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INTEGRATION OF WEATHER INFORMATION INTO THE DISPATCHER PRE-FLIGHT ROUTE SELECTION PROCESS

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Abstract

This paper will describe a field study of the procedures and weather information sources used by a major airline's dispatchers in the pre-flight route selection process in the presence of significant weather. Additionally, this paper will describe how the AWIN decision-support tool, an aide for selecting optimal four-dimensional routes that avoid weather hazards, could be incorporated into the flight dispatch process to produce safer, more fuel-efficient routes that avoid hazardous weather. During days with significant weather, dispatchers look at multiple, independent weather information sources to determine the impact of weather on their flights. Airlines typically have a pre-defined set of "company routes" and the dispatcher will select any route that avoids weather, with little consideration for fuel optimality. Weather information is not typically integrated into route visualization tools and dispatchers must make routing decisions while looking across multiple applications. Additionally, weather avoidance criteria can differ from dispatcher to dispatcher, resulting in different outcomes and safety margins. The proposed paradigm shift to a free-flight environment offers an opportunity to optimize flight routes for fuel and/or time as well as avoiding hazardous weather. The challenges lie in effectively integrating route and weather information in the same application to facilitate decision-making, and to standardize the definitions of what weather is to be avoided and the thresholds of severity across an airline's dispatchers. The current work processes of a major airline's dispatchers were studied via a combination of observational field studies, interviews, written questionnaires, and surveys. In addition, a Web-based survey was conducted across airlines to study which weather information sources dispatcher use. This information is used to discuss the potential incorporation of the AWIN decision-support tool in an airline setting. With such a system in place, airlines can expect gains in safety, in fuel efficiency of planned routes, and in time efficiency in the pre-flight dispatch process.

Introduction

Motivation

Airline dispatchers are the focal point of the System Operations Center's (SOC) mission of flight and schedule management. Dispatchers share operational control of every flight with the Pilot-In-Command (PIC). As such, the dispatchers are responsible for release of the flight, forwarding weather briefings, coordinating operating plans, and providing operational status feedback to the pilot during flight following [1]. The focus of this paper is the pre-flight route selection task. The dispatcher's location in the SOC allows him or her access to real-time information of on-going operations and developing environmental conditions. The dispatcher has a much broader view of the conditions in which the flight operates, both with respect to airline operations and weather conditions. During days with significant weather, dispatchers look at multiple information sources to determine the impact on the flights that they are dispatching. It is the duty of the dispatcher to pull information from multiple, independent weather sources, and to integrate that information with the route planning results. In bad weather days, when the optimally fuel-efficient route (calculated without taking into account intersections with hazardous weather) travels through areas of hazardous weather that should be avoided, dispatchers need to choose a different route that avoids weather. Typically an airline will have a pre-defined set of "company routes" and the dispatcher will select the first company route that avoids weather, with little consideration for fuel or time optimality. Weather information is not typically integrated into the route visualization and the dispatcher must make routing decisions while looking across multiple screens and applications. In addition, weather avoidance criteria can differ from dispatcher to dispatcher, and from day to day, resulting in different outcomes and safety margins.

Challenges

The proposed paradigm shift to a free-flight environment offers an opportunity to better optimize flight routes when avoiding hazardous weather. The challenges lie in effectively integrating route and weather information in the same application to facilitate decision-making. In addition, standardizing the definitions of what weather is to be avoided and the thresholds of severity across an airline's dispatchers will lead to more consistent and accountable outcomes.

Technical Approach and Benefit

Through a combination of observational studies, interviews, written questionnaires, and surveys, we studied the nominal work processes of one major airline's dispatcher's pre-flight route selection duties. In addition, we conducted a Web-based survey across airlines to study what weather information sources were used by dispatchers when routing aircraft. In addition to detailing the results of the studies and surveys, this paper will describe how such a tool could be used in an airline setting to improve route selection in the face of hazardous weather during pre-flight route selection.

The AWIN tool is a decision aide for selecting optimal (minimum fuel or minimum time), 4-dimensional routes that avoid weather and other hazards. In other words, the tool tries to find the route that uses the least amount of fuel (or the least amount of flying time) while avoiding areas defined as hazardous weather. The software will plan a route that is not only optimal for forecast winds and temperatures aloft, but also avoids weather and other hazards. The user can specify that routes be optimized for winds only, weather only, or both winds and weather. The tool also allows visualization of potential routes in both lateral and vertical dimensions. The tool, in addition, allows comparison of potential routes for estimated duration, fuel use, distance, and hazards encountered. Specific weather hazards supported by the tool are convection, icing, ozone, turbulence, and ash. The tool also supports custom hazards that can be used to specify weather hazards, special use airspace, or other restrictions. Hazards are represented as convex polygons and hazard thresholds are user selectable. Hazard thresholds may also be set company wide to reflect company policy about what weather (and its severity) is to be avoided.

Integration of weather and routing information allows for the calculation of fuel-optimal routes that avoid hazardous weather. With such a system in place, airlines can expect gains in safety, in fuel efficiency of planned routes, and in time efficiency in the pre-flight dispatch process.

The software tool aims to provide airline dispatchers with a decision aide for selecting fuel- or time-optimal routes that avoid weather and other hazards.

Overview of Current Practice

Honeywell researchers made visits to several airlines and an in-depth study of one major airline's SOC to conduct interviews with managers, dispatchers, and meteorologists. From the interviews, a picture of how dispatchers currently route around weather emerged, for the airline being observed. What follows is a brief discussion of an example of the current practice in Pre-Flight Route Planning by dispatchers for one particular airline. Other airlines may have differences in their work process, but the tasks remain essentially the same. See [7] for a more complete description of dispatchers tasks and work processes.

