", will be shown on the screen. In addition, the timer will stop. The label on the "Pause" button will change to "Resume," and the cards will not be displayed again until this button is selected.
- If the student wants to leave the game and come back at a later time without losing his or her progress, then the "Suspend" button can be selected. Upon selecting this button, a pop-up message will appear saying, "Saving game and exiting" and all boards that have been completely finished will be recorded, and those cards will not be shown again. The student will be returned to the main menu.
- The student will be able to restart a game from the beginning by selecting the "Restart" button. When this button is selected, a pop-up message will appear saying, "Do you want

to start over? All your progress will be lost. Yes/No.” Selecting Yes will bring up a new board of randomly selected cards.

- When the “Exit “button is selected, a pop-up window will appear saying, “Are you sure you want to Exit the game? Any progress you have made will be lost. Yes/No.” Selecting Yes will return the student to the main menu.

3.1.1.2.1 Game Feedback

Within each game, students will be provided with information indicating their level of proficiency and the amount of progress they have made while going through all the airline information. This information will be displayed along the bottom of the screen:

- A timer (consisting of minutes and seconds) will start once a set of cards on a board has been dealt. The timer will show the students how long it is taking them to complete each board and will reset to zero once all of the cards on a board have been matched.
- A score will be shown, which is the cumulative score from all of the boards played.
- The number of “perfect hands” will be displayed. A perfect hand will be achieved whenever a student completes a board without making any mistakes in less than a parameter amount of time (currently set to 25 seconds).
- The number of “perfect streaks” will be displayed. This is the number of consecutive “perfect hands” a student has achieved. (Note: This counter will reset to zero once a streak of perfect hands has been broken).
- There will be a strikes indicator which will show the student how many strikes have been accumulated on the current board.
 - Any time the student makes an incorrect match, a large red “X” will be shown, and a buzzer will sound.
- Any time the student matches 3 cards correctly, the callsign will be played from a file created by the TTS system.
- Students will be able to monitor the percentage of the complete set of cards they have viewed. This is intended to allow them to gage their progress.
 - Once the card counter reaches 100 percent and all of the matches have been made, the student will be shown his or her final score, along with congratulatory animation.
- All scores and streaks are reset to 0 when a new game is started or the current game is restarted.

3.1.1.2.2 Scoring

Students will be able to gain points while playing the game based on the following rules:

- For every correct match the student makes, 100 points will be awarded.
 - Since there are five possible matches on a board, the student can score up to 500 points.
- There will also be time bonus points awarded when certain conditions are met. For example, if the student completes a board within less than a parameter time (currently set to 25 seconds), then a time bonus of 100 points will be awarded. If the student completes

a board within another parameter time (currently set between 26 and 30 seconds), then 50 points will be awarded. No time bonus will be awarded if it takes 31 or more seconds to complete the board.

- If the student has a perfect hand, an additional 50 point bonus will be awarded.
- There will be no point deductions for incorrect matches.
- The student has the potential to receive a maximum of 650 points per board.
- Each time a student completes an entire game, the score will be recorded. The student's highest score will be displayed on the stats page.

3.1.2 Match 3 Pro

3.1.2.1 Description

Match 3 Pro starts with the cards being shuffled and a set of cards being randomly dealt onto the board. As soon as the cards are in place, the student can begin matching them. Whenever a match is made, points are awarded. Unlike Match 3, in this game, mistakes result in point deductions and the matches are not shown beforehand. The student must match all of the sets of cards, leaving only the dummy cards remaining, in order to move on to the next one. Following the completion of a board, a score breakdown is provided. If the student makes three incorrect matches, he or she must replay the board. Prior to replaying a board, the student will have the opportunity to see the matches (if desired). Once the student has matched the cards on all of the boards, the game is over. (Note: The total number of boards the student needs to complete will depend on how many different airlines traverse a given facility. For example, for the evaluations at PCT, there were 15 boards.)

3.1.2.2 Specifications

When "Match 3 Pro" is selected from the main menu, the game board will be shown with a parameter number of place holders for cards. (Note: During the evaluations, this parameter was set to 27, allowing for 7 sets of matching airline information and six dummy cards). A menu will overlay the board offering three options:

- The first option is to start a new game ("New Game").
- The second option is to resume a saved game ("Resume Game"). (Note: The first time Match 3 Pro is played, this option will be grayed out. It will only be active if a game has been suspended (or saved)).
- The last option is to return to the main menu ("Exit").

After "New Game" is selected, the following will occur:

- 27 cards will be dealt face up onto the board. The dealing action will be animated, and the cards will be dealt from left to right, one row at a time. Card sound effects will accompany the animation. The locations where the cards are placed will be completely randomized.
 - Unlike Match 3, this game will not show the matches beforehand.
 - The seven sets of matching cards will be randomly selected from the complete set of facility airline information.

- The dummy cards will be taken out of the existing pool of cards and will not match anything. They will not count in the system as a used card (this is to not affect the percentage of cards in the deck seen).
- Once all of the cards are in place, a timer will start, and the student can begin matching.

Figure 3-5 shows an example of what a board might look like while a game is in progress.

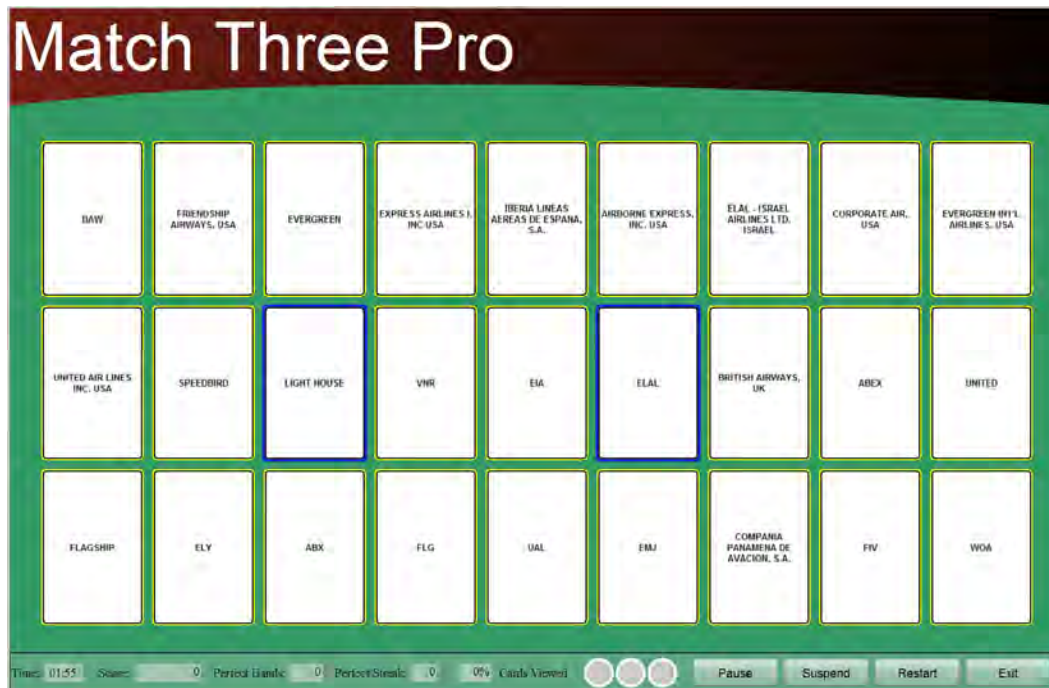


Figure 3-5. Match 3 Pro During Game

The following rules prescribe the game behavior:

- The student will move the cursor and select, or click on, the three cards that constitute a matching set of airline information (i.e., the callsign, three-letter identifier, and company name). When a card is selected, its border will be highlighted. If the student clicks on a card that has already been selected, the card will be unselected. Following each successful match, the callsign will be stated, and the three matching cards will be flipped over.
- Once the student has matched all seven sets, the board is complete, and a new set of 27 cards will be dealt. A pop-up window will appear between boards to show the student's score on the completed board.
- After the student has successfully completed all of the boards, Match 3 Pro will end, and the student will be asked if he or she wants to "Play Again," or "Exit" (leave the game and return to the main menu). The total number of boards the student needs to complete will depend on how many different airlines traverse a given facility. For example, for the evaluations at PCT, there were 15 boards in this game. (Note: When the game goes to the last board and there are not enough new (first time seen) cards to fill the board, then the rest of the board will be randomly filled with cards that the student has already seen. Until that point, the same card will not be shown twice).

