NormSTAD Flight Analysis Tool: Visualizing Air Traffic Patterns over the United States

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ABSTRACT
In this paper, we describe the NormSTAD Flight Analysis Tool, a novel interactive visualization application of air traffic patterns using Aircraft Situations Display to Industry (ASDI) data. A web-based visualization is demonstrated which allows users to analyze flight data and make discoveries pertaining to their 4D trajectories which include their time, distance, altitude, and speed. Unique patterns discovered in this application could result in less fuel consumption and more efficient management of departure and arrivals by air traffic controllers.

The application consumes ASDI data then normalizes flight attributes including distance, speed, altitude, and time along the flight path. This information is then displayed on a line chart which can be customized through filtering, coloring and selection. Attributes pertaining to selected flights can be viewed in a details on demand fashion. The result is a both intuitive and visually appealing visualization with the goals of revealing flight paths, spotting trends and revealing outliers.

Categories and Subject Descriptors
H.3.3 [Information Storage and Retrieval]: Information Search and Retrieval—Information filtering;
H.3.5 [Information Storage and Retrieval]: Online Information Services—Web-based services;
H.5.2 [Information Interfaces and Presentation]: User Interfaces

General Terms
Design, Human Factors, Performance

1. INTRODUCTION
The National Airspace System (NAS) is a complex nondeterministic system that is impacted continually by both major and minor variables including aircraft delays and human decisions that largely cannot be accurately forecasted. The system has developed to offer feedback and response at all levels from gate agents to the Command Center with the intent of restoring the desired efficient state. The result is a self-ordering system that is broadly similar, but has different daily operations. An important point to note is that a seemingly insignificant event such as a delay in obtaining a wheelchair can have large impacts in delays as slots are missed and reassigned. At every stage decisions are being made to recover the system and keep it as close to optimal given its current state. However, there is currently no method of quantifying the effects of a decision or comparing them to an alternate decision. NAS operations are recorded concurrently across different systems in different formats. If this information was collated and catalogued, it would be possible to analyze the NAS operations to identify inefficiencies, disruptive events and poor decisions along with the resulting impacts on airspace users.

In 1992 the Federal Aviation Administration (FAA), started a program to provide real-time flight plan and track information for the NAS to airlines and other organizations. The feed known as Aircraft Situation Display to Industry (ASDI) is a product of the Enhanced Traffic Management System (ETMS). It originates from the Traffic Flow Management (TFM) Production Center located at the William J. Hughes Technical Center in Atlantic City, New Jersey. Figure 1a shows the number of ASDI messages for a single random day while Figure 1b shows the number of supporting records for the main message set. As can be by Figure 1, tens of millions of ASDI messages are recorded each day.

A novel visualization system is needed to aggregate this data in order for users to detect anomalies and discover unique patterns. To be able to compare flights of varying distance or time, the data values are normalized to create a standardized display of time series allowing direct comparison between flights.

The rest of this paper is organized as follows. Section 2 discusses related work. Section 3 explains the ASDI data and its attributes. Section 4 describes the overall architecture and the interface is described in Section 5. Section 6 provides the experts’ evaluation and feedbacks of the implementation. Section 7 discusses future work, while our conclusions are outlined in Section 8.

2. RELATED WORK
There has been a great amount of research in flight data pertaining to algorithms for optimal trajectories, anomaly detection and conflict resolution [8, 9, 12, 17, 20, 21]. Liu et al. [17] studied departure and arrival delays and how these
delays can propagate to future flight delays and cancellations. Our system instead focuses on in-air flight data to help study why these delays may be happening with respect to time of day, flight number, airline or flight trajectory. Chu et al. [12] had a similar approach to NormSTAD in that they attempted to detect anomalies in aircraft cruise data by using time, location, altitude and speed. They also normalized their data as was done in the NormSTAD tool. However, the NormSTAD tool utilizes historical data while their system studied the results of a simulation. While the study of such algorithms for detection of anomalies and conflict resolution is vitally important to the field of aviation, the goal of the NormSTAD Flight Analysis Tool is to allow easy and timely analysis of large amounts of flight data without the need for such algorithms.