Dispatchers have a worklist that orders the flights they are responsible for by their departure time. Dispatchers work through this list, attempting to release domestic flights two hours in advance, and international flights three hours in advance of their departure times. In good weather, all dispatchers may be releasing their domestic flights as much as three hours in advance, to build up extra time in case they get busy later. Dispatchers go straight from calculations of fuel and route selection through to release unless external factors (such as weather) affect the flight. On a perfect weather day, releases may only take two to three minutes to complete. However, on a bad weather day they can take considerably longer (up to 30 minutes), and dispatchers have to be careful not to fall behind on their releases.

Dispatchers have a set of approved, "company routes" for each city-pair. Typically flight planning software is used to order the company routes according to fuel optimality when taking current conditions (wind and temperature) data into account, but the flight planner cannot take into account other weather. There exist many applications that can visualize routes on a graphical display, usually on a two-dimensional world map At one airline, dispatchers used an Aircraft Situation Display (ASD) to display non-computed company routes (i.e. no fuel information is included) graphically on a two-dimensional world map. A similar tool is a common Flight Planning tool, which integrates route visualization with route planning software. Each has a limited capability to display raw weather graphics directly on the two-dimensional world map.

If weather impinges on the selected flight route, the dispatcher will search for another company route that avoids the weather, with little consideration of optimization of fuel or cost. If a route cannot be found that avoids the hazardous weather, a typical strategy may be to select the first company route and compensate by adding additional fuel to the release. Pilots can also change the dispatch release, for instance by adding more fuel than was originally in the release. The crew may also send the dispatcher an Aircraft Communications and Reporting System (ACARS) message to discuss changes in alternate airport assignments. Dispatchers can create a new route to take into account the hazards, but this is laborious and very rarely done. A dispatcher will usually be satisfied with any company route that goes around the hazards, regardless of the route's fuel inefficiency.

During days with significant weather, dispatchers look at multiple information sources to determine the impact of weather on the flights that they are dispatching. Especially during the thunderstorm season, dispatchers watch the weather constantly, and may have three or four radar sources on their workstation at once. Typically, the dispatcher will look at the weather at the origin and destination airports, to determine if takeoff and destination alternates are called for. If so, then the dispatcher will also check the weather at all or some of the potential alternate airports around the destination airport. Then the dispatcher will look at AIRMETs (Airman's Meteorological Information, for turbulence), SIGMETs (Significant Meteorological Information), satellite radar, and other weather tools to see if weather will impact the flight en-route. Additionally, some companies have an in-house "SIGMET-like" visualization tool that has been coded by staff meteorologists.

Dispatchers currently have wide latitude in deciding which information sources they will use for determining weather hazards. The information sources available to dispatchers are described in detail in [7] and described briefly later in this paper. At one airline, for instance, only four weather information sources are officially "approved" by management for decision-making purposes: Pilotbrief Vector by WSI, Weather for Windows by WSI, an internal (in-house) data system, and the Collaborative Convective Forecast Product (CCFP). All other weather information sources are to be used for advisory purposes only, and decisions cannot be based solely on the information found there. Company policies are arbitrarily followed by dispatchers in deciding weather hazard severity.

The current steps in selecting a route are as follows:

1. The dispatcher enters aircraft parameters and the city-pair into a flight planner.
2. The flight planner combines dispatcher-supplied information with the route specifications, current winds, and current temperature to calculate the recommended route, usually from a list of company routes. Note that the recommended route does not take into account any other weather or hazard information.
3. The dispatcher now looks at the recommended route graphically on a (possibly different) display and tries to determine if the recommended route goes through weather or other hazards.
4. The dispatcher often has to go to several other displays and information sources to get an accurate weather picture, all this while retaining a mental picture of routes.
5. If the dispatcher realizes the recommended route goes through any hazards, the dispatcher typically will pick the first company route they can find that doesn't go through any hazards.

Note that this route does not take into account any company preferences for route selection, including cost considerations.

6. The dispatcher can create new routes, though we expect this would be atypical based on our interviews.
7. Once a route has been selected, the dispatcher can complete the flight release.

The workflow chart below (Figure 1) illustrates an example of a set of steps a dispatcher may currently follow in doing pre-flight route planning.

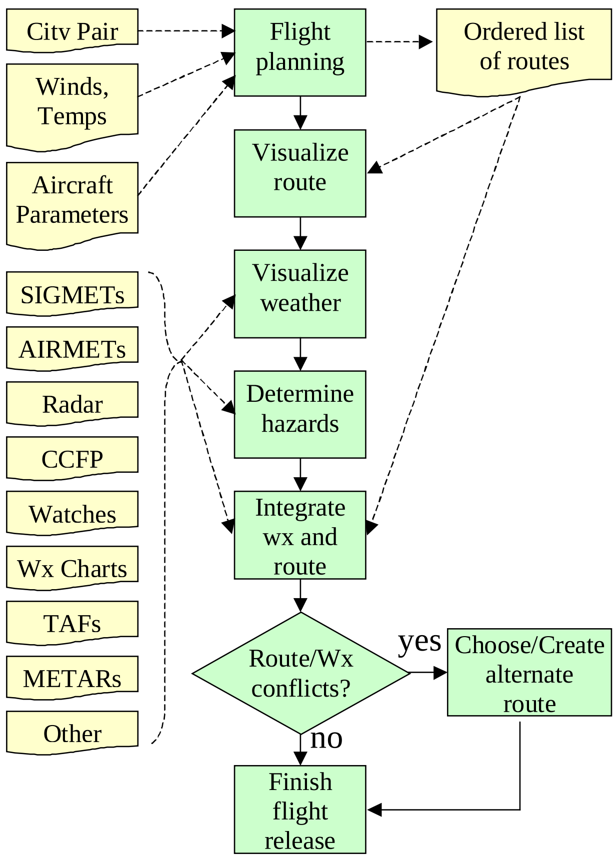

Figure 1. Current pre-flight route selection for one airline.

