Presented at the American Meteorological Society
Eighth Conference on Aviation, Range, and Aerospace Meteorology
Dallas, TX January 10-15, 1999

14.7 ADDRESSING THE WEATHER DELAY PROBLEMS OF THE NEW YORK CITY AIRPORTS WITH THE INTEGRATED TERMINAL WEATHER SYSTEM *

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1. INTRODUCTION

The three major New York City (NYC) air carrier airports (Kennedy, LaGuardia, Newark) currently experience high delays due to adverse terminal weather, both in an absolute sense and relative to other major airport complexes. Significantly expanding the NYC airports (e.g., by adding new runways) to reduce delays is not feasible. One alternative is to provide aviation weather decision support systems to air traffic, airline, and airport operations personnel to help them operate more safely and effectively with the existing runway/taxiway complexes.

Under an innovative partnership between the Port Authority of New York and New Jersey and the Federal Aviation Administration (FAA), Massachusetts Institute of Technology, Lincoln Laboratory has installed and is currently operating a functional prototype Integrated Terminal Weather System (ITWS) to conduct research on improving the safety and efficiency of operations at the NYC airports during adverse weather[1]. The New York terminal area provides a stringent test of the ITWS ability to safely reduce delays due to both the meteorology and the operational usage challenges not found at the earlier ITWS test locations of Orlando, Memphis, and Dallas.

In this paper, we describe key features of the New York terminal environment and the ITWS prototype, the initial experience in addressing the meteorological and operational usage challenges of the New York terminal area, and describe plans for the coming years.

2. CHALLENGES OF THE NEW YORK TERMINAL AREA

The New York airports and terminal area pose a number of major new challenges not encountered in the ITWS testing to date at Memphis, Orlando and Dallas. Significant delays arise from coastal storms and snowstorms and strong surface winds as well as from thunderstorms. The ITWS functional prototypes have not previously operated in the Northeast meteorological environment, so an important part of the initial program will be to evaluate the ability of the ITWS weather detection and prediction algorithms to address phenomena such as sea breeze effects on storm and gust front movements, winds aloft during coastal storms, and radar propagation effects in a maritime environment.

The air traffic system at New York poses a number of challenges for the weather products. The New York airports operate at full capacity for many periods a day during fair weather, such that almost any type of adverse weather can result in delays. The major New York airports are in such close proximity that changing runway usage at one airport to address a weather problem can necessitate changes in the runways used at the other airports. The terminal airspace is very congested due to the high traffic volume along the northeast corridor, and New York terminal airspace usage must be coordinated with the three en route control facilities (Washington, New York, and Boston) that directly feed traffic into the New York terminal airspace.

The many constraints on traffic flow management mean that when convective activity occurs in the New York terminal area, there is an acute need for very high quality information on storm locations and movement. Additionally, it is very important that there be a high degree of common weather situational awareness between all of the major FAA facilities that control air traffic to and from the New York airports for all those weather factors that result in rapid time changes in the traffic flow rates.

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*This work was sponsored by the Port Authority of New York and New Jersey under a Cooperative Research and Development Agreement (CRDA) with Massachusetts Institute of Technology, Lincoln Laboratory. The views expressed are those of the authors and do not necessarily reflect the official policy or position of the Port Authority of New York and New Jersey.

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[1] The Lincoln work is being accomplished under a four-year Cooperative Research and Development Agreement (CRDA) with the Port Authority of New York and New Jersey.

3. HOW THE NEW YORK ITWS WILL COPE WITH THESE CHALLENGES

There are a number of ITWS features developed over the past five years that are expected to be very effective in addressing the problems that adverse weather poses for the New York terminal area and airports. By mosaicing together data from some seven FAA and National Weather Service weather sensing radars, as shown below, the New York ITWS will be able to accurately depict the locations of storms with a 1 km spatial resolution precipitation map that is updated every 30 seconds. Estimates of the storm motion and 20 minute extrapolated predictions of storm future locations will be updated every 2 minutes within the TRACON product coverage region shown in Figure 1. The ASR9 from Philadelphia is included in the radar mosaic to provide improved coverage for the southwest "gate" of the NY terminal area that is a key location for convective weather impacts.

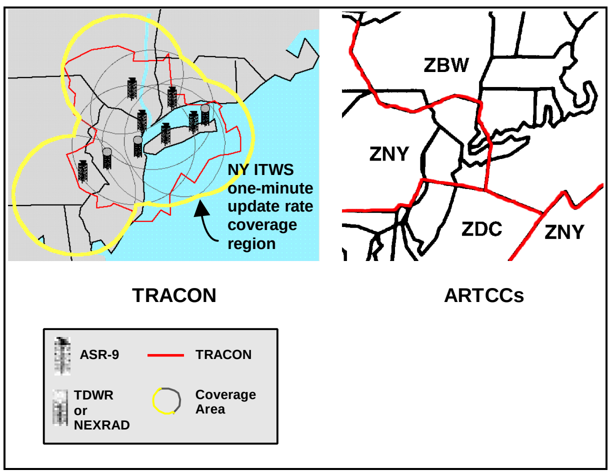

Figure 1. New York terminal coverage, radars, and radar coverage plus enroute boundaries for NY ITWS. (A color image of this, and Figures 2 and 3, is available at *http://www.ll.mit.edu/AviationWeather/*)

Additionally, the NY ITWS accesses base data from both the Brookhaven (NY) and Ft. Dix (Philadelphia) NEXRAD systems so that new NEXRAD products not yet available from the NEXRAD narrow band product ports (e.g., AP edited composite reflectivities, radial velocity products with greater velocity value resolution, mesocyclone, hail and tornado vortex signature) can be operationally evaluated.