Landry [16] and Khoury et al. [14] stress the importance of informative visualizations for the study of air traffic control systems. Landry reviewed and analyzed the current air traffic control system which has evolved around the air traffic controller and pilots while not updating to the increasing air traffic. Landry states that the current visualizations may not concisely display the operator with the necessary information. Khoury et al. focus their attention on construction of a 3D model of only airport operations. Their analysis of delays is limited in that they do not include flight sensory data in their analysis.

Many other researchers have created flight data visualizations [11, 13, 15, 18, 19]. Hurter et al. [13] designed a metro style visualization for flight paths in the Air Traffic Control context in order to avoid severe overlaps of the lines along with a complete method to produce an efficient layout. This visualization is clear and visually appealing, but fails to inform the user of differences in flight paths since it does not use the actual latitude and longitude coordinates of the flight. The AIRNET platform by Pestana et al. [19] provides a 3D model for surveillance, control, guidance and decision support services by airport operators. The NormSTAD tool avoids 3D visualization to reduce complexity by allowing the axes to be changed by the user.

After reviewing the current state-of-the-art of flight visualizations, we decided to follow Wehrend’s ideas [22]. Wehrend believes that visualizations should break problems into smaller problems and find applicable techniques for each of these smaller problems. The visualization is then a unified representation of the smaller problems in order to solve larger problems. It is with this belief that the NormSTAD Flight Analysis Tool was based and designed using four connected view panels for information display and interaction. The Filters panel allows for data filtering which is separated from our data visualization and selection Line Chart. Details on demand are displayed in two separate panels, the Map and Details on Demand panel. Using this application, airline operators will be able to better determine flight plans, discover holding and slow-down patterns caused by disruptive events, consume less fuel and save time, money and the environment in the process.

### 3. ASDI DATA

In this section, we introduce ASDI data and its attributes. In addition, we describe the data normalization process that NormSTAD uses.

The ASDI subsystem of the Traffic Flow Management System (TFMS) [7] allows near real-time air traffic data to be disseminated to members of the aviation industry. The data stream is made available through the U.S. Department of Transportation’s Volpe Transportation Center. The data stream consists of data elements which show the position and flight plans of all aircrafts in the United States. Attributes include the location, altitude, airspeed, destination, estimated time of arrival and tail number or designated identifier of air carrier and general aviation aircraft operating on IFR flight plans within the United States airspace.

Due to the limitations in the web tools employed by NormSTAD, only a subset of the historical ASDI data was used. The data set included Delta Airlines and Delta Connection, Atlantic Southeast Airlines’ flights departing from Seattle Tacoma Airport (KSEA) for the duration of July and August 2012.

Flights pertaining to Delta Airlines consisted of the following flight numbers:

- DAL842, departing from Seattle Tacoma and arriving at New York JFK Airport
- DAL1043, departing from Seattle Tacoma and arriving at New York JFK Airport
- DAL2410, departing from Seattle Tacoma and arriving at Detroit Metropolitan Wayne County Airport

Flights pertaining to Delta Connection, Atlantic Southeast Airlines consisted of the following flight numbers:

- ASA24, departing from Seattle Tacoma and arriving at Boston Logan International Airport
ASA678, departing from Seattle Tacoma and arriving at Denver International Airport

The dataset was generated by merging a subset of various message types including:
- Departure Information
- Track Information
- Flight Management Information

The process yielded the following fields:
- Source Date
- Source Time
- Aircraft Id
- Speed
- Altitude
- Latitude
- Longitude

In addition, certain values were normalized so that various flights or time series of different flights could be overlaid on the same line chart. Normalized values for interactive visualization included:
- Altitude
- Speed
- Distance
- Planned Flight Time
- Actual Flight Time

Normalized values range between 0 and 1 where 0 denotes the minimum possible for a given value (i.e. the departure airport in the case of distance) and 1 denotes the maximum possible for a given value (i.e. the arrival airport in the case of distance) for all values with the exception that Actual Flight Time may exceed 1 or be below 1 due to the fact that it does not correspond exactly to the Planned Flight Time.