Overview of the HL Decision-Support Tool

The AWIN decision-support tool (patents: [8][6]) is a decision aid for selecting minimum fuel, optimal, 4-dimensional routes that avoid weather and other hazards. The software will plan a route that is not only optimal for forecast winds and temperatures aloft, but also avoids weather and other hazards. The user can specify that routes be optimized for winds only, weather-avoidance only, or both winds and weather-avoidance. The tool also allows visualization of potential routes in both lateral and vertical dimensions. The tool, in addition, allows comparison of potential routes for estimated duration, fuel use, distance, and hazards encountered.

Specific weather hazards supported by the tool are convection, icing, ozone, turbulence, and ash. The tool also supports custom hazards that can be used to specify weather hazards, special use airspace, or other restrictions (e.g. heavy overflight charges). Hazards are represented as convex polygons and hazard thresholds are user selectable or system-wide selectable. Hazards and options are displayed in a single user interface as shown in Figure 2.

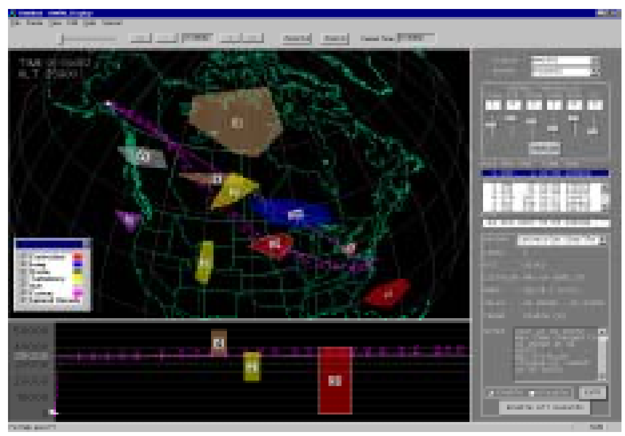

Figure 2. The AWIN Decision Support Tool.

The AWIN tool has, integrated with route information, weather information that has been processed by meteorologists to contain boundaries and severity levels, rather than simply raw weather information. This “processed” weather information is then used to calculate fuel- or time-optimal routes, since the flight planner now has a representation of the weather data. Additionally, raw weather information can be likewise overlaid on the tool to allow dispatchers to assess their degree of confidence in the polygon definitions (and to assist in the ease by which meteorologists will define weather polygons).

The initial user interface was designed in earlier phases of this program by members of the

Honeywell Laboratories Human Centered Systems group[3]. User requirements were generated from field visits to a Flight Service Station, a weather service vendor, a major U.S. Airline Operations Center (AOC), and the National Center for Atmospheric Research (NCAR) in Boulder, CO. Requirements were also produced from interviewing aviation weather consultants, corporate pilots, airlines, and examining existing state-of-the-art weather products.

The user interface design also reflects design modifications due to the results of an earlier usability evaluation involving airline dispatchers, airline pilots, and corporate pilots[10]. The work presented in this paper was done in part to prepare for an empirical evaluation of the AWIN tool [4].

Overview of Proposed AWIN-Based Practice

In the proposed AWIN-based system, hazard information will be integrated with route information on the same display. Dispatchers will be able to view both vertical and lateral route information. All company routes will be available in AWIN. In addition, AWIN-generated routes will be available. Fuel information will be provided with the routes. Dispatchers can use the fuel information for route comparisons.

Company policy will be followed for entering weather hazards into the tool. The company meteorologist is responsible for entering the weather hazards and their severity levels. Dispatchers will be able to choose a route that is expressly optimized to go around the weather and other hazards. Non-weather hazards will also be more easily distributed since they can be entered once and appear integrated with each dispatcher's route information.

Figure 3 illustrates the envisioned the workflow when the AWIN tool is be used for Pre-Flight flight planning. At any time during the day, a meteorologist (or other qualified personnel) can enter any known weather hazards using the AWIN tool User Interface. Similarly, the person in charge of the Traffic Management Unit (TMU) desk (or other qualified personnel) at any time can enter other hazards using the AWIN tool User Interface.

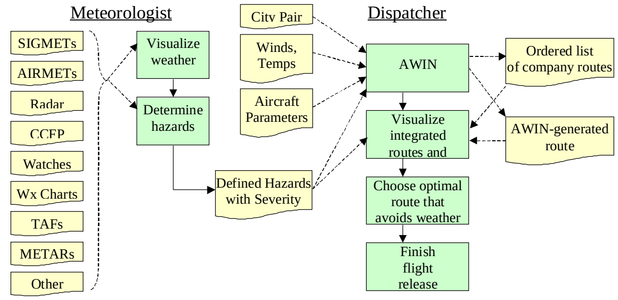

Figure 3. Pre-flight route selection using AWIN.

The steps taken by the airline meteorologist to define weather and other related hazards are as follows:

1. The company meteorologist accesses available sources of weather information to develop an awareness of current weather activity.
2. The meteorologist defines boundaries and severities for weather-related "no-fly zones" that represent areas of hazardous weather that he or she has determined, in keeping with company policy, are to be avoided by flights.
3. The weather hazards in AWIN specified by the airline meteorologist are augmented with any other hazards (e.g. Special Use Airspace (SUA)).
4. The meteorologist produces a hazards file that is distributed to the dispatchers on duty.

