13.5 PMTIP: A NEW DIRECTION IN PARTNERSHIPS FOR AVIATION PERFORMANCE METRICS

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1. INTRODUCTION

The Meteorological Service of Canada (MSC) branch of Environment Canada (EC) has provided aviation weather services since November 1, 1996 to NAV CANADA, the Canadian civil air navigation services provider. These services are part of an agreement with NAV CANADA which provides a number of quality assurances and performance measurement initiatives as well as service guarantees and standards.

Aviation weather forecasts are used by various clients; in Canada the primary users include NAV CANADA staff, pilots and airline dispatchers. However, performance metrics produced by MSC for NAV CANADA were not always directly useful and easy for pilots and dispatchers to understand and not easily accessible to view and use. Through discussions between the MSC, NAV CANADA, Air Canada and Jazz Aviation (formerly Air Canada Jazz), the Aerodrome Forecast (TAF) Performance Measurement System Improvements Project was created in order to address these issues and enhance end-user decision making. The project name was changed to the Performance Measurement TAF Improvement Project (PMTIP) to more formally emphasize its scope. PMTIP is a new performance-based decision support system available to outside users through a website with a user account.

Figure 1. The PMTIP Website

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2. DEVELOPMENT

The most used aviation weather product produced by meteorologists at MSC is the Aerodrome Forecast (TAF). These forecasts are one of the many tools that are used by airline dispatchers and pilots to plan their flights and to decide how much fuel they need to carry. Consideration of potential weather conditions of a planned flight's destination and its alternate will directly affect the decisions made by the pilot or dispatcher. With this in mind, it was the TAF that would be the focus in the planning and development of PMTIP.

The main goal of PMTIP was to eliminate unnecessary fuel upload/carriage in order to lower costs to aviation users and to reduce related greenhouse gas emissions. One important tool that airlines can use to save fuel is to fly No Alternate Instrument Flight Rules (NAIFR). Canadian aviation regulations allow an Instrument Flight Rules (IFR) flight to be conducted such that the requirement to identify and carry fuel for an alternate airport is removed as long as certain meteorological conditions are not forecast in a TAF within 2 hours of the expected arrival time, the destination airport has two usable runways, an IFR approach system with backup power and the flight is certified to fly using the NAIFR allowance. NAIFR as defined for the PMTIP project is a ceiling at or above 1500 feet, visibility at or above 6 statute miles or ceiling at or above 2500 feet, visibility at or above 3 statute miles. Additionally, in the TAF there can be no forecast (including PROB) of thunderstorms, freezing rain or freezing drizzle.

When a pilot or dispatcher files a flight for NAIFR they reduce the amount of fuel carried thus decreasing the weight and reducing fuel burn and related greenhouse gas emissions. This situation is optimal when the forecast is accurate but when it is not it has an adverse effect on the airlines. Flights enroute may have to land for a fuel stop. This creates a situation where extra costs are incurred by the airline which could have been avoided if the TAF was more accurate.

Since the TAF is the primary tool for flight planning, TAF accuracy is critical. A 2002 study by NAV CANADA, the Assessment of Aerodrome Forecast (TAF) Accuracy Improvement report (NAV CANADA 2002), looked at the accuracy of MSC TAFs. It indicated that the current performance metrics for TAFs produced by MSC could be improved upon to more fully support the needs of pilots and dispatchers. This study and discussion with users revealed the interest in producing a performance metric that would be easier for dispatchers and pilots to use. What was needed was a product that would facilitate the flight dispatch process and focus on critical operating limits. In 2004 a project was proposed by NAV CANADA for the development of PMTIP.

Over the next few years a plan was developed to produce new performance metrics that were suggested through the project proposal. Client consultations allowed for the discussion of additional performance metrics which would benefit the user, thus increasing the effectiveness of the product. The final performance metrics that were decided upon were for Critical Ceiling and Visibility limits including NAIFR criteria, Severe Weather and Wind. To generate and display the PMTIP metrics a computer system was built consisting of four main components. The components are the Ingest & Database, the Dashboard, Report Generator and website. The Ingest & Database component consists of all observations and TAFs. The Dashboard is a management tool that provides easy access for managing the system. The Report Generator produces the performance metrics that are used for the website and the website itself displays these metrics to users.