4. IMPLEMENTATION

The NormSTAD Flight Analysis Tool is a web-based implementation which is primarily built using the D3 JavaScript library. D3, which stands for Data-Driven Documents, is a library that allows users to bind arbitrary data with a Document Object Model (DOM) and achieve data-driven transformations [1]. NormSTAD utilizes a predefined API of D3 to import our data from a local file and store the normalized values of time, distance, speed and altitude for each flight. Flight information including flight number, airline and date are also imported using D3. After the data is finished being imported, the filters are dynamically created.

All filters in the Filters section are created using HTML syntax and JavaScript apart from the input text bar to search for a specific flight which is created using jQuery UI [4]. Filters to select airlines and flights are bound to the imported data using D3 so that they can update the visualization accordingly. Filters to select the date of flights are created using the DHTMLX [2] JavaScript library.

Drop down menus for choosing the line chart type and color and the checkbox for map display are implemented in JavaScript with events handled in D3 to link filters with the line chart. The NVD3 [6] JavaScript library is used for the line chart, horizontal axis selection and the legend. The Google Maps JavaScript API [3] provides our flight path map, airport markers and flight path drawing. The Details on Demand panel is a dynamic HTML table which changes as a result of selection in the line chart.

A simple model of the interaction between the panels and the libraries that they use is shown in Figure 2.

5. USER INTERFACE

The NormSTAD Flight Analysis Tool user interface initially shows four panels of display as seen in Figure 3 labeled Filters, Line Chart, Map and Details on Demand. Each panel allows for direct interaction or display of the data and can be minimized to give more room to the other panels by selecting the arrow in the upper right corner of the specific panel. In the following sub sections, we will introduce each panel to give readers a better sense of the functionality of the NormSTAD Flight Analysis Tool.

5.1 Filters

On the left-side of the tool, there is a Filters panel which allows the user to limit the results that they see on the Line Chart. The first section, “Choose Airlines”, is for selection of airlines to display in the Line Chart. The NVD3 [6] JavaScript library is used for the line chart, horizontal axis selection and the legend. The Google Maps JavaScript API [3] provides our flight path map, airport markers and flight path drawing. The Details on Demand panel is a dynamic HTML table which changes as a result of selection in the line chart.

Figure 2: Interaction of the implementation files and libraries for the NormSTAD Flight Analysis Tool
Figure 3: NormSTAD Flight Analysis Tool’s interface showing Normalized Actual Flight Time for the range from 0.81 to 0.93 with respect to Normalized Actual Distance. One flight is selected (red line) with its corresponding path shown on the map and details in Details on Demand.

Figure 4: NormSTAD’s Line Chart showing Normalized Actual Flight Time for the range from 0.55 to 0.68 with respect to Normalized Distance for flight ASA678. An outlier is selected and displayed in red.
Figure 5: (a) Filtering to display only the Normalized Speed vs. the Normalized Actual Flight Time for the range from 0.4 to 0.6 along the horizontal axis for flights ASA24 and DAL842. Flights are colored by airline. (b) Displaying Normalized Altitude vs. the Normalized Actual Flight Time colored by flight number.
can be further filtered by limiting the flight date using the “Start Date” and “End Date” drop-down calendar menus. As shown in Figure 6, a calendar is populated after a user clicks the text box. Users can then easily select two dates to filter the date range of flights to show in the Line Chart. Below the date selector, there is a search bar which allows specific flights to be shown.

Apart from filters to control the flights shown in the Line Chart, NormSTAD also allows changing of the attributes displayed and the color of the lines in the Line Chart. The “Line Chart Type” value changes the axes and updates the normalized data displayed. By default, this value is set to “Distance vs. Actual Flight Time”, but it can be changed to “Distance vs. Planned Flight Time”, “Altitude vs. Actual Flight Time”, or “Speed vs. Actual Flight Time”. The line can be colored by its airline or by its flight number using the “Color by” drop-down menu. After changing the color, the legend above the Line Chart updates with the new color scheme. In Figure 5a, we show “Speed vs. Actual Flight Time” colored by airline and in Figure 5b we show “Altitude vs. Actual Flight Time” Line Chart colored by flight number.