The steps taken by the dispatcher to select a route are as follows:

5. The dispatcher enters the city-pair and other aircraft parameters into AWIN.
6. AWIN combines this information with route specifications, current wind data, current temperature data, and the pre-defined hazards to calculate the fuel and flight details of the company route. Note that the company route specifics do not take into account any other weather or other hazard information.
7. AWIN calculates the 4D optimized route that avoids the specified weather hazards.
8. All the routes are displayed in the AWIN display, which include the company routes as well as the AWIN optimized routes. The hazards are also displayed.
9. The dispatcher can create new routes, though we expect this would be atypical based on our interviews.

10. The dispatcher can use the AWIN comparison tool to do fuel comparisons between potential routes. The dispatcher then makes one route active.
11. Once a route has been selected, the dispatcher can complete the flight release.

The next section introduces the Weather Source Survey and discuses the results.

Weather Surveys

Motivation and Method

The dispatcher has at his or her disposal a number of tools and information sources to visualize weather. Honeywell Laboratories has conducted two surveys to assess which weather information dispatchers use and how dispatchers use that weather information during pre-flight route selection. The first study was an in-depth survey of one major airline's dispatcher department. It was conducted to gain insight into the dispatcher work process. We found that only four weather information tools are "approved" by the airline, in the sense that dispatcher decisions can be based on the information found in an in-house information application, WSI Pilotbrief Vector, WSI Weather for Windows, and Collaborative Convective Forecast Product (CCFP). All other information sources are advisory. However, dispatchers make heavy use of advisory weather sources during the course of planning routes for flight releases. There is a wide range of tools available to dispatchers, and different dispatchers will use a different subset of tools. Different airlines may have a different set of approved vs. advisory tools as well. Results of the this survey can be found in [7].

As a follow up, Honeywell Laboratories conducted a second survey to assess weather information use in support of both pre-flight and in-flight routing decision-making. This second survey was targeted at the broader airline community, and thus the survey was administered as a web-accessible survey available from the Airline Dispatchers Federation (http://www.dispatcher.org/survey/survey.html) and the European Federation of Airline Dispatchers Associations (http://www.eufalda.org/lnk_weather.php3) websites.

The survey explored the following areas: weather information subscriptions availability, potential sources of weather information, in-house weather sources, approved vs. advisory weather sources, and weather integration with route planning. This chapter describes the results of the survey

Overview of Available Weather Information Sources

This section briefly describes the more commonly used tools. A more complete description can be found in [7].

Internal Text-Based Information Systems. Most airlines have a text-based information and messaging system; this internal data system can be used for passenger reservations, weather information, messaging, etc. This often is the predominant tool for weather information. It is a text-based internal data system that responds to weather information queries, and can return the current weather conditions at any airport, as well as station ATIS information.

WSI Pilotbrief Vector. This is a subscription-based web service provided by WSI. Examples of weather information available ranges across satellite, radar, watches, surface and upper air analysis, AIRMETs, SIGMETs, PIREPs, and much more. WSI is one of the predominant weather information service providers.

WSI Weather for Windows. The information in this tool is supplied by a direct feed from WSI. This product allows dispatchers to look at many different weather phenomena. This program can display weather fronts, for instance, which some dispatchers find useful.

Collaborative Convective Forecast Product (CCFP). This site is used by most airlines and the FAA to assist in their weather collaboration, usually during the summer thunderstorm season. There is a daily briefing, where several different airlines' meteorologists and ATC are available to discuss the day's weather-related concerns. The web site (http://cdm.awc-kc.noaa.gov/ccfp/forecast/?display=js) offers a display where severe weather (thunderstorms, turbulence) is denoted with polygons on a map display.

Aviation Digital Data Service (ADDS). This is a government sponsored web site with a host of weather-related information and Java-based tools. Java tools include a tool for METARs (Hourly surface analysis). The display of surface analysis information for any airport, including temperature, weather, dewpoint, altimeter, ceiling, and visibility, is updated every hour. The ADDS National Convective Weather Forecast (NCWF) Java tool allows users to predict where thunderstorms will be in the next hour, or see where they have been in the previous hour. The same information is available on in-house systems, but only as a snapshot updated every hour. This tool is used most often in the summer due to the frequency of thunderstorms. Other ADDS Java tools include TAFs, AIR/SIGMETs, and PIREPS. Some tools also allow you to overlay VORs, ARTCCs, etc. (http://adds.awc-kc.noaa.gov/).

Airline Dispatchers Federation (ADF) website [2]. This site is often used by dispatchers, since it provides access to several weather products and other weather-related sites, including ADDS. The list of sources is organized in order of significance (i.e. most severe weather impact: significant weather, thunderstorms, lightning, etc).

Harris. Information available includes NEXRAD, plain language weather conditions, and plain language snow accumulation.

Forecast Systems Laboratory (FSL) is a National Oceanic and Atmospheric Administration research laboratory. This is a turbulence data display (http://www-frd.fsl.noaa.gov/mab/tke/).

Aeroplanner. A web-based service that offers on-line flight planning services, with current data (http://www.aeroplanner.com/).

Web-Based Weather Information Sources. There are at least dozen or so sources of weather data on the Web including providers like WSI and Kavouras as well some public web sources like ADDS and ADF.

Custom Weather Overlay Products. WSI has a tool that allows a meteorologist to create custom weather displays in the form of a Tag Image File Format (TIFF) graphic file that can be viewed as a map overlay on an Aircraft Situation Display (ASD) or as a Web-page. WSI is part of the NASA consortium. For a detailed description of the definition process, the reader is referred to [7].