3. IMPLEMENTATION

The first release of PMTIP was v1.0 in 2007 and this version was used as a demonstration version to users that were involved with the development. Other users were invited to access it to view the development of the website and to provide initial feedback. Feedback from users was evaluated to determine their initial impressions of the website and the metrics that were displayed and to incorporate improvements.

In the fall of 2008 PMTIP v1.1 was released to allow TAF data to be ingested in the new TAF format and to accommodate TAF validity periods of up to 30 hours. PMTIP v1.2 is the current operational version and was implemented in October of 2010. This version included some minor bug fixes and improvements to some of the metrics.

4. PMTIP METRICS

Currently there are three types of Performance Metric reports: Critical Ceiling and Visibility Categories including NAIFR, Severe Weather for Thunderstorms and Freezing Precipitation, and Wind. These metrics can be displayed for all aerodromes in Canada that have a TAF produced by MSC. The metrics can also be displayed for various months and years using a database that currently has over 10 years of data.

4.1. *Critical Ceiling & Visibility Categories including NAIFR*

A number of forecast categories and observation categories were identified as being important to the airline industry and requiring verification feedback. Each forecast category and corresponding observation category is known as a scenario. A category is defined by upper ceiling and visibility limits as well as lower ceiling and visibility limits. The occurrence of severe weather is also factored in because the NAIFR criterion requires that there be no severe weather in the TAF.

To produce these metrics the TAF is first broken down using the lowest ceiling and visibility condition and takes into account the temporal and probabilistic terms of a TAF which includes BECMG, TEMPO, PROB30 and PROB40. The comparison of the forecast and that of the observations are done on a minute by minute basis. The percentage of time each scenario occurred is computed for each of the scenarios identified. The chart in figure 2 below shows a number of scenarios where the forecast category is NAIFR. Green coloured bars are an indication for forecast reliability and red forecast unreliability. Besides producing the NAIFR performance metric there are also five additional ceiling and visibility categories for which metrics are produced.

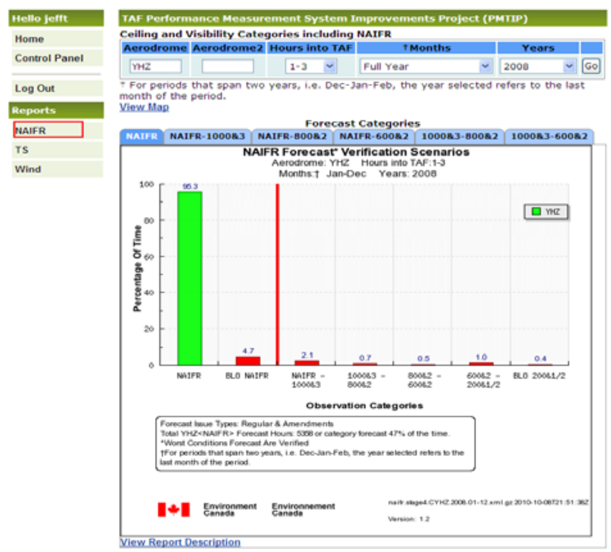

Figure 2. Graphic showing the percentage of time (95.3 %) NAIFR conditions occurred when the forecast was NAIFR.

4.2. *Severe Weather*

Severe weather as it relates to aviation includes thunderstorms, freezing drizzle, freezing rain, and ice pellets. Planning for severe weather is important not only to dispatchers and pilots but also for the many airport authorities. A high degree of accuracy in predicting severe weather is essential for planning purposes. When there is an actual severe weather event there is always one TAF that is the first to warn users that it will occur. The difference between the issue time of this TAF and the actual time of the observation of the event when it is uninterrupted is the earliest lead time performance metric. Uninterrupted means that for every TAF issued before the actual event it must have the severe weather event in the forecast.