5.3 Details on Demand

A mouse click on a line has the effect of updating the Details on Demand panel on the bottom right to display a summary of the selected flight information. The Details on Demand panel displays the flight number, the departure and arrival airports, the date, the arrival time and the duration of the flight in minutes for the flights selected in the Line Chart. As a result of the feedback from an expert reviewer, when the user selects multiple lines, the records in the Details on Demand panel dynamically increases. The same is true for when lines are deselected and the Details on Demand removes the row corresponding to the line from its display.

5.4 Map

Below the Line Chart, there is a Google Maps map ini-
tially showing a map of the United States. If the “Show Flight Path” checkbox is checked in the Filters panel, then a mouse click on a line repositions the map windows and displays the flight path in the Map panel on the map for the sampled latitude and longitude points along with labels displaying the departure and arrival airport codes at their corresponding locations. A mouse click on another line will reposition the map window (if necessary) and show the new flight path along with labels for the departure and arrival airports. To enhance the visualization, a small green circle is animated moving along with the flight path starting at the departure airport and ending at the arrival airport as seen in Figure 7. This quickly informs the user on the direction of the flight without having to reference the Details on Demand panel. If the “Show Flight Path” checkbox is unchecked, the flight path is not shown. With the map view, users are able to find the locations of the flights where abnormal flight patterns occur in the Line Chart.

6. EVALUATION

In this section, we present the experts’ reviews and feedback of the NormSTAD Flight Analysis Tool. Due to the niche nature of our subject matter, Air Traffic Management, we decided that an expert review aided by a questionnaire would be the best way to get detailed information pertaining to the NormSTAD tool. Three subject-matter experts were selected to be reviewers. Of these three subject-matter experts, one was from academia and two were from industry. The subject from academia is a member of the Independent Experts Operational Goals Group of the Committee on Aviation Environmental Protection, part of the International Civil Aviation Organization that sets the standards and policies for world-wide civil aviation. The other two subjects are from the aviation industry with an average of thirty years of experience in Air Traffic Control and Air Traffic Management. Both of the industry experts are now retired, but were affiliated with the Federal Aviation Administration serving at various positions in the Air Traffic System Command Center.

We began our evaluation by giving a brief introduction and twenty-minute tutorial of the NormSTAD Flight Analysis Tool which was followed by ten minutes where each expert was allowed to interact with the tool on their own. Following the training and interaction, the experts were each given three specific tasks to complete. During this process, we encouraged the experts to “think-aloud” and recorded their thought process.

During the task completion session, the expert from academia commented that “NormSTAD provided a very novel way of looking at flights. Due to normalized values, time series of the same flights or even flights with different flight numbers regardless of their flight duration, departure and arrival airports, air speed and altitude. They could be overlaid for pattern recognition.” The expert also commented that the tool could be more responsive when the user toggled from one line chart to another.

One of the experts from industry commented during task completion that “You should demonstrate this to the FAA. They would benefit from using it!” The same subject-matter expert also commented that the dataset revealed some interesting patterns, pointing to one of the fluctuating vertical paths. He further analyzed and discovered details on this flight.

Figure 8: The results of the questionnaire shown in Appendix A for NormSTAD for each of our three experts.

The other expert from industry commented that he enjoyed using the tool and that “It was very easy to use”.

The goal of the training and task completion sessions was to determine if the NormSTAD tool met the experts’ expectations with regards to its functionality, responsiveness, intuitiveness, and interactivity. Upon completion of the tasks, the experts were given a questionnaire modelled after Chin et al. [10] and the NASA ARC Project [5] in which they were asked to rate the tool from various perspectives including its capabilities, terminology, graphical user interface, learning, and overall reaction. The experts were also allotted space to record their feedback and comments in open-ended text forms.