The weather and planning tools mentioned in this section are used by varying degrees by individual dispatchers, depending on their preferences. The weather survey described in this chapter is an attempt to assess which weather information sources are used most frequently across the airlines.

Survey Structure

A web-based survey was developed to evaluate what weather information sources were used across airlines. The survey consisted of six major sections:

1. General Information
2. Weather Information Subscriptions
3. Potential Sources of Weather Information
4. In-house Weather Sources
5. Approved vs. Advisory Weather Sources
6. Weather Integration with Route Planning

The General Information section asked respondents for their age, years of experience, typical shifts worked, company name, position or title, and location (U.S. or specified non-U.S.).

The Weather Information Subscriptions section asked respondents to list all the third-party vendor, weather information subscriptions they have access to in their jobs. They were given a list and could make multiple selections from (Harris, Jeppesen, Kavouras, and WSI), as well as the ability to write in any others.

The Potential Sources of Weather Information section asked respondents to rate each weather source/tool, and the weather information that can be found there, on how frequently they use that source when doing pre-flight and in-flight route selection between a city pair. They also reported if that weather source or tool was available to them. Weather sources included ADDS, WSI Pilotbrief Vector, Harris, Aeroplanner, Weather for Windows, Collaborative Convective Forecast Product (CCFP), FSL Turbulence Data, and ADF Quick Brief. Respondents were also given an opportunity to write in any other sources they may use.

The In-house Weather Sources section asked respondents to list the types of weather information available to them through an airline-specific software application.

The Approved vs. Advisory Weather Sources section asked respondents to list those weather sources that have been pre-approved for decision-making by their airline. They were given a list from which they could make multiple selection (ADDS, in-house Weather information Applications, WSI Pilotbrief Vector, Harris, Aeroplanner, Collaborative Convective Forecast Product (CCFP), FSL, and ADF Quick Brief), as well as the ability to write in any others. Respondents were also asked to write in any other advisory weather information sources available to them.

Finally, the Weather Integration with Route Planning section asked respondents to name any tools or techniques they have that can assist them in integrating weather information with route information when deciding if a planned flight route may be impacted by weather.

The resulting Web page was sponsored by NASA and links hosted on the Airline Dispatchers Federation [2] and the European Federation of Airline Dispatchers Associations [5] websites.

Results

The link to the web-survey was published on the EUFALDA website in early January 2002, and on the ADF website in late January 2002. As of March 2002, 16 responses have been received, 15 of which contained complete data. Each web-survey response was from a dispatcher at a different airline, and the responses from the earlier initial survey were averaged to form one additional data set. With the responses from the initial survey added to the data analysis, there were 16 distinct sets. The data consisted of 11 U.S.-based airlines, and 5 non-U.S. airlines.

General Information

The average age of the web-survey respondents was 38.7 years (the 11 US dispatchers average age was 42.8; the 5 non-U.S. dispatchers average age was 36.7). Experience ranged from 1.5 to 31 years, with an average experience of 11 years.

Shift start and end times vary across airlines, but there are generally three shifts: (1) morning, e.g. 6:00 AM – 2:00 PM, (2) afternoon, e.g. 2:00 PM - 10:00 PM, and (3) night, e.g. 10:00 PM – 6:00 AM. Of the three non-U.S.-based dispatchers who listed the shifts typically worked, two worked all shifts and another worked shifts 1 and 3. Of the U.S.-based dispatchers who listed the shifts typically worked, three worked all shifts, one worked shifts 1 and 2, five worked shift 2 only, and one worked shift 3 only.

Each respondent worked for a different airline. Of the five non-U.S. dispatchers, four worked for European-based airlines, and one for a Chinese airline. Of the 10 U.S. based dispatchers, nine worked for major regional or national carriers, and one for a national package delivery service.

Weather Information Subscription Services

Respondents were asked to list all third-party vendor, weather information subscriptions accessible to them in their jobs. They were given a list from which allowed multiple selections (Harris, Jeppesen, Kavouras, and WSI), and could write in any others. Figure 4 graphs the results: 14 of the 17 dispatchers responding used WSI, eight of 17 used Kavouras, and six of 17 used Jeppesen. No other subscription service was available to more than two of the 17 airlines represented.

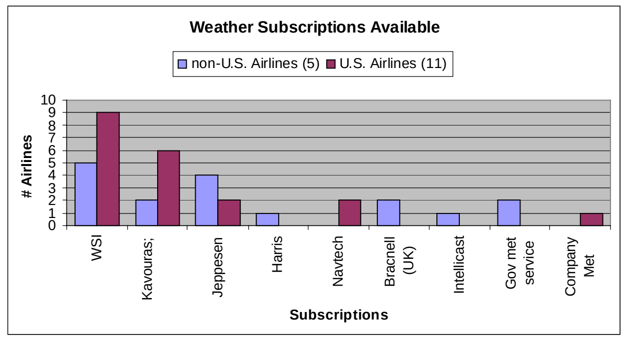

Figure 4. Subscriptions available to dispatchers.

Potential Sources of Weather Information

The Potential Sources of Weather Information section really asked respondents three separate questions about each type of weather data available from a source: (1) was it available, (2) frequency of use for pre-flight routing, and (3) frequency of use for in-flight re-routing.

Weather Data Availability. The survey asked these three questions of 34 different specific types of weather data available from nine different sources. The weather sources included ADDS, WSI Pilotbrief Vector, Harris, Weather for Windows, Aeroplanner, Collaborative Convective Forecast Product (CCFP), FSL Turbulence Data, and ADF Quick Brief. Respondents could also write in any other sources and specific data types that they may use. Aggregate information is illustrated in Table 1, where the number of data types for each source is in parenthesis.

Table 1. Weather source availability, indexed by source and location.