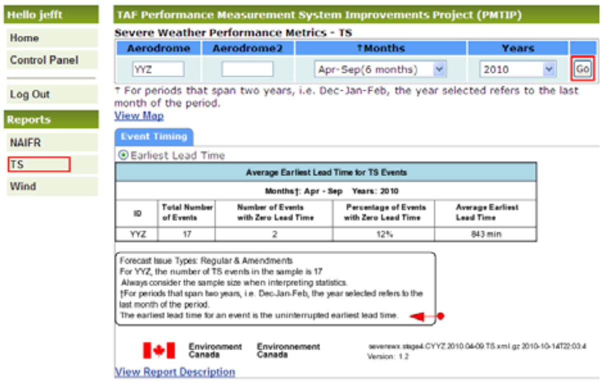

Figure 3. Average Earliest Lead Time for Thunderstorms

PMTIP also produces an onset time accuracy and end time accuracy metric. The onset time comparison is between the start time of the actual event and the start time of the severe weather forecast. The error is calculated for each comparison and then the summary score, Mean Absolute Error (MAE), is computed for the forecast sample. This gives an indication of forecast error on the onset timing of severe weather. The end time accuracy metric is produced using the same method except it uses the end time of the event.

4.3. *Wind*

Wind is also a significant factor along with No Alternate IFR (NAIFR) in flight planning. For pilots and dispatchers, knowing the active runway upon arrival will have an impact on the fuel upload/carriage since the aircraft may have to go into a holding pattern before being cleared to land. Airport configuration is very important as every runway will have a different airport arrival and departure rate depending on the wind direction and speed.

Another key factor in decision-making is that certain aircraft cannot land on certain runways due to the available approach instrumentation of these runways or the runway length does not meet its regulatory requirements. This can happen even when the weather is good so knowing the wind direction and speed is very important in the flight planning process. The performance metric for wind will be used to plan the preferred runway at the time of arrival. Peak wind was identified as being important in the TAF and is verified on an hourly basis. Peak wind from a TAF is associated with the wind group with the highest wind speed in either the predominant or temporary forecast groups, which includes gusts. In the observation it is the highest wind reported within an hour and includes gusts. Wind speed and direction errors are calculated for each forecast hour. The summary scores generated for the forecast sample are the Mean Absolute Error (MAE) for both wind speed and direction accuracy as well as the bias for wind speed.

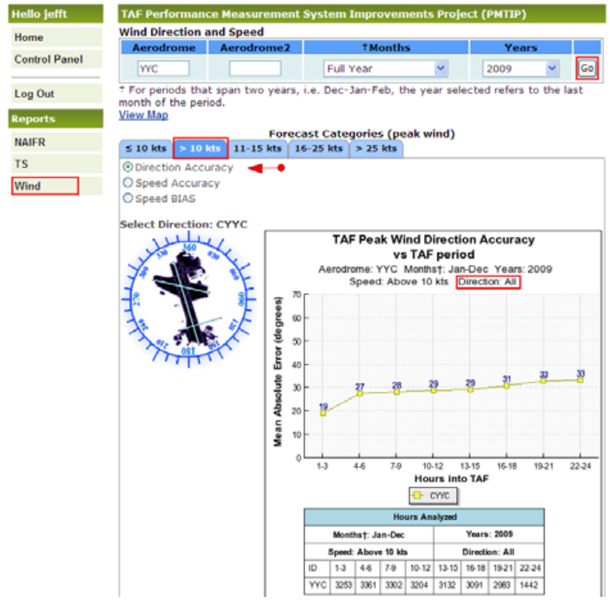

Figure 4. Peak Wind Direction Accuracy

The Direction Accuracy metric can be displayed for all directions and also in 30 degree slices which can be shown by choosing a slice on the wind radial diagram to the left of the display. Airport runway configurations are displayed on the wind radial diagram for major airports only. Different ranges of speed can also be chosen for any directions. Speed Accuracy and Speed Bias are displayed with the same options as direction and in the same format.