- Anytime the student selects three cards (consecutively) that are not part of a matching set, a strike will be assigned. Following three strikes within a board, the student will not be allowed to continue playing the current board and will be provided with the following options: “Try Again” (play the exact same board again), “See Matches” (view the three cards that go together for each airline), or “Exit” (leave the game and return to the main menu). If the student decides to save and exit the game, upon resumption to the game he or she will be given a random selection of cards that have not been dealt from the “deck” of cards. (Note: Strikes that are accumulated will not be carried over from one board to the next; for example, if the student completes a board with two strikes, when the next set is dealt, the strike counter will be reset to 0).
 - If “See Matches” is selected, all of the cards will be removed from the board. The matching cards will then be dealt into columns, and the dummy cards will be excluded from display. While the matches are shown, the “Deal Cards” (blinking) will appear above the cards. This button will then reshuffle the matching and dummy cards and begin play when the student selects it.
- During the game, the student may choose to stop playing by selecting the “Pause” button. When this button is selected, the cards in play will be removed, and the message, “Paused”, will be shown on the screen. In addition, the timer will stop. The label on the “Pause” button will change to “Resume,” and the cards will not be displayed again until this button is selected.
- If the student wants to leave the game and come back at a later time without losing his or her progress, then the “Suspend” button can be selected. Upon selecting this button, a pop-up message will appear saying, “Saving game and exiting” and all boards that have been completely finished will be recorded, and those cards will not be shown again. The student will be returned to the main menu.
- The student will be able to restart a game from the beginning by selecting the “Restart” button. When this button is selected, a pop-up message will appear saying, “Do you want to start over? All your progress will be lost. Yes/No.” Selecting Yes will bring up a new board of randomly selected cards.
- When the “Exit” button is selected, a pop-up window will appear saying, “Are you sure you want to Exit the game? Any progress you have made will be lost. Yes/No.” Selecting Yes will return the student to the main menu.

3.1.2.2.1 Game Feedback

Within each game, students will be provided with information indicating their level of proficiency and the amount of progress they have made while going through all the airline information. This information will be displayed along the bottom of the screen:

- A timer (consisting of minutes and seconds) will start once the set of cards on a board has been dealt. The timer will show the students how long it is taking them to complete each board and will reset to zero once all of the cards on a board have been matched.
- A score will be shown, which is the cumulative score from all of the boards played.
- The number of “perfect hands” will be displayed. A perfect hand will be achieved whenever a student completes a board without making any mistakes in less than a parameter amount of time (currently set to 25 seconds).

- The number of “perfect streaks” will be displayed. This is the number of consecutive “perfect hands” a student has achieved. (Note: This counter will reset to zero once a streak of perfect hands has been broken).
- There will be a strikes indicator which will show the student how many strikes have been accumulated on the current board.
 - Any time the student makes an incorrect match, a large red “X” will be shown, and a buzzer will sound.
- Any time the student matches 3 cards correctly, the callsign will be played from a file created by the TTS system.
- Students will be able to monitor the percentage of the complete set of cards they have viewed. This is intended to allow them to gauge their progress.
 - Once the card counter reaches 100 percent and all the matches have been made, the student will be shown his or her final score, along with congratulatory animation.
- All scores and streaks are reset to 0 when a new game is started or the current game is restarted.

3.1.2.2.2 Scoring

Students will be able to gain points for playing the game based on the following rules:

- For every correct match the student makes, 100 points will be awarded.
 - Since there are nine possible matches, the student can score up to 900 points.
- There will also be time bonus points awarded when certain conditions are met. For example, if the student completes a board within less than a parameter time (currently set to 35 seconds), then a time bonus of 200 points will be awarded. If the student completes a board within another parameter time (currently set between 35 and 49 seconds), then 100 points will be awarded. No time bonus will be awarded if it takes 50 or more seconds to complete the board.
- If the student has a perfect hand, an additional 100 point bonus will be awarded.
- 300 points will be deducted for each incorrect match.
- The student has the potential to receive a maximum of 1200 points per board (while also being able to lose up to 900 points for each board).
- Each time a student completes an entire game, the score will be recorded and the highest score will be displayed on the stats page.

3.1.3 Fill ID

3.1.3.1 Description

At the start of Fill ID, the cards are dealt and arranged in columns on the board. In each column, the first card is reserved for the airline’s callsign, the second card for the three letter-identifier, and the third card for the company name. In this game, the callsigns and company names are shown, and the three-letter identifiers are replaced with empty fields. Students must complete the matches by typing in the correct three-letter identifier for each airline. Whenever the correct

information is entered, points are awarded while mistakes result in point deductions. Following the completion of a board, a score breakdown is provided. If the student makes three mistakes, he or she must replay the board. Prior to replaying a board, the student will have the opportunity to see the matches (if desired). The game will end once the student has gone through all of the airline information.

3.1.3.2 Specifications

When “Fill ID” is selected from the main menu, the game board will be shown with a parameter number of place holders for cards. (Note: During the evaluations, this parameter was set to 21, allowing for 7 sets of matching airline information). A menu will overlay the board offering three options:

- The first option is to start a new game (“New Game”).
- The second option is to resume a saved game (“Resume Game”). (Note: The first time Fill ID is played, this option will be grayed out. It will only be active if a game has been suspended (or saved)).
- The last option is to return to the main menu (“Exit”).

After “New Game” is selected, the following will occur:

- 21 cards will be dealt face up onto the board. The dealing action will be animated, and the cards will be dealt in columns the same way there are in Match 3. Card sound effects will accompany the animation.
 - The seven sets of cards will be randomly selected from the complete set of facility airline information.
- The cards in the first and third rows will have information on them (callsign and company name, respectively). The second row of cards will be blank as they will be placeholders for each airline’s three-letter identifier. Unlike the matching games, where students select cards, Fill ID requires the use of the keyboard to type in the appropriate information.
- Once all of the cards are in place, the student can begin entering the three-letter identifiers.

Figure 3-6 shows an example of what a board might look like while a game is in progress.

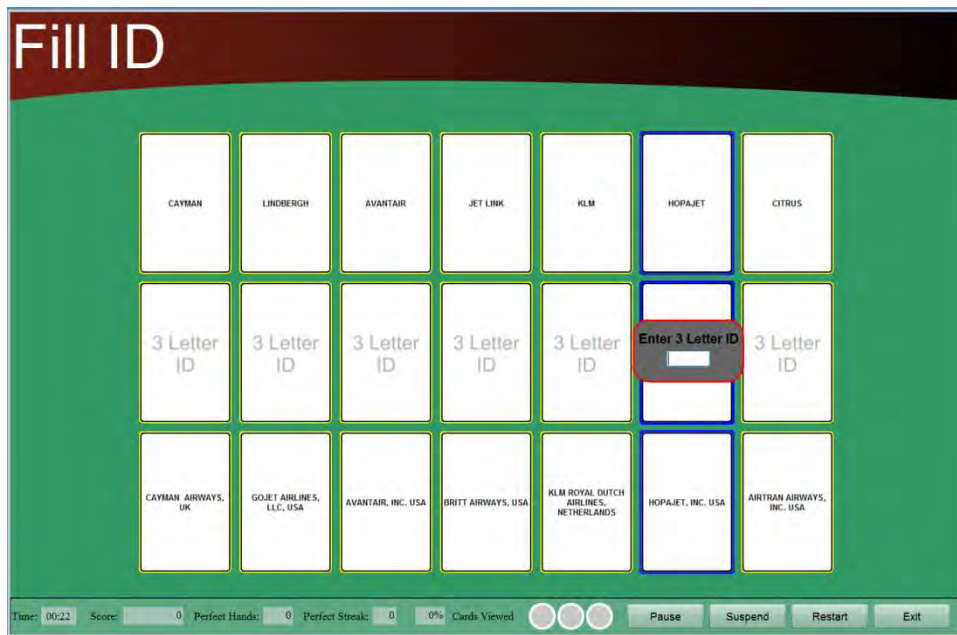


Figure 3-6. Fill ID During Game

The following rules prescribe the game behavior:

- The cards on the second row will have a grayed out placeholder that displays the phrase “3 Letter ID.”
- The student will move the cursor and select, or click on, the card for which he or she would like to enter the three-letter identifier. When the student is done typing the answer, he or she will submit it by either pressing the Enter key or selecting the next blank card. (If a card is left blank and the student moves to a different card, nothing happens).
 - Once the student submits the information for a card, the insertion point (for typing) will then move to the next card. If the student goes through the cards in the order of left to right, without having filled in all the cards, then the insertion point will move back to the “first” unanswered card in that order.
 - Regardless of the keyboard settings (such as Caps Lock or Shift), whatever letters the students type for the three-letter identifiers will be capitalized.
- Any time the student matches 3 cards correctly, the callsign will be played from a file created by the TTS system.
- Once the student has completed all seven sets, the board is complete, and a new set of 21 cards will be dealt. A pop-up window will appear between boards to show the student’s score on the completed board.
- After the student has successfully completed all of the boards, Fill ID will end, and the student will be asked if he or she wants to “Play Again,” or “Exit” (leave the game and return to the main menu). The total number of boards the student needs to complete will depend on how many different airlines traverse a given facility. For example, for the evaluations at PCT, there were 21 boards in this game. (Note: When the game goes to the last board and there are not enough new (first time seen) cards to fill the board, then the rest of the board will be randomly filled with cards that the student has already seen. Until that point, the same card will not be shown twice).