Weather Source (#data types)	Yes Non-US (5 disp.)	No Non-US (5 disp.)	Yes US (11 disp.)	No US (11 disp.)	% Yes (Non-US)	% Yes (US)
ADDS (6)	16.0	14.0	66.0	0.0	**53.3**	**100.0**
ADDS Java Tools (6)	12.0	18.0	60.0	6.0	**40.0**	**90.9**
WSI (10)	37.0	12.0	67.0	25.0	**75.5**	**72.8**
Harris (7)	7.0	27.0	7.0	53.0	**20.6**	**11.7**
Aeroplanner (1)	1.0	3.0	1.0	7.0	**25.0**	**12.5**
CCFP (1)	1.0	4.0	7.0	2.0	**20.0**	**77.8**
FSL (1)	1.0	3.0	4.0	6.0	**25.0**	**40.0**
WxForWindows (1)	1.0	3.0	1.0	9.0	**25.0**	**10.0**
ADF Quick Brief (1)	2.0	3.0	9.0	2.0	**40.0**	**81.8**

Figure 5 depicts which weather information sources were available to dispatchers, when aggregating the different specific weather data types by source. For instance, the survey asked about six different specific weather data types found from the ADDS survey. Of the 11 U.S. dispatchers, 100% of the answers to all six "availability" questions (one for each weather data type) were positive. Conversely, of the 6 non-U.S. dispatchers, 53.3% of the "availability" questions were answered positively. The complete survey data can be found in [3].

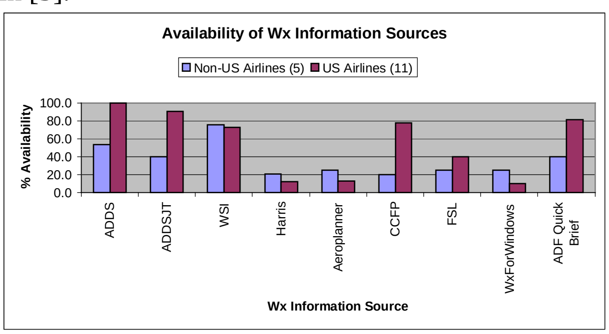

Figure 5. Availability of Weather Information Source.

Frequency of use for pre-flight routing. Frequency of use ratings were on a five-point scale: always (5 points), often (4), sometimes (3), rarely (2), and never (1). In this paper, only results for the sources listed with greater than 50% availability are given. For full results, see [3].

Aviation Digital Data Service. Survey respondents were asked to rate how often they used particular types of weather information available from Aviation Digital Data Service (ADDS): Turbulence, Icing, Winds/Temps, Prog Charts, Satellite, and Radar. In addition, the ADDS Web site contains a set of Java Tools: Flight Path, Convective METARs, TAFs, AIR/SIGMETs, and PIREPs. Results for US and Non-US airlines are illustrated in Table 2. Note that the ratings are an average of the use ratings *for those dispatchers that have that data source available to them*. In other words, if a dispatcher does not have the ADDS source available to them, their rating of its use (presumably never) is not included in the averages shown in Table 2. In this case, all 11 U.S. dispatchers had ADDS available to them (and 10 of 11 had ADDS Java Tools available to them). The results illustrate that the ADDS site is widely used, with scores for all dispatchers (both U.S. and non-U.S.) of 3.2 to 3.8 for each weather data type. Use of the Java tools was slightly lower, ranging from 2.8 to 3.3 with one score of 4.0.

Table 2. ADDS Frequency of Use.

Weather Information Type	Avg. non-U.S. (# responses)	Avg. U.S. (# responses)	Avg. All (# responses)
ADDS - Turbulence	4.7 (3)	3.6 (11)	3.8
ADDS - Icing	4.0 (3)	3.6 (11)	3.7
ADDS - Winds/Temp	5.0 (3)	3.0 (11)	3.5
ADDS - ProgCharts	5.0 (3)	2.8 (11)	3.3
ADDS - Satellite	1.5 (2)	3.6 (11)	3.3
ADDS - Radar	2.5 (2)	3.3 (11)	3.2
ADDSJT-FlightPath	3.0 (2)	2.8 (10)	2.8
ADDSJT-Convective	2.0 (1)	3.3 (10)	3.2
ADDSJT-METARs	5.0 (2)	2.8 (10)	3.2
ADDSJT-TAFs	5.0 (2)	2.7 (10)	3.1
ADDS-AIR/SIGMETs	4.5 (2)	3.1 (10)	3.3
ADDSJT-PIREPs	4.0 (2)	4.1 (10)	4.0

Figure 6 illustrates the frequency of use for each weather data type, graphed for non-U.S. and U.S. dispatchers.

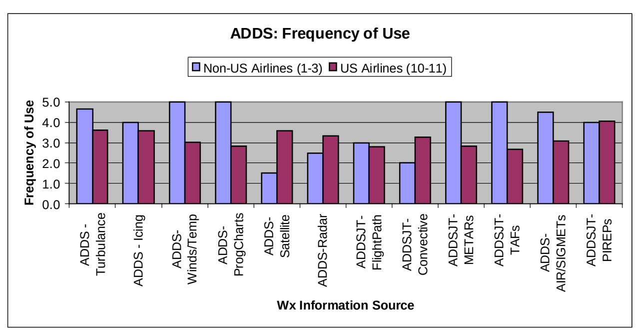

Figure 6. ADDS Frequency of use.

WSI PilotBrief. The WSI Pilotbrief is a "comprehensive aviation weather briefing system designed for the professional pilot. The service provides access to the most current WSI NOWrad mosaic radar imagery, NEXRAD single site radar imagery, WSI satellite imagery, and WSI's special AVchart aviation graphics, as well as the full array of National Weather Service text data products. Coverage is world-wide." [11].

