Flight Awareness Collaboration Tool Development

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***Abstract*—NASA is developing the Flight Awareness Collaboration Tool (FACT) to support airline and airport operations during winter storms. The goal is to reduce flight delays and cancellations due to winter weather. FACT concentrates relevant information from the Internet and FAA databases on one screen for easy access. It provides collaboration tools for those managing the winter weather event including the airline operations center, airport authority (runway treatment), the Federal Aviation Administration air traffic control tower, and de-icing operators. Prediction tools are being added to improve FACT capabilities including one that anticipates changes in airport departure rates from weather forecasts. We have formed two user teams from affected airports to guide the design and evaluate the web-based prototype. Future work includes adding more automated capabilities and conducting a simulation to evaluate FACT in a realistic environment.**

Keywords—airline operations center, winter storms, airports, decision support tool, collaboration

I. Introduction

The airport surface can be a major constraint on the throughput of National Airspace System (NAS). Winter weather events may slow airport surface operations due to snow, freezing precipitation, and icing. The need for aircraft de-icing can lead to taxi delays and to actions to ensure that aircraft do not exceed their holdover times. The requirement to treat (remove snow from) runways and taxiways may result in runway closures and changes in airport configuration with negative effects on acceptance rates. Winter operations also pose challenges in complying with regulations regarding passenger tarmac and crew fatigue time. Collaborative decision making during such conditions may be hampered by less than ideal shared situation awareness between flight deck, airport authority, air traffic control, and airline operations centers (AOCs).

II. Objectives

The goal of the NASA Flight Awareness Collaboration Tool (FACT) task is to gain a better understanding of the effects of winter storms on NAS operations and to develop the knowledge and tools needed to improve efficiency (reduce cancelations and delays). Its user base includes the AOC, air traffic control tower, airport operator or authority, and de-icing facilities. This task is developing a software application for improving winter weather management within the AOC and at airports. It will gather onto one screen the critical data required by decision makers prior to and during winter weather events. FACT will also support collaboration and information sharing. Historical data on the effects of winter weather are being used to build predictive models of airport capacity in response to anticipated storms. The prototype will be evaluated in selected AOCs and airport environments.

III. Design Process

The NASA task manager organized a team to design and build FACT. Three senior dispatchers were located and served as subject matter experts (SMEs). A user interface (UI) designer was recruited and a certified dispatcher was included in the NASA project staff.

NASA had previously developed a web-based software tool to support NASA missions involving science aircraft. It is called the Mission Tools Suite (MTS). Given that some parts of the FACT UI would be similar to MTS, it was decided to use this prior work as a basis for FACT.

We reviewed the types of information that would be useful to a dispatcher while managing a winter storm. The list included:

- Weather status and predictions
- Prediction/reporting of runway closures for snow/ice treatment
- Runway braking action
- Visual display of surface traffic movement at airport
- Hourly arrival and departure rates at specific airports
- Airport runway configuration
- De-icing durations, type of fluid needed, anti-ice needed
- Earlier knowledge of Federal Aviation Administration (FAA) actions (e.g., ground stops, miles-in-trail, etc.)
- Notice to Airmen
- Field conditions
- FAA Operational Information System
- Aviation Digital Data Service icing information
- Taxi time (from gate push back to departure, including de-icing)
- Runway visual range
- Tracking of arrival flights in en route airspace to determine if hold or divert will be needed (based on runway closures, braking, arrival rate)

IV. User Interface Design

Given that FACT needed to provide several types of information and capabilities, a "quad" design was selected for the UI. The UI was designed with a waterfall, contextual architecture. Architecture in relation to user interface refers to information flow, visual composition, navigation, component selection (i.e., buttons, menus) and notification (i.e., alerts, alarms).

FACT's waterfall information flow is based on a user's selection within each of four levels or "views." This selection in turn determines the data to be shown in the next view. This method was chosen based on a long and deep history of flight procedures, as detailed by the FACT SMEs.

The interface architecture was tested through a process of subject matter input, feature definition, hand sketching, medium fidelity graphics design, and design iteration. Challenges were mitigating screen clutter, allowing visual room for future expansion, and inventing a more efficient method for user communication. In the existing operational environment, communication is accomplished using common instant messaging clients, browser tabs, and telephone conversations. The new approach is for the interface to keep and share important events in a queue and in context. As the system is used, the communication portion of FACT in particular offers a rich source of future exploration.

Fig. 1 shows the overall design of FACT. The size of each of the quandrants can be changed by clicking and moving the central circular icon. The four quadrants that comprise the UI are described in the following paragraphs.