- Anytime the student enters an incorrect three-letter identifier, a strike will be assigned. Following three strikes within a board, the student will not be allowed to continue playing the current board and will be provided with the following options: “Try Again” (play the exact same board again), “See Matches” (view the three cards that go together for each airline), or “Exit” (leave the game and return to the main menu). If the student decides to save and exit the game, upon resumption of the game he or she will be given a random selection of cards that have not been dealt from the “deck” of cards. (Note: Strikes that are accumulated will not be carried over from one board to the next; for example, if the student completes a board with two strikes, when the next set is dealt, the strike counter will be reset to 0).
 - If “See Matches” is selected, this will toggle the three-letter identifiers onto the board (i.e., no animation, just instantly shown). While the matches are shown, a button will appear above the cards that say “Deal Cards” (blinking). This button will then reshuffle the cards and begin play when the student selects it.
- During the game, the student may choose to stop playing by selecting the “Pause” button. When this button is selected, the cards in play will be removed, and the message, “Paused”, will be shown on the screen. In addition, the timer will stop. The label on the “Pause” button will change to “Resume,” and the cards will not be displayed again until this button is selected.
- If the student wants to leave the game and come back at a later time without losing his or her progress, then the “Suspend” button can be selected. Upon selecting this button, a pop-up message will appear saying, “Saving game and exiting” and all boards that have been completely finished will be recorded, and those cards will not be shown again. The student will be returned to the main menu.
- The student will be able to restart a game from the beginning by selecting the “Restart” button. When this button is selected, a pop-up message will appear saying, “Do you want to start over? All your progress will be lost. Yes/No.” Selecting Yes will bring up a new board of randomly selected cards.
- When the “Exit” button is selected, a pop-up window will appear saying, “Are you sure you want to Exit the game? Any progress you have made will be lost. Yes/No.” Selecting Yes will return the student to the main menu.

3.1.3.2.1 Game Feedback

Within each game, students will be provided with information indicating their level of proficiency and the amount of progress they have made while going through all the airline information. This information will be displayed along the bottom of the screen:

- A timer (consisting of minutes and seconds) will start once the set of cards on a board has been dealt. The timer will show the students how long it is taking them to complete each board and will reset to zero once all of the correct information has been entered.
- A score will be shown, which is the cumulative score from all of the boards played.
- The number of “perfect hands” will be displayed. A perfect hand will be achieved whenever a student completes a board without making any mistakes in less than a parameter amount of time (currently set to 25 seconds).

- The number of “perfect streaks” will be displayed. This is the number of consecutive “perfect hands” a student has achieved. (Note: This counter will reset to zero once a streak of perfect hands has been broken).
- There will be a strikes indicator which will show the student how many strikes have been accumulated on the current board.
 - Any time the student makes an incorrect match, a large red “X” will be shown, and a buzzer will sound.
- Any time the student enters the information correctly, the callsign will be played from a file created by the TTS system.
- Students will be able to monitor the percentage of the complete set of cards they have viewed. This is intended to allow them to gage their progress.
 - Once the card counter reaches 100 percent and all the matches have been made, the student will be shown his or her final score, along with congratulatory animation.
- All scores and streaks are reset to 0 when a new game is started or the current game is restarted.

3.1.3.2.2 Scoring

Students will be able to gain points for playing the game based on the following rules:

- For every three-letter identifier the student enters correctly, 100 points will be awarded.
 - Since there are seven “answers,” the student can score up to 700 points.
- There will also be time bonus points awarded when certain conditions are met. For example, if the student completes a board within less than a parameter time (currently set to 30 seconds), then a time bonus of 100 points will be awarded. If the student completes a board within another parameter time (currently set between 30 and 44 seconds), then 50 points will be awarded. No time bonus will be awarded if it takes 45 or more seconds to complete the board.
- If the student has a perfect hand, an additional 100 point bonus will be awarded.
- 200 points will be deducted for each incorrect answer.
- The student has the potential to receive a maximum of 900 points per board (while also being able to lose up to 600 points for each board).
- Each time a student completes an entire game, the score will be recorded and the highest score will be displayed on the stats page.

3.1.4 Fill Callsign

3.1.4.1 Description

At the start of Fill Callsign, the cards are dealt and arranged in columns on the board. The three-letter identifiers and company names will be shown, and the callsigns will be replaced with empty fields. Students must complete the matches by typing in the correct callsign for each airline. Whenever the correct information is entered, points are awarded while mistakes result in point deductions. Following the completion of a board, a score breakdown is provided. If the

student makes three mistakes, he or she must replay the board. Prior to replaying a board, the student will have the opportunity to see the matches (if desired). The game will end once the student has gone through all of the airline information.

3.1.4.2 Specifications

When “Fill Callsign” is selected from the main menu, the game board will be shown with a parameter number of place holders for cards. (Note: During the evaluations, this parameter was set to 21, allowing for 7 “sets” of matching airline information). A menu will overlay the board offering three options:

- The first option is to start a new game (“New Game”).
- The second option is to resume a saved game (“Resume Game”). (Note: The first time Fill ID is played, this option will be grayed out. It will only be active if a game has been suspended (or saved)).
- The last option is to return to the main menu (“Exit”).

After “New Game” is selected, the following will occur:

- 21 cards will be dealt face up onto the board. The dealing action will be animated, and the cards will be dealt in columns the same way there are in Match 3. Card sound effects will accompany the animation.
 - The seven sets of cards will be randomly selected from the complete set of facility airline information.
- The cards in the second and third rows will have information on them (three-letter identifier and company name, respectively). The first row of cards will be blank as they will be placeholders for each airline’s callsign. Unlike the matching games, where students select cards, Fill Callsign requires the use of the keyboard to type in the appropriate information.
- Once all of the cards are in place, the student can begin entering the callsigns.

Figure 3-7 shows an example of what a board might look like while a game is in progress.

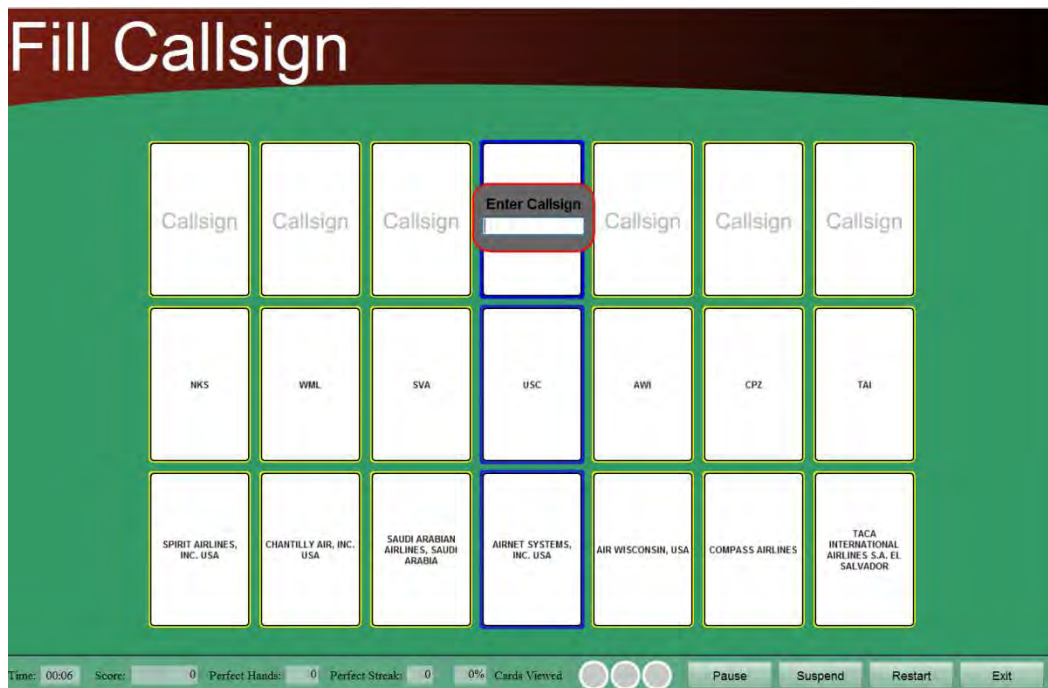


Figure 3-7. Fill Callsign During Game

The following rules prescribe the game behavior:

- The cards on the first row will have a grayed out placeholder that displays the phrase “Callsign.”
- The student will move the cursor and select, or click on, the card for which he or she would like to enter the callsign. When the student is done typing the answer, he or she will submit it by either pressing the enter key or selecting the next blank card. (If a card is left blank and the student moves to a different card, nothing happens).
 - Once the student submits the information for a card, the insertion point (for typing) will then move to the next card. If the student goes through the cards in the order of left to right, without having filled in all the cards, then the insertion point will move back to the “first” unanswered card in that order.
 - Regardless of the keyboard settings (such as caps lock or shift), whatever letters the students type for the three-letter identifiers will be capitalized.
- Following the entry of the correct callsign, the callsign will be read aloud by the game.
- Once the student has completed all seven sets, the board is complete, and a new set of 21 cards will be dealt. A pop-up window will appear between sets to show the student’s score on the completed board.
- After the student has successfully completed all of the boards, Fill Callsign will end, and the student will be asked if he or she wants to “Play Again,” or “Exit” (leave the game and return to the main menu). The total number of boards the student needs to complete will depend on how many different airlines traverse a given facility. For example, for the evaluations at PCT, there were 21 boards in this game. (Note: When the game goes to the last board and there are not enough new (first time seen) cards to fill the board, then the

rest of the board will be randomly filled with cards that the student has already seen. Until that point, the same card will not be shown twice).