Figure 8 gives summary information on the results of our questionnaire. Among the three expert reviewers, the retired Air Traffic Controller 1 provided lower scores than the other two experts mainly due to the fact that he thought the tool could have been more flexible in terms of consuming other types of data, being more responsive to user interaction, and presenting fewer details on demand. As a result of his and other comments, changes were made to the software many of which are outlined below. The other two experts provided comparable ratings, one giving a full score for the “Screen” section. The version used by our experts received an 87% overall satisfaction rating.

Based on the feedback that we received in the questionnaires, the following changes were made to the NormSTAD tool as a direct result of the comments listed below:

**Comment:** The tool displayed an unnecessary amount of detailed information in the Details on Demand panel

**Solution:** Only summary information is now displayed in a stacked view

**Comment:** Limited selection of data representation in the line chart

**Solution:** Added three additional modes to display different sets of data on the line chart

**Comment:** Terminology was unclear or repetitive

**Solution:** Terminology was changed to clarify and shorten labels. For example “Normalized Estimated Time” was replaced with “Planned Flight Time” and a note was added to inform the user that all values were normalized

**Comment:** Would like to be able to use multi-select using the Control key
Solution: Added multi-select for the Control and Shift keys

Comment: Unclear color-coding of line chart

Solution: Legend with color codes added to line chart

Comment: Hard to see which lines were selected as they were just larger, but stayed same color

Solution: Lines are now enlarged and changed to red on selection.

Although we did not perform any additional expert reviews following NormSTAD updates, we are confident that with these improvements our scores would increase. The NormSTAD Flight Analysis Tool still has room for improvement with the help of more expert reviewers. Appendix A includes a copy of the questionnaire that was given to each of our expert reviewers.

7. FUTURE WORK

Throughout the design, development and review process a few features were brought to our attention that did not end up being in the current version of NormSTAD. A limitation that we were not able to incorporate in our data was in displaying all sensory data that we have for a given flight without sampling. While this was our initial intention, we quickly realized that this reduced the usability of our tool by making it much slower to update. We plan to utilize faster algorithms and load the data as necessary in order to give more accurate data points. We also plan to extend the data displayed beyond flight sensory data. In the current NormSTAD tool, we only display flight sensory data which is in-air data, but we plan to add information from departure gate to arrival gate to show the entire flight.

8. CONCLUSION

This paper demonstrated the NormSTAD Flight Analysis Tool for analysis of flight data with respect to normalized actual flight time, normalized planned flight time, normalized altitude, and normalized speed in an interactive line chart. Filtering can be applied to the visualization without data manipulation via simple selection. Selection of lines in the line chart allow for the flight trajectory to be overlaid on a map and displaying of flight summary information.

We have shown through a brief tutorial how an outlier can be spotted in flight data using the NormSTAD Flight Analysis Tool. It is our belief that researchers and those in the aviation field by initially using our tool will be able to see where further analysis is required by spotting outlier or slow-down patterns in order to design better flight plans and discover problem flights. As a result of these potential findings by our users, savings in time and money could be seen as efficiency is increased and fuel consumption is decreased. While future features would benefit the NormSTAD Flight Analysis Tool as outlined in Section 7, it is already ready for deployment after undergoing extensive analysis from our expert reviewers and testing from the developers.

For a demonstration of the NormSTAD Flight Analysis Tool, please see the video located at http://goo.gl/2XLyZ.

9. ACKNOWLEDGEMENTS

We would like to thank all of the participants who helped us evaluate alpha and beta versions of the tool. We were able to make improvements based on their expert reviews, and feedback. We would especially like to thank Professor Michael Ball of the Smith School of Business at the University of Maryland at College Park for his valuable guidance on determining a niche area in air traffic control and management to work on and overcoming issues pertaining to design and implementation of the NormSTAD Flight Analysis Tool. We would also like to thank Professor Ben Shneiderman for his advice that motivated us and kept us focused along the way.

10. CREDITS

Samet Ayhan Flight data finder, normalizer, parser, analyzer and stored it in a data structure. Found and setup appointments for our expert reviewers. Helped with design of the interface. In charge of expert reviews and relaying feedback to others. Wrote Abstract, Introduction, Related Work, ASDI Data, and the Evaluation sections along with supplying both of the tables for this paper. Wrote the manuscript for the video demonstration.