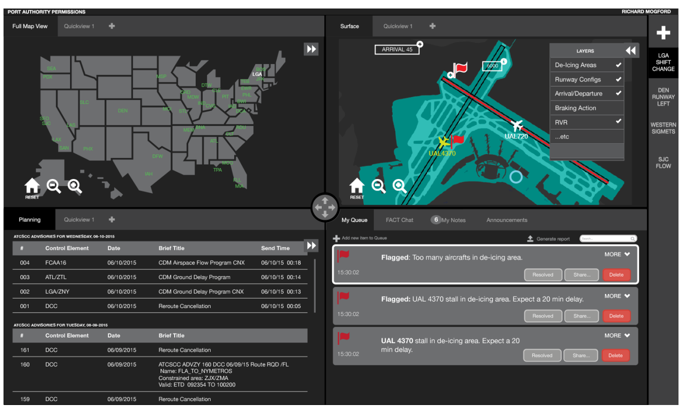

Fig. 1. FACT user interface general layout

The upper left quadrant in the "Primary Map View" and is a map of the US with several overlays relating to weather and navigation (see Fig. 2). Major airports appear in green text and the user can select an airport for closer monitoring. Aircraft targets are displayed and can be color coded by airline (e.g., my airline versus all other flights).

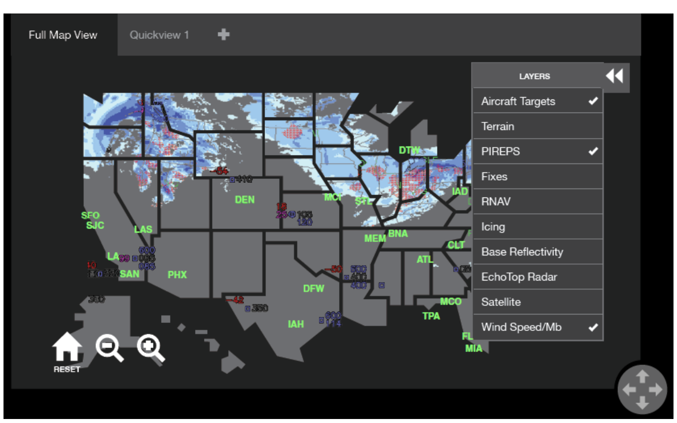

Fig. 2. Primary Map View

The upper right quadrant shows the "Surface Map View" of the selected airport's surface. (See Fig. 3.) Aircraft targets are included as well as a selection of information items controlled by a menu. The status of runways (open/closed), location of de-icing trucks, visibility, and braking action are important data for winter operations.

Fig. 3. Surface Map View

The lower left quadrant is called the "Information View" and shows data gleaned from web sites frequently used by dispatchers during severe winter weather operations (see Fig. 4). We decided to only pull in data of interest for the selected airport rather than all the data from a web site. This view can show either textual or graphical information.

We are developing an automation tool to add to this quadrant that predicts airport departure rates based on winter storm weather forecasts. It is called the Winter Weather Airport Capacity Model (WWACM) by Metron Aviation [1].

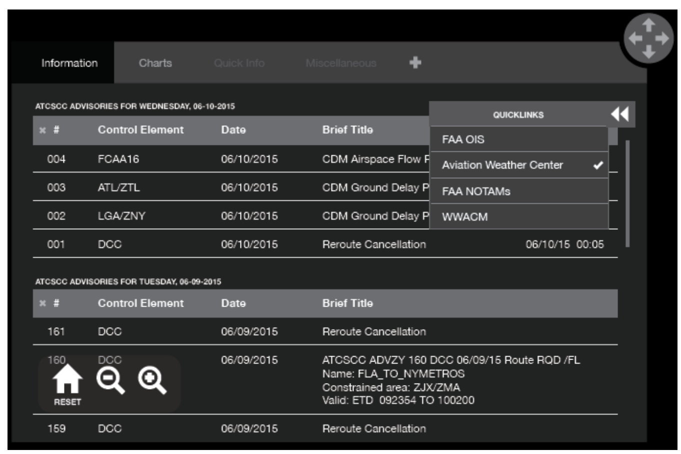

Fig. 4. Information View

Metron refined a previous version of WWACM to focus its predictive modeling capabilities on three major U.S. airports: Chicago O'Hare International Airport, John F. Kennedy International Airport (JFK), and Pittsburgh International Airport. WWACM was revised to use new weather forecast products that are operationally supported by the National

Oceanic and Atmospheric Administration with guaranteed 24/7 availability, ensuring uninterrupted provision of weather forecast inputs to WWACM.

Metron calibrated parameters and coefficients describing relationships among precipitation rate and type, temperature, de-icing capabilities, snow removal equipment, and airport procedures. These parameters and coefficients were used by WWACM to translate forecast winter weather conditions to their estimated impact on airport capacity. The results showed good accuracy of WWACM predictions, exceeding $R^2 \geq 0.8$ for two of the three selected airports. (The model is currently being extended to include Detroit Metropolitan Airport (DTW)).