- Anytime the student enters an incorrect three-letter identifier, a strike will be assigned. Following three strikes within a board, the student will not be allowed to continue playing the current board and will be provided with the following options: “Try Again” (play the exact same board again), “See Matches” (view the three cards that go together for each airline), or “Exit” (leave the game and return to the main menu). If the student decides to save and exit the game, upon resumption to the game he or she will be given a random selection of cards that have not been dealt from the “deck” of cards. (Note: Strikes that are accumulated will not be carried over from one board to the next; for example, if the student completes a board with two strikes, when the next set is dealt, the strike counter will be reset to 0).
 - If “See Matches” is selected, this will toggle the callsigns onto the board (i.e., no animation, just instantly shown). While the matches are shown, a button will appear above the cards that say “Deal Cards” (blinking). This button will then reshuffle the cards and begin play when the student selects it.
- During the game, the student may choose to stop playing by selecting the “Pause” button. When this button is selected, the cards in play will be removed, and the message, “Paused”, will be shown on the screen. In addition, the timer will stop. The label on the “Pause” button will change to “Resume,” and the cards will not be displayed again until this button is selected.
- If the student wants to leave the game and come back at a later time without losing his or her progress, then the “Suspend” button can be selected. Upon selecting this button, a pop-up message will appear saying, “Saving game and exiting” and all boards that have been completely finished will be recorded, and those cards will not be shown again. The student will be returned to the main menu.
- The student will be able to restart a game from the beginning by selecting the “Restart” button. When this button is selected, a pop-up message will appear saying, “Do you want to start over? All your progress will be lost. Yes/No.” Selecting Yes will bring up a new board of randomly selected cards.
- When the “Exit” button is selected, a pop-up window will appear saying, “Are you sure you want to Exit the game? Any progress you have made will be lost. Yes/No.” Selecting Yes will return the student to the main menu.

3.1.4.2.1 Game Feedback

Within each game, students will be provided with information indicating their level of proficiency and the amount of progress they have made while going through all the airline information. This information will be displayed along the bottom of the screen:

- A timer (consisting of minutes and seconds) will start once the set of cards on a board has been dealt. The timer will show the students how long it is taking them to complete each board and will reset to zero once all of the correct information has been entered.
- A score will be shown, which is the cumulative score from all of the boards played.

- The number of “perfect hands” will be displayed. A perfect hand will be achieved whenever a student completes a board without making any mistakes in less than a parameter amount of time (currently set to 25 seconds).
- The number of “perfect streaks” will be displayed. This is the number of consecutive “perfect hands” a student has achieved. (Note: This counter will reset to zero once a streak of perfect hands has been broken).
- There will be a strikes indicator which will show the student how many strikes have been accumulated on the current board.
 - Any time the student makes an incorrect match, a large red “X” will be shown, and a buzzer will sound.
- Any time the student enters the information correctly, the callsign will be played from a file created by the TTS system.
- Students will be able to monitor the percentage of the complete set of cards they have viewed. This is intended to allow them to gage their progress.
 - Once the card counter reaches 100 percent and all the matches have been made, the student will be shown his or her final score, along with congratulatory animation.
- All scores and streaks are reset to 0 when a new game is started or the current game is restarted.

3.1.4.2.2 Scoring

Students will be able to gain points for playing the game based on the following rules:

- For every callsign the student enters correctly, 100 points will be awarded.
 - Since there are seven “answers,” the student can score up to 700 points.
- There will also be time bonus points awarded when certain conditions are met. For example, if the student completes a board within less than a parameter time (currently set to 30 seconds), then a time bonus of 100 points will be awarded. If the student completes a board within another parameter time (currently set between 30 and 44 seconds), then 50 points will be awarded. No time bonus will be awarded if it takes 45 or more seconds to complete the board.
- If the student has a perfect hand, an additional 100 point bonus will be given.
- 200 points will be deducted for each incorrect answer.
- The student has the potential to receive a maximum of 900 points per board (while also being able to lose up to 600 points for each board).
- Each time a student completes an entire game, the score will be recorded and the highest score will be displayed on the stats page.

3.1.5 Pick 2 Review

3.1.5.1 Description

In Pick 2 Review, students are presented with one card at a time. The card shows a company name and is selected from the set of airlines the student has had trouble mastering. Once the card

is shown, the student must select the two corresponding pieces of information (callsign and three-letter identifier) from a board filled with various cards. Whenever a match is made, points are awarded while mistakes result in point deductions. Following a match, the board is cleared, and then the next company name, and set of cards, is dealt. If the student makes a total of three mistakes, the game will automatically end. The student finishes the game once all of the boards have been completed successfully. Note: Data is collected as students play Pick 2 Review. As students' performances change (i.e., improve or regress), the list of airlines presented to them will be adjusted.

3.1.5.2 Specifications

When "Pick 2 Review" is selected from the main menu, the game board will be shown with a parameter number of place holders for cards. (Note: During the evaluations, this parameter was set to 21). A menu will overlay the board offering two options:

- The first option is to start a new game ("New Game").
- The other option is to return to the main menu ("Exit").

After "New Game" is selected, the following will occur:

- 21 cards will be dealt face up onto the board. The dealing action will be animated, and the cards will be dealt from left to right (as they are in Match 3 Pro). Card sound effects will accompany the animation. The locations where the cards are dealt will be completely randomized.
- A "deck" of cards will be shown, with one card flipped over (face up) on top of it. That card will have a company name displayed.
 - The two cards (callsign and three-letter identifier) that match the company name and complete the set will be among the 21 cards.
 - The other 19 cards will be randomly selected from the full deck of cards.

A parameter set of airlines that students have had the most trouble with will be selected for each Pick 2 Review game. (Note: During the evaluations, this parameter was set to 10). The 10 "difficult" airlines are calculated as follows:

- The number of times an airline has been answered correctly in all the games will be divided by the number of times an airline has been answered incorrectly plus 3 (correct/(incorrect+3)). By starting with +3 incorrect, this defaults the cards to difficult status and students must complete Match 3, Match 3 Pro, Fill ID, and Fill Callsign at least once without mistakes to change them into "easy" cards.
 - Any set of cards that receives a correct/incorrect ratio of 1 or greater will be considered "easy" and are treated equally (i.e., they are all considered equal to 1).
 - Any set of cards that receives a ratio less than 1 will be considered a "difficult."
- The 10 "difficult" airlines with the lowest ratio value will be used in the game.
 - If there are multiple airlines that have the same "difficult" ratio values, then they will be randomly selected from the "difficult" pool to complete the 10 sets needed for a game.

- If there are not enough “difficult” sets to populate the game, then airlines will be randomly selected from the easy pool to complete the 10 sets needed.
- If there are no “difficult” sets of cards to choose from, airlines will be randomly selected from the easy pool to complete the 10 sets needed for a game.
- The results from each Pick 2 Review game will be entered into the database to be used as part of future calculations.

Figure 3-8 shows an example of what a board might look like while a game is in progress.

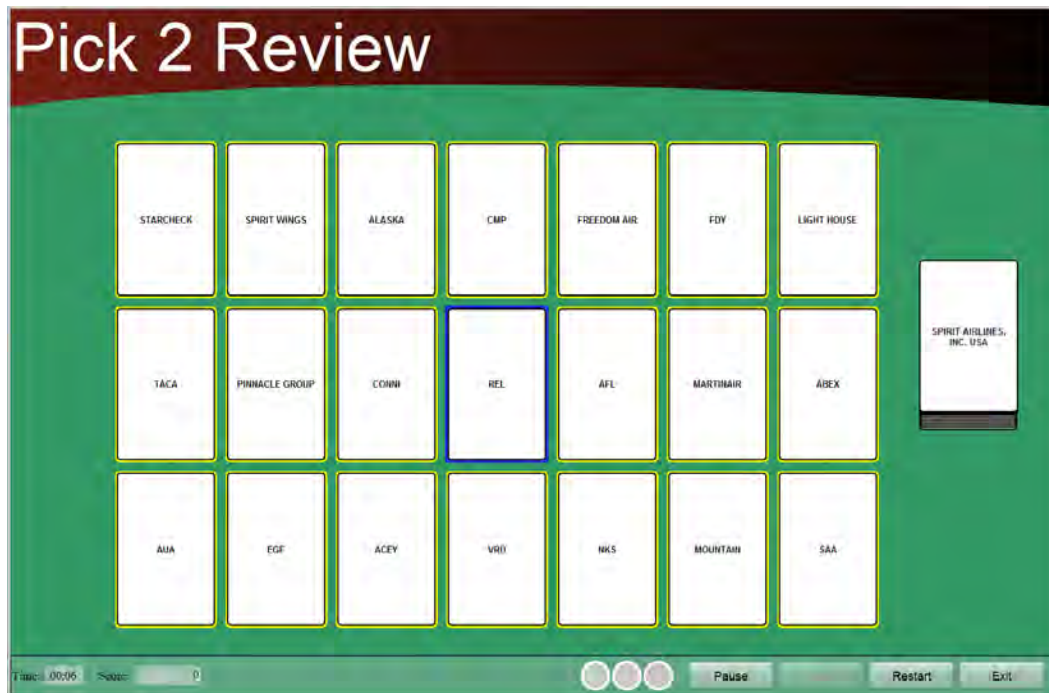


Figure 3-8. Pick 2 Review During Game

The following rules prescribe the game behavior:

- The student will move the cursor and select, or click on, the two cards that go along with the company name shown. If the student clicks on a card that has already been selected, the card will be unselected. Following each successful match, the callsign will be stated, and the board will be cleared.
- The next set will be dealt, again with 21 cards on the board, and one company name face up on top of the deck.
- After the student has matched the sets on all of the boards, Pick 2 Review will end, and the student will be asked if she or she wants to “Play Again,” or “Exit” (leave the game and return to the main menu).
- Anytime the student selects two cards that are not part of a matching set, a strike will be assigned. The strikes will be carried over from one board to another. Following three strikes, the game will be over, and the student will be provided with the following options: “Try Again” (play the game again) or “Exit” (leave the game and return to the main menu).