Survey respondents were asked to rate how often they used particular types of weather information available from WSI. Table 3 lists the average frequency ratings for each weather data type available from WSI. Note that the ratings are an average of the use ratings *for those dispatchers that have that data source available to them*. In other words, if a dispatcher does not have the WSI source available to them, their rating of its use (presumably never) is not included in the averages shown in Table 3. U.S. dispatchers rated their use of WSI weather products in the range of 2.6 to 4.0, with seven of the 10 weather data types getting a rating of 3.4 or higher. Similarly, non-U.S. dispatchers used six of the 10 data types from WSI with a frequency of 3.3 or higher. Overall, the average scores across all dispatchers ranged from 2.9 to 3.8.

Table 3. WSI frequency of use.

Weather Information Type	Avg. (non-U.S.)	Avg. (U.S.)	Avg. (all)
WSI-NOWradRadar	2.3 (3)	3.5 (7)	3.2
WSI-NEXRAD	2.0 (2)	3.7 (6)	3.3
WSI-Satellite	2.7 (3)	3.8 (8)	3.5
WSI-Avchart	3.5 (4)	4.0 (6)	3.8
WSI-METARs	2.8 (5)	3.0 (7)	2.9
WSI-TAFs	3.6 (5)	3.0 (7)	3.2
WSI-NOTAMs	3.8 (4)	2.6 (7)	3.0
WSI-PIREPs	3.3 (3)	3.4 (7)	3.4
WSI-SIGMETs	3.8 (5)	3.9 (7)	3.8
WSI-AIRMETs	3.3 (4)	3.5 (7)	3.4

Results are illustrated graphically in Figure 7, where results have been separated into U.S. and non-U.S. dispatchers for each information type.

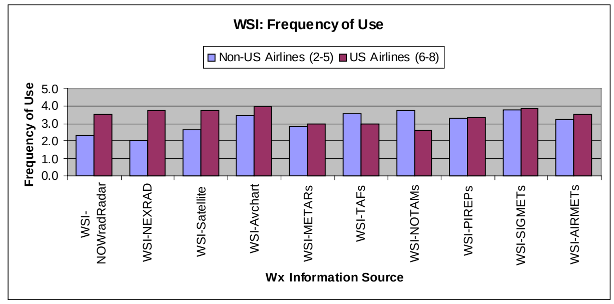

Figure 7. WSI frequency of use.

CCFP and ADF Quick Brief. The only two other sources available to more than 50% of dispatchers surveyed were the Collaborative Convective Forecast Product (CCFP) and the ADF Quick Brief, which is a one stop web page that has current images of 12 Weather information products ranging from surface weather depictions to PIREPS of turbulence to Pressure changes. Table 4 contains the results for the frequency of use ratings for the other weather sources listed in the survey. Again number of responses is listed in parentheses in each data cell, since many respondents did not have access to these weather products. Thus the data is only for those dispatchers who had the sources available to them in the first place. Of the five sources listed in the survey, a significant number U.S.-based dispatchers had both CCFP and ADF Quick Brief available to them. Of those that did have it available to them (seven out of 10 possible), the frequency of use was quite high, 4.1 and 3.9 respectively.

Table 4. Frequency of Use for CCFP and ADF Quick Brief.

Weather Information Type	Avg. non-U.S. (# responses)	Avg. U.S. (# responses)	Avg. All (# responses)
CCFP	5.0 (1)	4.1 (7)	4.2
ADF Quick Brief	3.5 (2)	3.9 (7)	3.8

In-House Weather Sources.

Of the 11 U.S.-based dispatchers, and the six non-U.S. based dispatchers, only three respondents to the survey listed information available through in-house weather information applications. The two U.S. based dispatchers listed Navtech weather and UAL weather (the regional airline's parent company). The non-U.S. dispatcher listed as information available through an in-house system as METARs, TAF, AIR/SIGMETs, and PIREPs.

Approved vs. Advisory Weather Sources

Nine U.S. based and one non-U.S. dispatcher filled out this section of the survey. Respondents were asked to list those weather sources that have been pre-approved for decision-making by their airline. Figure 8 illustrates the number of dispatchers that indicated that a certain weather information source was approved by their airline. More than half (five of nine) U.S. dispatchers indicated that WSI Pilotbrief was an approved source. Four of nine indicated that the in-house weather information application was approved for decision making. A third of U.S. respondents indicated ADDS site, with another dispatcher making the comment "I don't think that ADDS is an approved source but many of us use it as supplemental and advisory information." No other source was listed by more than two of nine dispatchers.

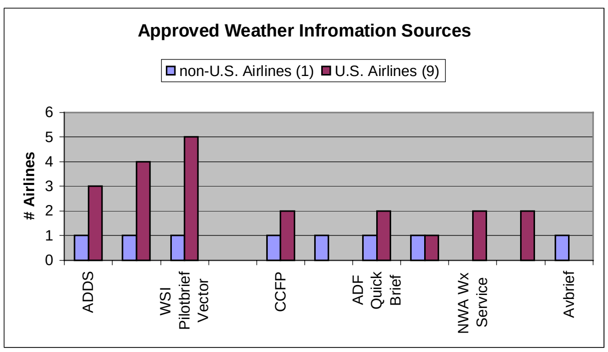

Figure 8. Approved weather information sources.

Survey respondents were also given the opportunity to write in any sources they used in an advisory capacity. No source was listed more than once. Listed sources were: WSI, Intellicast, IIDA/IIFA development pages, NASA interactive satellite products, Navy METOC, International Radar sites, WeatherTap, "all internet sources". One dispatcher wrote that the "Internet is the biggest tool for real-time weather; backed up by official approved weather sources in-house."