The work also included improvements to the WWACM web-based prototype implementation so that it can be integrated with FACT. The improvements include implementation of several enhancements to the UI design suggested by internal and NASA subject matter experts.

WWACM runs in real-time, ingesting available weather forecasts and observations and refreshes predicted airport capacity values every 10 minutes, thus constituting a potentially valuable source of key traffic flow management planning data input (i.e., predicted airport capacity) for FACT users.

Returning to the FACT UI design, the lower right quadrant is the "Communication View" and consists of two messaging capabilities. (See Fig. 5.) One is called "My Queue" and allows the user to place markers or flags on the two maps to point out events or details. The second is a standard "chat" window that supports communication with other team members.

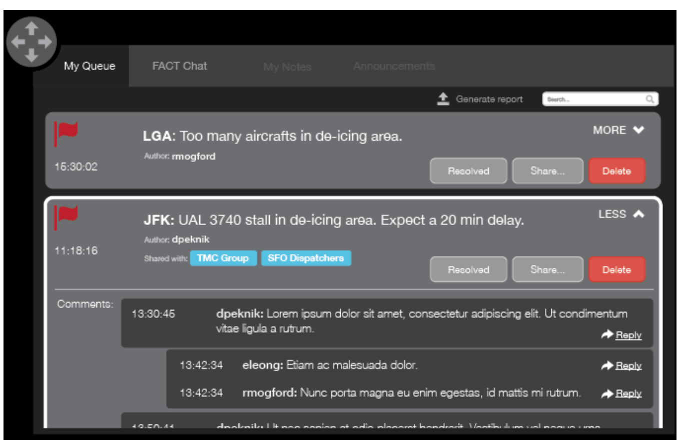

Fig. 5. Communication View

V. Target User Community

At first, the airline dispatcher was presumed to be the primary user for FACT. However, as we progressed, we were advised by our SMEs that FACT could be valuable for coordination during a winter weather event.

At the airport being impacted by a winter storm, the FAA air traffic control tower, airport authority, and de-icing operators all work together to ensure continuous and smooth operations. The tower manages the traffic flow, the airport authority clears the runways (and decides when to close them for treatment), and the de-icing trucks (or pads) prepare the aircraft for deptarture.

To follow up on this, we contacted DTW and JFK airports and formed FACT user groups of personnel from each of the three areas (tower, airport authority, and de-icing). We are holding regular telecons with the airports and receiving guidance on how to adapt FACT to support collaboration.

VI. FACT Software Development

The FACT front-end runs as a single page application and leverages v1 of Google's Polymer's Web Component Framework. Web components refer to set of capabilities being advanced by the World Wide Web Consortium that will allow developers to create fully encapsulated and interoperable custom HyperText Markup Language elements [2]. Polymer is a library that provides cross-browser polyfills until the standard is fully adopted and cross-browser implementation has materialized.

The FACT back-end operates in the Node.js runtime environment and leverages a number of frameworks and open-source libraries for delivering static content and real-time updates to support the FACT client. JAVA Messaging System messages from the Traffic Flow Management and System Wide Information Management (SWIM) Terminal Data Distribution business services are first consumed by the NASA Airborne Science Program's consumer interface [3]. Real-time message access is then made available to the FACT server through the Simple (or Streaming) Text Orientated Messaging Protocol [4].

To limit unnecessary network traffic, FACT uses a subscription-based approach, whereby the client can subscribe to specific topics based on user selections. For example, when a user selects JFK as their primary airport, the FACT client would subsequently subscribe to inbound and outbound flight messages for that specific airport. This could then be used to enable updates in the FACT map view. Likewise, the FACT client would also subscribe to surface movement messages to support the visualization for the surface view.

In addition to real-time updates, the ASP SWIM interface provides service endpoints for obtaining recent history to populate the client interface. In the examples above, surface movement data from the past n-minutes can be requested and then used to populate the client state that is subsequently augmented by the messages received from the real-time feed.

VII. Future Developments

When FACT prototype has been completed in late 2016, we will make it available to our user community consisting of dispatcher consultants and airport representatives from the FAA, airport authority, and de-icing operations at DTW and JFK airports. We will also seek feedback from Virgin America, with which NASA has a collaborative agreemeht. Their input will make it possible to improve and refine the functionality and user interface.

Once we have a good foundation in FACT of useful information to support winter weather management, we will explore ideas for addition automation tools that could enhance FACT. For example, we are considering adding a capabilty to anticipate the capacity of airports to accept diverted traffic. Another concept is to create tool to help manage snow removal operations.

We are also developing methods to simulate AOC and airport operations at NASA. We plan to link FACT with our air traffic control tower and terminal radar simulators so that we can evaluate the effectiveness of the tool in various situations.

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