- During the game, the student may choose to stop playing by selecting the “Pause” button. When this button is selected, the cards in play will be removed, and the message, “Paused”, will be shown on the screen. In addition, the timer will stop. The label on the “Pause” button will change to “Resume,” and the cards will not be displayed again until this button is selected.
- The student will not be able to suspend the game of Pick 2 Review. This option will be grayed out.
- The student will be able to restart a game from the beginning by selecting the “Restart” button. When this button is selected, a pop-up message will appear saying, “Do you want to start over? All your progress will be lost. Yes/No.” Selecting Yes will bring up a new board of cards.
- When the “Exit” button is selected, a pop-up window will appear saying, “Are you sure you want to Exit the game? Any progress you have made will be lost. Yes/No.” Selecting Yes will return the student to the main menu.

3.1.5.2.1 Game Feedback

Within each game, students will be provided with information indicating their level of proficiency and the amount of progress they have made while going through all the airline information. This information will be displayed along the bottom of the screen:

- A timer (consisting of minutes and seconds) will start once the first set of cards has been dealt. The timer will show the students how long it takes them to complete the game and will not reset to 0 when a new board is shown.
- A score will be shown, which is the cumulative score from all of the boards played.
- There are no perfect hands or streaks.
- There will be a strikes indicator which will show the student how many strikes have been accumulated for the entire game (This is unlike the other four games, where the strikes reflect the incorrect matches/answers only for that board).
 - Any time the student makes an incorrect match, a large red “X” will be shown, and a buzzer will sound.
- Any time the student matches 3 cards correctly, the callsign will be played from a file created by the TTS system.
- Students will be able to monitor the percentage of the complete set of cards they have viewed. This is intended to allow them to gauge their progress.
 - Once the ten matches have been answered correctly, the student will be shown his or her final score, along with congratulatory animation.
- All scores reset to 0 when a new game is started or the current game is restarted.

3.1.5.2.2 Scoring

Students will be able to gain points for playing the game based on the following rules:

- For every correct match the student makes, 500 points will be awarded.
 - Since there are 10 sets, the student can score up to 5000 point.

- There will also be time bonus points awarded when certain conditions are met. For example, if the student completes all ten boards in less than a parameter time (currently set to 100 seconds), then a time bonus of 1000 points will be awarded. If the student completes all of the boards within another parameter time (currently set between 100 and 139 seconds), then 50 points will be awarded. No time bonus will be awarded if it takes 140 or more seconds to complete the all the boards.
- 1000 points will be deducted for each incorrect answer.
- The student has the potential to receive a maximum of 6000 points for the game.
- Each time a student completes an entire game, the score will be recorded. The student's highest score will be displayed on the stats page.

3.1.6 Tests and Challenge

As part of the field evaluations at MIA, PCT, and ZID, students were required to take pretests to determine their level of knowledge prior to playing the games. Although these modules are depicted in Figure 3-1, they are not necessary for a production version of the system. This section describes the requirements for the three-letter identifier test, callsign test, and aural challenge.

3.1.6.1 Test ID

Students can access a test that will evaluate their knowledge of three-letter identifiers by selecting the “Test ID” module. The test, which is shown in Figure 3-9, is similar to the paper test (a table) that is traditionally used at facilities today.

Three Letter ID Test		
3 Letter ID	Callsign	Aircraft Operator
	D-H-L	ASTAR AIR CARGO, USA
	GOJET	EUROJET AVIATION LTD
	FEDEX	FEDERAL EXPRESS CO. USA
	LIGHT HOUSE	FRIENDSHIP AIRWAYS, USA
	FLAGSHIP	EXPRESS AIRLINES I, INC USA
	ACEY	ATLANTIC SOUTHEAST AIRLINES
	MESABA	MESABA AVIATION
	LABQUEST	QUEST DIAGNOSTICS, USA
	DELTA	DELTA AIR LINES, INC. USA
	AIR SHUTTLE	MESA AVIATION SERVICES, INC. USA
	BANKAIR	BANKAIR, INC. USA
	RYAN INTERNATIONAL	RYAN AVIATION, USA
	OPTIONS	FLIGHT OPTIONS, USA
	JET LINK	BRITT AIRWAYS, USA
	JAMAICA	AIR JAMAICA, JAMAICA
	JAZZ	AIR CANADA REGIONAL INC, CANADA
	KOREANAIR	KOREAN AIR LINES CO., LTD. REPUBLIC OF KOREA
	SIAMROCK	AER LINGUS, IRELAND
	ALITALIA	ALITALIA, ITALY
	KALITTA	KALITTA FLYING SERVICE, INC. USA
	BRICKYARD	REPUBLIC AIRLINES, INC. USA
	BIZEX	BUSINESS EXPRESS, USA
	KITTYHAWK	KITTY HAWK AIRCARGO, INC. USA
	CONTINENTAL	CONTINENTAL AIR LINES, INC. USA

Figure 3-9. Three-Letter Identifier Test

When “Test ID” is selected, the following will occur:

- A table will be displayed that includes the callsign and company name (aircraft operator) for each airline. Entry fields will be blank for the three-letter identifiers.
 - The company names will be listed in random order (e.g., not alphabetical).
- After moving the cursor to an entry field and selecting the field (anywhere in the box), the three-letter identifier can be typed.
 - Once an identifier has been entered, students can click on another box in order to begin typing. (Note: The student can proceed in any order desired).
- Once students have finished entering the three-letter identifiers, the “Print” button can be selected.
 - If answers have not been entered for all of the airlines, then a message will appear asking, “You have left some of the answers blank. Do you want to continue?” If “No” is selected, the student will be able to go back to the test as can be seen in Figure 3-10. If “Yes” is selected, the test will be printed and the student will be finished.