Weather Integration with Route Planning

This section of the survey asked respondents to name any tools or techniques they have that can assist them in integrating weather information with route information when deciding if a planned flight route may be impacted by weather. Eight of 17 respondents answered the question posed, and their answers are listed in Table 5. Most responses have to do with the limited ability to overlay isolated weather graphics on top of route visualization (see [7] for a detailed discussion of ASD overlays).

Table 5. Tools or techniques used to integrate weather with route information (survey responses)

***Question*: What tools or techniques do you have that can assist you in integrating weather information with route information when deciding if a planned flight route may be impacted by weather?**	**Location**
Answer: "Our Flight Planning Computer [sic] collects most available weather info and incorporate these in the result of our requested flightplan (temp/winds/etc. [sic])"	Non-U.S.
Answer: "Jeppesen"	Non-U.S.
Answer: "nothing in house...ADDS too unwieldy [sic] and only covers US... so its what little grey matter I have."	U.S.
Answer: "Dimensions International Flight explorer supposedly has in beta test a new version which you can overlay user-defined routes (i.e. route string). This is supposed to be a big change in helping route flights - have not seen it yet personally."	U.S.
Answer: "flight explorer aircraft situational display (approved for use)"	U.S.
Answer: "Wind/Temp and Sigwx overlays	Non-U.S.
Answer: "Flight explorer"	U.S.
Answer: ASD with Weather overlays [paraphrased]	U.S.

Discussion

The survey garnered responses from 16 different airlines, including both U.S.-based (11) and non-U.S.-based dispatchers (5). Average Age was 38.7, and experience ranged from 1.5 to 31 years, with an average experience of 11 years. Of the possible information sources available (10 were listed, and users wrote in six more), U.S. dispatchers consistently used a subset that included ADDS (100% of respondents had the source available), WSI Pilotbrief vector (73%), CCFP (78%), and ADF Quick Brief (82%). Of the dispatchers who had access, the frequency of use rating for pre-flight routing ranged from 3.2 to 4.2 (on a scale of 5) with only one lower score (2.9 for WSI METARs). Not surprisingly, with high availability and high use, most of the aforementioned tools were approved by a significant number of airlines for the basis of route decision-making. Even if the information source was used in an advisory capacity only, it was valued, with one dispatcher making the comment "I don't think that ADDS is an approved source but many of us use it as supplemental and advisory information." About half the respondents had limited weather integration capability built into their route planning software.

The field studies of operational practice and the weather surveys described in this paper were conducted to support an empirical evaluation experiment for the Honeywell decision-support tool. The experiment (described in detail in [4]) is conducted in a simulated operations area. Dispatchers will be given scenarios in which they are presented with stored routes for a particular city pair and aircraft type. A diverse set of external weather information sources is represented by a stand-alone display, containing the weather data typically used by dispatchers (as determined by the surveys described in this paper). The evaluation will assess gains in hazardous weather avoidance, in fuel efficiency of planed routes, and in time efficiency in the pre-flight dispatch process through the use of the AWIN decision aide.

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References

[1] *Airline Operational Control Overview,* Prepared by the Airline Dispatchers Federation and Seagull Technology, Inc., Under the direction of the Federal Aviation Administration and Boeing Commercial Airplane Group per Cooperative Research and Development Agreement 93-CRDA-0034, May 1995.

[2] Airline Dispatchers Federation (ADF) Webpage (online), http://www.dispatcher.org/survey/survey.html

[3] Dorneich, M. C., Pratt, Steve, Olofinboba, O., and Osborne, D. (2002). "AWIN AWIN Weather Avoidance using Route Optimization as a Decision Aid: Weather Survey Source Results, Revised Experiment Plan, and Revised Integration Plan." NASA/CR 2002. Prepared for NASA Langley Research Center under contract NCC-1-362, Milestone #5 Technical Report, Honeywell Laboratories, March 15, 2002.

[4] Dorneich, Michael C., Olofinboba, Olukayode, Pratt, Steve, Wilson, Ian, and Herbster, Chris (2002). "An Experimental Evaluation of Weather Avoidance using Route Optimization as a Decision Aid," to appear *in The Proceedings of the 2002 IEEE International Conference on Systems, Man, and Cybernetics*, Hammamet, Tunisia, 6-10 October 2002. (Invited)

[5] European Federation of Airline Dispatchers Associations (EUFALDA) Webpage (online), http://www.eufalda.org/lnk_weather.php3.

[6] European Patent, "System for Planning Vehicle Routes," Euro 00973409.6-2213-US0027327.

[7] Olofinboba, Olu, Dorneich, Michael, Osborne, Dannielle, and Ververs, Patricia, (2001). "AWIN Weather Avoidance using Route Optimization as a Decision Aid: An AWIN Topical Study. Experimental Plan", prepared for NASA Langley Research Center under contract NCC-1-362, Milestone #4 Technical Report, *Honeywell Laboratories*, September 29, 2001.

[8] US Patent, "Interfaces for Planning Vehicle Routes," US 6,289,277.

[9] *Weather Avoidance Using Route Optimization as a Decision Aid: An AWIN Topical Study,* Phase 1 Report, Honeywell Technology Center, Minneapolis, MN, December 30, 1998.

[10] *Weather Avoidance Using Route Optimization as a Decision Aid: An AWIN Topical Study*, Final Report, Honeywell Technology Center, Minneapolis, MN, November, 1999.

[11] WSI home page (online). Available at http://www.wsi.com/sites/sites.htm. 2002.