Brendan Fruin Helped with the design of the interface. Implementation of the line chart with horizontal range selection and the updating of the map to display the flight path. NormSTAD tool tester for all panels. Wrote Related Work, User Interface, Future Work, and Conclusion along with supplying the interface figures for this paper. Editor and formatter for this paper. Narrated the video demonstration.

Fan Yang Helped with the design of the interface and choosing of tools to use for implementation. Implementation of the filters and the details on demand panels. Extensive work done in the line chart selection functionality and work done in flight path display in the map. NormSTAD tool tester for all panels. Wrote the Implementation section along with supplying the Calendar and Map figures for this paper. Recorded the video demonstration.

11. REFERENCES


Flight Patterns: Visualizing Air Traffic Patterns over the United States

Thank you for participating in this Air Traffic Flight Pattern Analysis project to assist Air Traffic Controllers. This document will provide an introductory tutorial for using the prototype of a web-based interactive visualization set of tools for Air Traffic Management. Please help us improve these tools by filling out the questionnaire and providing your comments to our research team after the tutorial exercises. Thank you for helping us refine these on-line tools and web user interfaces. This project will benefit from evaluation by experts like you.

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System Requirements for accessing Web-based Flight Pattern Analysis Tool:
- Hardware: Standard PC or Mac. 2GHz CPU or above recommended,
- Operating System: Windows XP, 7, Mac OS x Mountain Lion, or Linux
- Web Browser: IE 9.0 or above, Firefox 15.0 or above, Google Chrome 23.0 or above
- Screen Resolution: 1024x768 or above recommended

Before we begin...

Please indicate what type of machine you are working on?
[ ] Windows (PC)  [ ] Mac  [ ] Linux  [ ] Other ________

Please indicate what type of Web Browser you are working on?
[ ] Internet Explorer  [ ] Firefox  [ ] Chrome  [ ] Other ________

Please indicate what display resolution you are using?
[ ] 800x600  [ ] 1024x768  [ ] 1280x1024  [ ] Other ________

Where is your test site? _________________________
What is your job title? __________________________

What is today’s date? ______________
Please write down the time you begin this tutorial. _________ (Hour): _________ (minutes)
SECTION 1 – TUTORIAL (15-20 minutes)

The major goal of this tutorial is to help you become familiar with online interactive visualization of flight pattern analysis tool developed by this project.

The first step is to launch your Web Browser.

- Type file:///term-proj-nada-master/term-proj-nada-master/gui.html on the URL address window.
- You will see the main page for the Flight Pattern Analysis tool as the following picture.

![Main Page](image)

- Select airline from the list under the “Choose Airline” combo box on the upper left corner on the main page.
- This will populate flights under the “Choose Flight” text box.
- Select flight number under the “Choose Flight” text box by clicking on it.
- This will load the data pertaining to the flight you’ve chosen on the line chart. The default line chart presents stacked view of Normalized Distance versus Normalized Actual Time.
- Draw an area of interest by dragging a rectangle on the bottom line chart. This will show zoomed in view of the area of interest on the top line chart. You can always adjust the size of the area of interest by resizing the border lines.
- Select start date indicating the start of the date range for the flights you would like to visualize by either typing in the text box under the “Start Date” or selecting the date from the calendar view.
- Select end date indicating the end of the date range for the flights you would like to visualize by either typing in the text box under the “End Date” or selecting the date from the calendar view.
Select line chart type from the combo box for the interactive visualization. Below is list of line chart types:

1. **Normalized Distance versus Normalized Actual Time**: This line chart displays distance values from the departure airport on Y axis and actual time elapsed since the flight departed from the departure airport on X axis. All values are normalized so that they all range between 0 and 1. Due to fact that non on-time flights take less or more than estimated time, the actual times usually result in non 1 value when the flight arrives to the destination airport.

2. **Normalized Distance versus Normalized Estimated Time**: This line chart displays distance values from the departure airport on Y axis and estimated time elapsed since the flight departed from the departure airport on X axis. All values are normalized so that they all range between 0 and 1. Due to fact that estimated time represents flight plan, all estimated times result in 1 when the flight arrives to the destination airport.