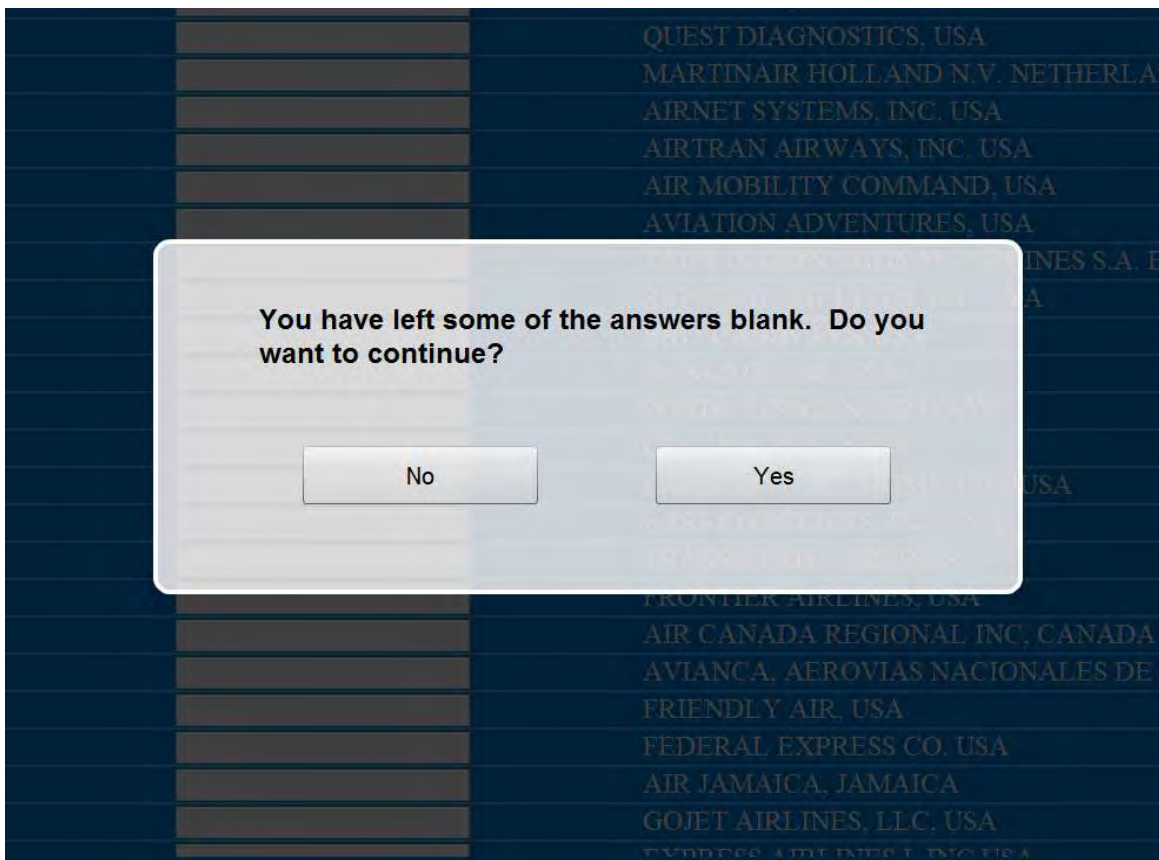


Figure 3-10. Three-Letter Identifier Printed Test Results

Upon selecting the “Print” button, the automation will check the answers submitted, comparing them with the identifiers stored in the database. A “scored” test will be sent to the printer, and the screen will be grayed out. An example of the printout is depicted in Figure 3-11. The “Print” button also acts as a submit command to record and grade the tests electronically with an option to print as required by a facility.

- The results will be printed in the form of a table with the type of test displayed at the top, along with a time stamp of when the test was started and finished.
- The answers will be arranged alphabetically, based on company names.
 - All incorrect answers will be highlighted.
- The number of correct answers out of the maximum possible will be shown at the bottom.

The Three-Letter Identifier Test will collect the results of a test as well as the time stamp for the start and submission of the test.

Three Letter Identifier Test		
Test Started	2:34pm	Student name
Test Submitted	3:12pm	Student ONE
3 LETTER ID	CALLSIGN	COMPANY NAME
EIN	SHAMROCK	AER LINGUS, IRELAND
AFL	AEROFLOT	AEROFLOT, RUSSIAN FEDERATION
AAL	AMERICAN	AMERICAN AIRLINES, INC. USA
ABX	ABEX	AIRBORNE EXPRESS, INC. USA
ACA	AIR CANADA	AIR CANADA, CANADA
JAZ	JAZZ	AIR CANADA REGIONAL INC, CANADA
AFR	AIRFRANS	AIR FRANCE, FRANCE
CCP	CHAMPION	AIR GRAND HOLDINGS, INC. USA
AJM	JAMAICA	AIR JAMAICA, JAMAICA
RCH	REACH	AIR MOBILITY COMMAND, USA
STC	STARCHHECK	AIRNET SYSTEMS, INC. USA
AWI	AIR WISCONSIN	AIR WISCONSIN, USA
CIT	CITRUS	AIRTRAN AIRWAYS, INC. USA
ASA	ALASKA	ALASKA AIRLINES INC, USA
AZA	ALITALIA	ALITALIA, ITALY
ANN	ALL NIPPON	ALL NIPPON AIRWAYS
AAL	AMERICAN	AMERICAN AIRLINES, INC. USA
AMT	AMTRAN	AMERICAN TRANS AIR, INC. USA
EGF	EAGLE FLIGHT	AMR AMERICAN EAGLE, INC. USA
NGF	ANGEL FLIGHT	ANGEL FLIGHT AMERICA, USA
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Figure 3-11. Three-Letter Identifier Printed Test Results

3.1.6.2 Test Callsign

Students can access a test that will evaluate their knowledge of callsigns by selecting the “Test Callsign” module. An example of this test is provided in Figure 3-12.

Callsign Test

3 Letter ID	Callsign	Aircraft Operator
JZA		AIR CANADA REGIONAL INC. CANADA
FLG		EXPRESS AIRLINES I, INC USA
WOA		WORLD AIRWAYS INC. USA
VNR		AVANTAIR, INC. USA
TRS		AIRTRAN AIRWAYS, INC. USA
KFS		KALITTA FLYING SERVICE, INC. USA
OPT		FLIGHT OPTIONS, USA
CPZ		COMPASS AIRLINES
AFL		AEROFLOT, RUSSIAN FEDERATION
NGF		ANGEL FLIGHT AMERICA, USA
RYN		RYAN AVIATION, USA
FIV		CITATIONSHARES, USA
FAW		FALWELL AVIATION PTY LTD, USA
AMT		AMERICAN TRANS AIR, INC. USA
WML		CHANTILLY AIR, INC. USA
EJM		EXECUTIVE JET MGMT, INC. USA
SVA		SAUDI ARABIAN AIRLINES, SAUDI ARABIA
DAL		DELTA AIR LINES, INC. USA
ASH		MESA AVIATION SERVICES, INC. USA
EJA		NETJETS AVIATION, INC. USA
FAO		FALCON AIR EXPRESS, USA
GAA		BUSINESS EXPRESS, USA
AJM		AIR JAMAICA, JAMAICA
COM		COMAIR, INC. USA

Figure 3-12. Callsign Test

When “Test Callsign” is selected, the following will occur:

- Students will be provided with an electronic table that includes the three-letter identifier and company name (aircraft operator) for each airline. Entry fields will be blank for the callsigns.
 - The company names will be listed in random order (e.g., not alphabetical).
- After moving the cursor to an entry field and selecting (anywhere in the box), the callsign can be typed.
 - Once a callsign has been entered, students can click on another box in order to begin typing. (Note: The student can proceed in any order desired).
- Once students have finished entering callsigns, the “Print” button can be selected.
 - If answers have not been entered for all of the airlines then a message will appear asking, “You have left some of the answers blank. Do you want to continue?” If “No” is selected, the student will be able to go back to the test. If “Yes” is selected, the test will be printed, out and the student will be finished.

Upon selecting the “Print” button, the automation will check the answers submitted, comparing them with the identifiers stored in the database. A “scored” test will be sent to the printer, and the screen will be grayed out. An example of the printout is depicted in Figure 3-13. The “Print” button also acts as a submit command to record and grade the tests electronically with an option to print as required by a facility.

- The results will be printed in the form of a table with the type of test displayed at the top, along with a time stamp of when the test was started and finished.
- The answers will be arranged alphabetically, based on company names.
 - All incorrect answers will be highlighted.

- The number of correct answers out of the maximum possible will be shown at the bottom.

The Callsign Test will collect the results of a test as well as the time stamp for the start and submission of the test.

Callsign Test		
Test Started	3:24pm	Student name
Test Submitted	4:38pm	Student ONE
3 LETTER ID	CALLSIGN	COMPANY NAME
FLC	FLIGHT CHECK	FINFO FLIGHT INSPECTION AIRCRAFT, USA
FLX	FLIGHT EXPRESS	FLIGHT EXPRESS, INC. USA
OPT	OPTIONS	FLIGHT OPTIONS, USA
FRL	FREEDOM AIR	FREEDOM AIRLINES
FDY	FRIENDLY	FRIENDLY AIR, USA
EMJ	LIGHT HOUSE	FRIENDSHIP AIRWAYS, USA
FFT	FRONTIER	FRONTIER AIRLINES, USA
GOJ	GOJET	EUROJET AVIATION LTD
HPJ	HOPAJET	HOPAJET, INC. USA
IBE	IBERIAN	IBERIA LINEAS AEREAS DE ESPANA, S.A.
JBU	JETBLUE	JETBLUE AIRWAYS CO. USA
LXJ	FLEXJET	JET SOLUTIONS, USA
CKS	CONNI	KALITTA AIR, LLC, USA
KFS	KALITTA	KALITTA FLYING SERVICE, INC. USA
KHA	KITTYH	KITTY HAWK AIRCARGO, INC. USA
KLM	KLM	KLM ROYAL DUTCH AIRLINES, NETHERLANDS
KAL	KOREANAIR	KOREAN AIR LINES CO., LTD. REPUBLIC OF KOREA
LOF	WATER SKI	LAKES OF THE OZARKS
MPH	MARTINAIR	MARTINAIR HOLLAND N.V. NETHERLANDS
ASH	AIR SHUTTLE	MESA AVIATION SERVICES, INC. USA
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Figure 3-13. Callsign Test Printed Results

3.1.6.3 Aural challenge

Students can access the final knowledge assessment tool by selecting the “Aural Challenge” module. After selecting this, the screen depicted in Figure 3-14 will be presented.