A key element of the NY ITWS operation will be the first use of a multi-window color situation display (Figure 2) specified for the production ITWS. The design of the display has been significantly influenced by the participation of FAA traffic management personnel from the NY TRACON on the ITWS users groups. For example, the product display windows have pan and zoom capabilities so that the users can utilize the full resolution of the data when determining whether a "gate" into the terminal area may be impacted by adverse weather. By contrast, the TDWR situation display has only fixed range scales that result in relatively poorer spatial resolution as one looks out further in range. The multi-window feature means that traffic managers can simultaneously monitor weather developments at the various airports while also monitoring weather developments at the edge of the TRACON or in en route airspace.

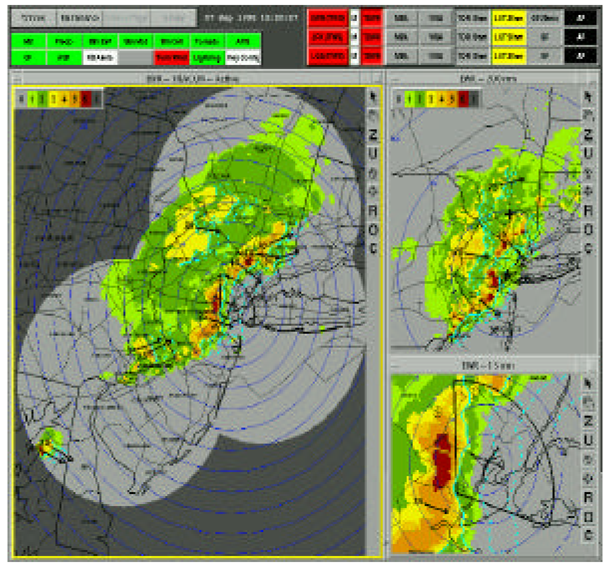

Figure 2. Situation display image from 7 September 1998.

Given the three en route centers that feed traffic directly into the NY terminal area and the impact that adverse weather at New York has on traffic flow throughout the nation, common situational awareness between all of the key decision-makers will be essential. This common situational awareness is achieved by providing the NY ITWS color situation display to four airport towers (Newark, LaGuardia, Kennedy, Teterboro), the New York terminal radar control room (TRACON) in Westbury, NY, the en route centers at Ronkonoma (NY), Nashua (NH), and Leesburg (VA) and to the FAA national traffic flow command center in Reston (VA), as shown in Figure 3. Major airline operations centers (e.g., American, Continental, Delta, Federal Express, Northwest, and US Air) will also have access to the NY ITWS display data through dedicated displays and a WWW site to facilitate collaborative decision making (CDM) between the airlines and the FAA and to allow airline dispatchers to minimize the impact of adverse weather on airline operations.

Given the complexities of changing runway usage at the New York airports, predictive warnings of wind shifts that will necessitate runway changes can significantly reduce delays. The ITWS Machine Intelligent Gust Front Algorithm (MIGFA) will provide major improvements over the current TDWR capability to provide 20-minute predictions of wind shifts due to gust fronts. Based on past experience, we expect

MIGFA to work very well at predicting wind shifts for Newark and Teterboro. The degree to which MIGFA operating on the Newark TDWR data can provide accurate wind shift predictions for LaGuardia and Kennedy airports is unclear until we have had more operational experience.

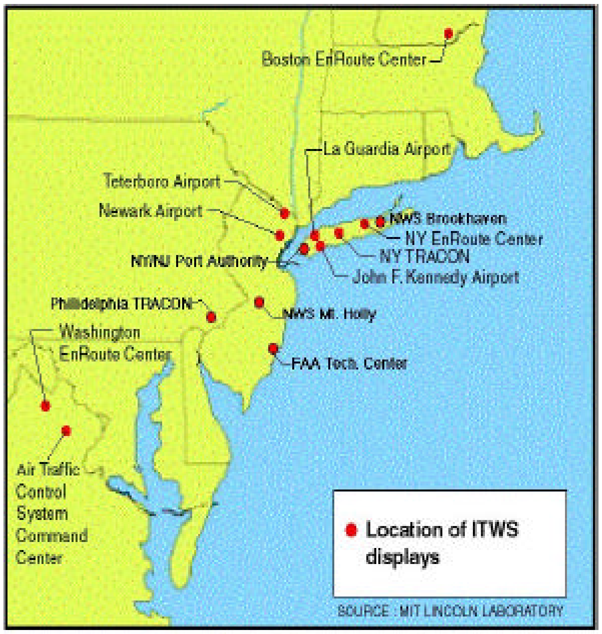

Figure 3. Location of NY ITWS user displays.