3. **Altitude versus Normalized Actual Time**: This line chart displays altitude values from the departure airport on Y axis and actual time elapsed since the flight departed from the departure airport on X axis.

4. **Speed versus Normalized Actual Time**: This line chart displays speed values from the departure airport on Y axis and actual time elapsed since the flight departed from the departure airport on X axis.

- Select color option under the “**Color by**” combo box. Based upon your selection, the lines will be colored either by flight number or by airline.
- Check the “**Show Flight Path**” box. This will display the animated flight on Google Map view at the bottom of the page.
- Select one of the flights on the top line chart by clicking on it so that its full attributes are displayed on Details on Demand table on lower right corner.
SECTION 2 – QUESTIONNAIRE (15-20 minutes)

Please record the time you completed the tutorial. _________ (Hour): _________ (minutes)

How long did it take you finish this tutorial? _________________________

Overall Reaction to the Software

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Screen

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</table>
Organization of information

confusing          very clear
1 2 3 4 5 6 7 8 9    N/A

Terminology and System Information

Use of terms throughout system
inconsistent       consistent
1 2 3 4 5 6 7 8 9    N/A

Terminology related to task
never              always
1 2 3 4 5 6 7 8 9    N/A

Position of messages on screen
inconsistent       consistent
1 2 3 4 5 6 7 8 9    N/A

Prompts for input
confusing          clear
1 2 3 4 5 6 7 8 9    N/A

Error messages
unhelpful          helpful
1 2 3 4 5 6 7 8 9    N/A

Learning

Learning to operate the system
difficult          easy
1 2 3 4 5 6 7 8 9    N/A

Exploring new features by trial and error
difficult          easy
1 2 3 4 5 6 7 8 9    N/A

Performing tasks is straightforward
never              always
1 2 3 4 5 6 7 8 9    N/A

Help messages on the screen
unhelpful          helpful
1 2 3 4 5 6 7 8 9    N/A

System Capabilities

Overall system speed
too slow          fast enough
1 2 3 4 5 6 7 8 9    N/A
<table>
<thead>
<tr>
<th></th>
<th>too slow</th>
<th>fast enough</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data loading speed</td>
<td>1 2 3 4 5 6 7 8 9</td>
<td>N/A</td>
</tr>
<tr>
<td>Response to user actions (zoom/pan)</td>
<td>too slow</td>
<td>fast enough</td>
</tr>
<tr>
<td>System reliability</td>
<td>unreliable</td>
<td>reliable</td>
</tr>
<tr>
<td>Correcting your mistakes</td>
<td>difficult</td>
<td>easy</td>
</tr>
</tbody>
</table>

**General**

List the most negative aspect(s)?
_____________________________________________________________________________
_____________________________________________________________________________
_____________________________________________________________________________

List the most positive aspect(s)?
_____________________________________________________________________________
_____________________________________________________________________________
_____________________________________________________________________________

Can you think of any functions that are missing in the Flight Pattern Analysis Tool? __________
_____________________________________________________________________________
_____________________________________________________________________________

What do you like about this expert review tutorial and questionnaire? _________________
_____________________________________________________________________________
_____________________________________________________________________________

Is there anything you do not like about this expert review tutorial and questionnaire? ______
_____________________________________________________________________________
_____________________________________________________________________________
SECTION 3 – TASKS (10-15 minutes)

Since you have completed the short tutorial, now please perform the following tasks:

1. Display all DAL2410 flights using Normalized Distance versus Normalized Actual Time line chart type.

2. Display all DAL1043 flights between 07/01/2012 and 08/31/2012 using Normalized Distance versus Normalized Estimated Time line chart type.

3. Display ASA678 flight on 07/02/2012 using Altitude versus Normalized Actual Time. Show flight path for this flight. Also, show the attributes for this flight in Details on Demand table.

Thank you for answering this questionnaire for the Air Traffic Flight Pattern Analysis project.

References:
http://map.sdsu.edu/arc/UserTest1new.pdf
http://hcibib.org/perlman/question.cgi?form=QUIS