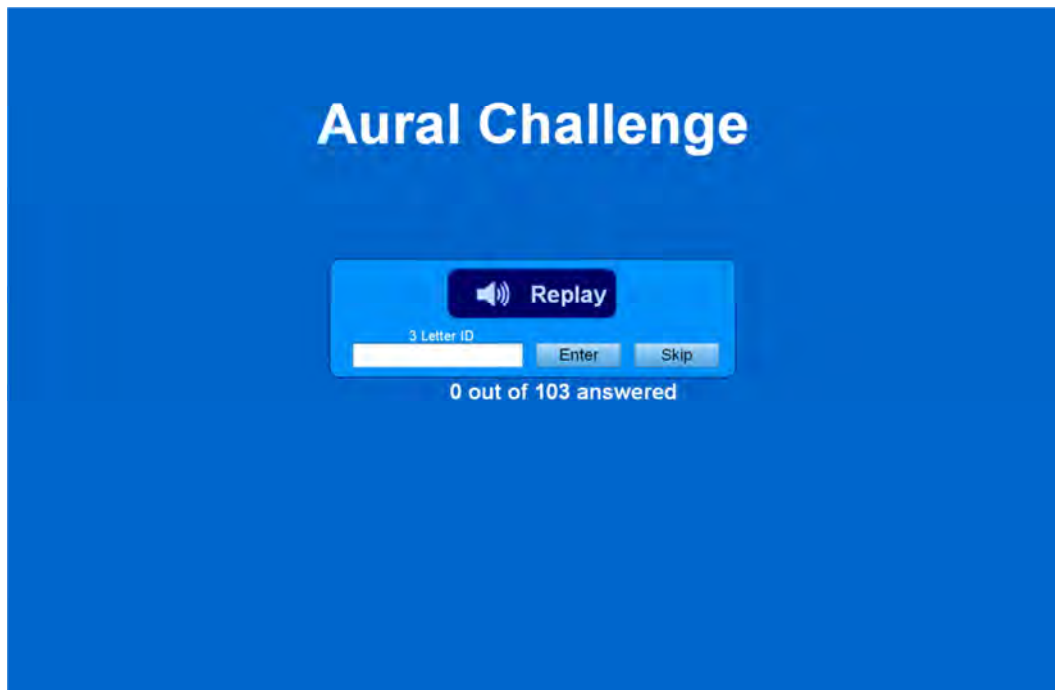


Figure 3-14. The Aural Challenge

The Aural Challenge will proceed as follows:

- The game will randomly select and read aloud a callsign for one of the airlines.
- Once the callsign is read aloud, the student can type the associated three-letter identifier in the input box, followed by “Enter” on the keyboard or screen.
- The student will be given the option to “Replay” a callsign; for example, when the student is not able to decipher the callsign the first time.
- The student will be given the option to “Skip” a callsign.
 - Skipping a callsign will put it at the end of the queue so the student can provide an answer later.
- A counter will show how many three-letter identifiers have been answered (e.g., 99 out of 103).
- Once the student has entered all of the three-letter identifiers, a print dialogue box will open.

Upon selecting the “Print” button, the automation will check the answers submitted. A “scored” challenge will be sent to the printer. An example of the printout is depicted in Figure 3-15. The “Print” button also acts as a submit command to record and grade the tests electronically with an option to print as required by a facility.

- The results will be printed in the form of a table with “Aural Challenge” displayed at the top, along with a time stamp of when the test was started and finished.
- The answers will be arranged alphabetically, based on company names.
 - All incorrect answers will be highlighted.
- The number of correct answers out of the maximum possible will be shown at the bottom.

The Aural Challenge will collect the results of a test as well as the time stamp for the start and submission of the test.

Aural Challenge		
Test Started	2:34pm	Student name Student ONE
Test Submitted	3:12pm	
3 LETTER ID	CALL SIGN	COMPANY NAME
EIN	SHAMROCK	AER LINGUS, IRELAND
AFL	AEROFLOT	AEROFLOT, RUSSIAN FEDERATION
AAL	AMERICAN	AMERICAN AIRLINES, INC. USA
ABX	ABEX	AIRBORNE EXPRESS, INC. USA
ACA	AIR CANADA	AIR CANADA, CANADA
JAZ	JAZZ	AIR CANADA REGIONAL INC, CANADA
AFR	AIRFRANS	AIR FRANCE, FRANCE
CCP	CHAMPION	AIR GRAND HOLDINGS, INC. USA
AJM	JAMAICA	AIR JAMAICA, JAMAICA
RCH	REACH	AIR MOBILITY COMMAND, USA
STC	STARCHECK	AIRNET SYSTEMS, INC. USA
AWI	AIR WISCONSIN	AIR WISCONSIN, USA
CIT	CITRUS	AIRTRAN AIRWAYS, INC. USA
ASA	ALASKA	ALASKA AIRLINES INC, USA
AZA	ALITALIA	ALITALIA, ITALY
ANN	ALL NIPPON	ALL NIPPON AIRWAYS
AAL	AMERICAN	AMERICAN AIRLINES, INC. USA
AMT	AMTRAN	AMERICAN TRANS AIR, INC. USA
EGF	EAGLE FLIGHT	AMR AMERICAN EAGLE, INC. USA
NGF	ANGEL FLIGHT	ANGEL FLIGHT AMERICA, USA
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Figure 3-15. Aural Challenge Printed Results

3.1.7 Stats, Tutorial, and Reference

Figure 3-16 shows the “Stats” page. It will show various statistics from the five different games. The student can open this page by selecting the “Stats” button on the main menu.

Game Stats					
	Match 3	Match 3 Pro	Fill ID	Fill Callsign	Pick 2 Review
Maximum Possible Points	13650	15000	14000	14000	6000
High Score					
High Score Time					

Main Menu

Figure 3-16. Stats Page

As shown in Figure 3-16, the page will display information for each game, including:

- The maximum score that can be achieved.
- The student’s high score, and the time associated with that high score.

Students also have the option to receive instructions on how to play the games in the form of an interactive tutorial. The tutorial can be launched by selecting the “Tutorial” button on the main menu. Once this button is selected, an avatar will walk students through the steps of game play, as well as describe the features and information shown on the screen. An example from the tutorial explaining scoring is shown in Figure 3-17. The avatar’s script is provided in Appendix A.

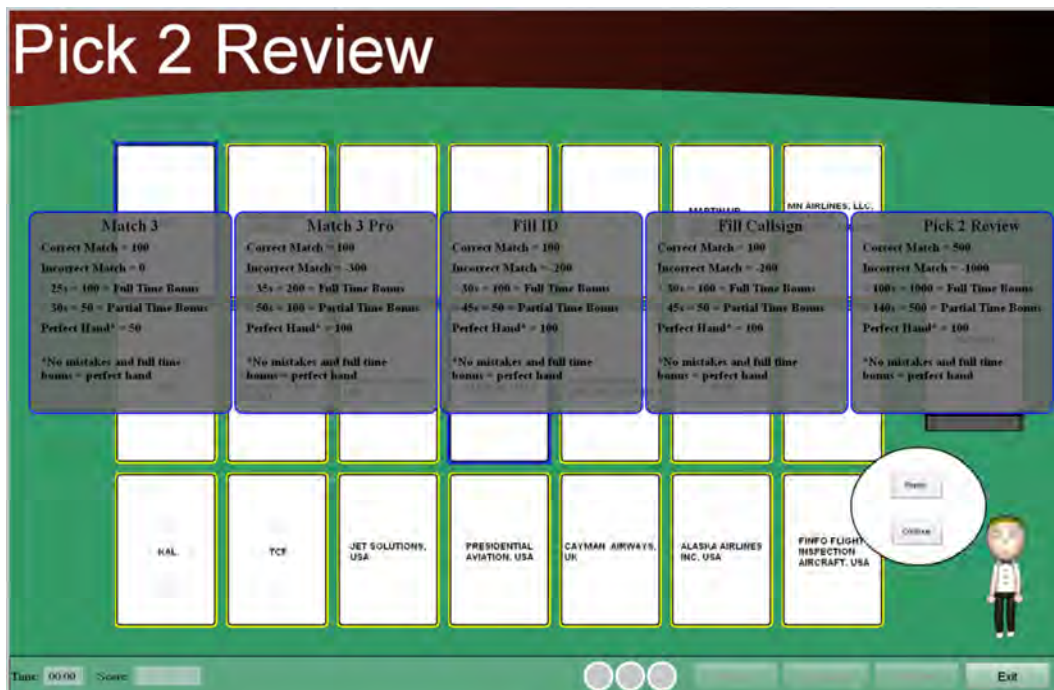


Figure 3-17. Tutorial

Students can access a reference page (See Figure 3-18) that displays all the airline information in a tabular format by selecting the “Reference” module. After selecting this, a table with three columns will be presented. (Note: The table will have the same look as the tests). The information will be arranged alphabetically by company name; however, selecting the heading for another column will alphabetize the information based on that header. The reference page will include a separate scroll bar so that students can view all of the airline information.