Coastal storms typically have strong, varying winds aloft that make it difficult for air traffic controllers to properly merge and sequence the aircraft because they cannot easily judge the time-of-flight (TOF) for the aircraft. Estimation of the TOF requires accurate wind data at flight altitudes. The ITWS provides three-dimensional information on terminal winds through statistical estimation algorithms operating on Doppler weather radar data, aircraft reports of winds, surface wind measurements, and NWS numerical prediction model wind estimates. The NY ITWS will accomplish the equivalent of triple Doppler analysis in real time every 5 minutes by using data from the Newark TDWR and the two NEXRADs.

This wind data is expected to provide significant reductions in delays at the New York airports during adverse wind conditions by enabling the TRACON supervisors to determine appropriate aircraft spacings throughout the terminal area for efficient aircraft merging and sequencing.

4. SAFETY BENEFITS OF THE NEW YORK ITWS

The New York ITWS will enhance safety at the New York airports and terminal areas in a number of ways. Low altitude wind shear protection at Newark will be significantly enhanced by the ITWS microburst and prediction algorithms and by the MIGFA algorithm. The ITWS microburst prediction algorithm uses TDWR three-dimensional reflectivity structures together with boundary layer thermodynamic information to predict the peak outflow strength of microbursts when surface divergence outflows are just beginning, thus increasing the warning time for pilots by several minutes.

The likelihood of plane encounters with severe weather (e.g., storms with hail, strong rotations aloft, tornados, and/or lightning) will be reduced by proactive routing of planes away from weather using the ITWS storm movement predictive products and the storm cell information product. By anticipating storm impacts on key terminal fixes and runways and proactively routing the traffic away from impacted regions, air traffic supervisors will be able to reduce controller workload. The ability to anticipate runway usage changes due to gust fronts will also reduce controller workload.

5. SYSTEM ARCHITECTURE

The NY ITWS products are generated in an operations center located in Westbury, NY (near the NY TRACON). Phone lines (T-1 lines in the case of the pencil beam radars) are used to provide the local sensor data to a Sun computer network at the operations center. National scale data (e.g., RUC II, national lightning, MDCARS, and ASOS data) are provided over a phone line from Lincoln Laboratory. The users' displays are all driven over phone lines. The product generation is accomplished fully automatically using the product generation algorithms to be used in the production ITWS. The operation of the algorithms and real time system product distribution system is monitored by Lincoln researchers when the products are being used operationally.

6. INITIAL OPERATIONAL RESULTS

The NY ITWS commenced operations on 28 August and is now operating 7 days/week. On Labor Day, a very severe storm (for the Northeast) moved through the NY metropolitan area producing hail and tornado storm warnings over a sizable area in New Jersey and on Long Island (including 1.5” hail at the ITWS operations center). Figure. 2 shows an ITWS situation display image from the storm.

The response from the operational users to the ITWS information provided during this event was very positive. The storm-extrapolated position enabled the users to anticipate the weather impacts and move planes proactively to avoid the weather. For example, the Teterboro tower was able to warn several VFR pilots practicing near the airport that severe weather would impact the airport in approximately 30 minutes. The VFR aircraft all landed promptly and safely.

The heavy precipitation associated with the storms caused significant attenuation to even the ASR9 S-band radars and major attenuation to the C-band TDWR precipitation product. Additionally, one of the ASR9 radars experienced abnormal severe attenuation of the weather return when switched to circular polarization. However, the use of a mosaic to create the TRACON precipitation product meant that these problems with the individual sensors at various times did not substantially degrade the quality of the mosaic product.

We have also observed substantial amounts of AP contamination on both the JFK ASR9 and the Brookhaven NEXRAD. However, the AP editing algorithms have thus far been very effective in removing AP from the ITWS product displays.

7. NEXT STEPS

The New York ITWS functional prototype has been designed to facilitate changes to address the various meteorological and operational issues encountered in the system use. It is clear from the very preliminary experience thus far that there will need to be ITWS algorithms to monitor the quality of the ASR9 information when a radar changes polarization. Additional products (e.g., the organized convection forecast product currently being tested at Dallas-Ft. Worth airport) [Hallowell, 1999] will be added to the NY ITWS product suite in 1999. We anticipate many more changes and refinements as the NY ITWS operations continue through the fall and winter storm seasons.

Another very important element of the NY ITWS operations will be post event operational analyses of the traffic and weather by a Lincoln/Air Traffic team to:

1. Assess how effectively the current products were used in improving operations, and
2. Identify situations where additional products could improve the safety and efficiency of operations at the New York airports.

8. REFERENCES

Hallowell, R.G, M.M. Wolfson, B.E. Forman, M.P. Moore, B.A. Crowe, T.M. Rotz. 1999: "The Terminal Convective Weather Forecast Demonstration." American Meteorological Society, Preprints: Seventh International Conference on Aviation Weather Systems, Vienna, VA.