Airline Information		
3 Letter ID	Callsign	Aircraft Operator
EIN	SHAMROCK	AER LINGUS, IRELAND
AFL	AEROFLOT	AEROFLOT, RUSSIAN FEDERATION
JZA	JAZZ	AIR CANADA REGIONAL INC, CANADA
ACA	AIR CANADA	AIR CANADA, CANADA
AFR	AIRFRANS	AIR FRANCE, FRANCE
AJM	JAMAICA	AIR JAMAICA, JAMAICA
RCH	REACH	AIR MOBILITY COMMAND, USA
AWI	AIR WISCONSIN	AIR WISCONSIN, USA
ABX	ABEX	AIRBORNE EXPRESS, INC. USA
USC	STARCHECK	AIRNET SYSTEMS, INC. USA
TRS	CITRUS	AIRTRAN AIRWAYS, INC. USA
ASA	ALASKA	ALASKA AIRLINES INC, USA
AZA	ALITALIA	ALITALIA, ITALY
ANA	ALL NIPPON	ALL NIPPON AIRWAYS
AAL	AMERICAN	AMERICAN AIRLINES, INC. USA
AMT	AMTRAN	AMERICAN TRANS AIR, INC. USA
EGF	EAGLE FLIGHT	AMR AMERICAN EAGLE, INC. USA
NGF	ANGEL FLIGHT	ANGEL FLIGHT AMERICA, USA
DHL	D-H-L	ASTAR AIR CARGO, USA
ASQ	ACEY	ATLANTIC SOUTHEAST AIRLINES
AUA	AUSTRIAN	AUSTRIAN AIRLINES
VNR	AVANTAIR	AVANTAIR, INC. USA
AVA	AVIANCA	AVIANCA, AEROVIAS NACIONALES DE COLUMBIA, S.A.

Figure 3-18. Reference Page

3.2 Data Collection

Objective data is collected to not only keep track of the students' game play and performance, but also to support the ITS design (e.g., to determine specific airline information for which the students require additional practice). The following data should be recorded by the system:

- The total amount of time students are spending on the games.
 - Summed time of all the boards completed whether “won” or “lost.”
- The number of times students see each airline.
 - Answered correctly + answer incorrectly = total.
- The number of times an airline is correctly matched/filled.
- The number of times an airline is incorrectly matched/filled.
 - If two airlines are mismatched, the airline with two matching cards is counted as having 2 incorrect responses while the third card is counted once.
 - If all three pieces (cards) of airline information are mismatched then those 3 airlines will receive one incorrect count each.
- The score for each game that is played.
- The score for each test that is taken.
- The score for each challenge that is taken.

4 Lessons Learned and Design Recommendations

This section presents some lessons learned through field evaluation as well as several recommended enhancements for the games. The recommendations include design enhancements that were suggested by students and instructors, as well as original design specifications that were considered but not implemented.

One of the challenges in implementing the airline memorization games pertained to inputting and updating all of the required facility-specific data. This was a manual process that involved referencing the FAA Order JO 7340.2B for the most accurate information and then entering the data into the prototype's database. At various times during the evaluation, airline information had to be added or deleted (e.g., when two companies merged or no longer traversed the facility). Ideally, an electronic repository could exist that would be readily available and have the most up-to-date information. The games could then populate the database by pulling information directly from this repository. In addition, when NAS-wide changes occur, the system could update itself. This would ensure that students were always being presented with the most current information.

Along with receiving repository information electronically, facilities should manage student information, such as test results, electronically. This will make the tracking and evaluation of student performance more efficient and accurate. However, due to current requirements at many facilities, paper documentation is still needed, and the system should have the ability to accommodate printouts.

The games were built with Flash using ActionScript. There was a webserver (Apache), application server (Adobe ColdFusion), and database (MySQL) that delivered the content to a web browser. This worked adequately for the airline memorization games, but the drawback is that many devices and web browsers do not support Flash. It may be necessary to look at other development technologies such as HTML5 as a delivery mechanism that is more encompassing.

There are several design enhancements that should be considered for implementation. The airline memorization games are intended to add some operational context to the learning of the information. For example, with the Aural Challenge, students hear a callsign being spoken and then must respond to it by typing a three-letter identifier. This challenge, as well as some of the games, can be further adapted with automated speech recognition to more closely reflect how airline information is used on the job. In other words, instead of having students enter the information with the keyboard, it could be spoken instead.

Finally, it is important to note that the concepts and capabilities used in the airline memorization games can be applied to the learning of other types of basic ATC information. For instance, similar card games can be designed to facilitate the memorization of various fixes, navigational aids, and airports.

5 References

- [1] J. Vu and M. Weiland, “Terminal Trainer Prototype Field Evaluation Report,” The MITRE Corporation, McLean, VA, MTR090445, November 2009.
- [2] A. Worden, “The Field Evaluation Report of Initial Intelligent Training System Capabilities Using the enroute**Trainer** Prototype,” The MITRE Corporation, McLean, VA, MTR100009, January 2010.
- [3] A. Worden, “Report on the Evaluation of Intelligent Training Systems Capabilities in the enroute**Trainer** Prototype,” The MITRE Corporation, McLean, VA, MTR100331, September 2010.
- [4] J. Vu and M. Weiland, “Terminal Trainer Prototype Field Evaluation Report: Potomac Consolidated TRACON (PCT),” The MITRE Corporation, McLean, VA, MTR110056, February 2011.
- [5] A. Worden, “En Route Field Evaluation Report: Intelligent Training System Capabilities,” The MITRE Corporation, McLean, VA, MTR090338, September 2009.
- [6] K. Baldwin et al., “Integrating Advanced Training Technologies at Air Traffic Control Facilities,” The MITRE Corporation, McLean, VA, MTR130184, April 2013.

Appendix A Avatar Script

1. Before any cards are dealt (on the playing area) the dealer/avatar (we will call him Jack) will appear (fading in) in the middle of the screen and introduce himself to the player. The background should be the playing board for Match 3.

Jack: Hello! Let me introduce myself! My name is Jack \pause and I will be your dealer. Let me show you how to play.

Select replay if you want me to repeat what I just said or continue to move on.

Thought bubble prompt: **Replay or Continue**

2. Jack: *The cards are dealt in this area.*

Avatar moves to the right of where the cards are dealt and points to them.

Jack: Let's first learn how to play the matching games. Only in Match 3 will you see the matches before you play the hand, like this.

Cards are then dealt as it would in the game.

Jack: When you think that you have studied the matches long enough, select the deal cards button to play.

The avatar then move towards and points to the “Deal” button.

Thought bubble prompt: **Replay or Continue**

3. Jack: *Go ahead and select the deal cards button.*

Make the button clickable. When the play presses the button the avatar disappears. Once the player selects this, this should behave as the game would with the cards being shuffled and randomly dealt onto the playing area. Now the avatar reappears on the side (doesn't matter which side) not pointing at anything.

Jack: Once the cards are dealt randomly and you can now match them. Follow me and click on the cards that I point to.

Have the avatar move and point to the first card. When the player selects that card (it should be the only one selectable), the avatar will then move to the next card until a set of three are select. Once one set of three cards are selected the game should behave as it normally would with the avatar moving back to the side (out of the way) and not pointing.

Jack: Well done! However, when you get a match wrong this is what you'll see.

Show the player the effect when cards are chosen incorrectly. (The big “X” and buzzer sound).

Jack: Please note that you can unselect a card by clicking it again. Also, in Match 3 Pro, you will be dealt “dummy” cards that do not have a match. Now on to the fill games.

Thought bubble prompt: **Replay or Continue**

4. Jack: This is how the fill games look.

Deal the cards for Fill ID with American airlines included.

Jack: *Depending on which game you play, you will need to type in either the callsign or three letter identifier.*

Have the avatar point to a blank card for three letter ID for American airlines.

Jack: *Click on this card and type A A L in the box. When you are done you can press enter or select another card.*

Let the player type in AAL. The avatar will move to the side and the game will behave as it normally would.

Jack: *Great! Now let's see Pick 2 Review.*

Thought bubble prompt: **Replay or Continue**

5. Jack: Pick 2 Review uses the airlines you missed the most often and this is how it looks.

Deal Pick 2 Review cards.

Jack: *This is a review, so you only need to select one match at a time. Follow me and select the cards that I point to.*

Have the avatar move and point to the first card. When the player selects that card (it should be the only one selectable), the avatar will then move to the next card to complete the set. Once the set is matched the game should behave as it normally would with the avatar moving back to the side (out of the way) and not pointing.

Jack: *Great! We're almost done.*

Thought bubble prompt: **Replay or Continue**

6. Jack: *Now that you know how to play, these are the points that you can score.*

Show five pop-up windows. Each one will represent one game and show all the scoring stats.

Thought bubble prompt: **Replay or Continue**

7. Bring up Match 3 as an example. Have avatar move and point to the bottom bar.

Jack: *To find out what the items at the bottom are for, you can move your mouse cursor over those items and a popup will appear with an explanation. Go ahead and give it a try.*

Thought bubble prompt: **Replay or Continue**

Jack: *Now you are ready for the games!*

Thought bubble prompt: **Exit**

Selecting "exit" will take the player back to the main menu.

Appendix B List of Abbreviations

Acronym	Definition
ARTCC	Air Route Traffic Control Center
ATC	Air Traffic Control
CAASD	Center for Advanced Aviation System Development
COTS	Commercial Off-the-Shelf
CPC	Certified Professional Controller
FAA	Federal Aviation Administration
ITS	Intelligent Training System
MIA	Miami TRACON
NAS	National Airspace System
OJT	On-the-Job Training
PCT	Potomac Consolidated TRACON
TRACON	Terminal Radar Approach Control
TTS	Text to Speech
ZID	Indianapolis ARTCC

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