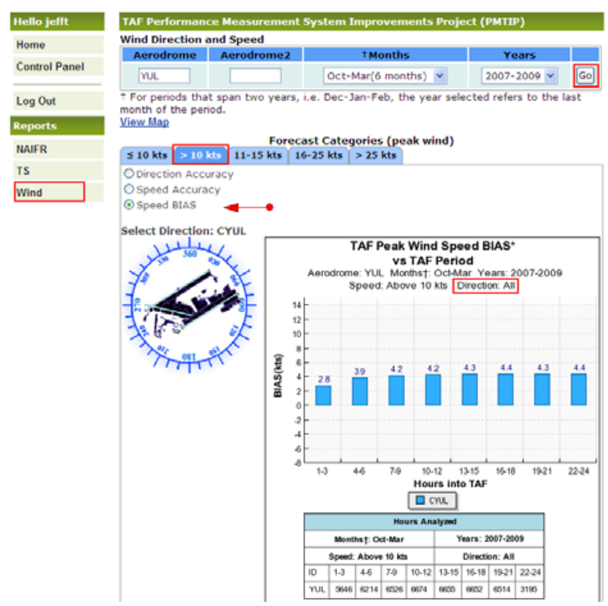

Figure 5. Peak Wind Speed Bias

5. CURRENT STATUS

PMTIP v1.2 is the operational version currently available to users. To date it has over 130 user accounts including MSC aviation offices, NAV CANADA, and several airlines. The PMTIP metrics are provided for over 200 aerodromes in Canada. Updates to PMTIP are made monthly as new data is produced and users are informed of this by email. There are monthly updates as well as planned releases for minor enhancements and bug fixes (if required). Major releases and new versions will be planned for the next few years and will consist of new metrics or displays.

At the time of writing, the Severe Weather performance metrics are only provided for Thunderstorms. The performance metrics for freezing precipitation are suppressed and are being reviewed due to an anomaly noticed in the output data. This should be corrected by the next release.

6. USE

PMTIP was developed with input and feedback from dispatchers and pilots and is currently being used mainly by flight dispatchers to aid in the flight planning process. It is also used by NAV CANADA staff and MSC meteorologists involved with forecast verification.

One of the reasons for the development of PMTIP was to aid in the flight planning process and to give dispatchers more confidence in the TAF. Since PMTIP became operational last year there have been many training sessions on its use and how to interpret the metrics. An example of how PMTIP can aid the dispatcher is described below.

> *Toronto Pearson is Canada's busiest airport (Statistics Canada, 2010) and the arrival and departure rate can vary depending on many factors, and wind direction has been identified as the most significant. When a TAF is showing a wind shift that will impact the arrival rate at the time of arrival the dispatcher needs to have confidence on the timing of it. By using the PMTIP wind metric one can display the MAE of direction and speed for Toronto Pearson for a period and time relevant for the flight arrival and along with other data the dispatcher can increase his/her confidence on that timing and decide on the best fuel load. The speed bias can also be used to see if the wind speed is generally over forecast or under forecast for the chosen period.*

Initial feedback on PMTIP has been positive and many airlines will be incorporating its use as part of their decision-making process for fuel upload/carriage, especially for the major airports in Canada. Once this is routinely done confidence in the TAF will increase for dispatchers and fuel load will decrease thus reducing the amount of fuel burn and related greenhouse gases emissions. This is an excellent outcome for both the environment and the user.

7. FUTURE CHALLENGES

As world fuel prices increase the need for an accurate TAF will become even more critical for the dispatcher and pilot. With a variety of users now onboard, the evolution of the product as one of the tools used in the flight planning process will increase. We are continuously developing new features to augment the display currently being used.

There are many airlines from all over the world that use the major airports in Canada and we feel that by promoting PMTIP worldwide these users will benefit from its use and potentially save significant amounts on fuel load and again reduce the emissions of greenhouse gases world wide.

8. ACKNOWLEDGEMENTS

The development of PMTIP was a joint initiative among Environment Canada, NAV CANADA, Air Canada and Jazz Aviation. We would like to thank NAV CANADA, Environment Canada and the Program of Energy Research and Development (PERD) operated by Natural Resources Canada for the funding of PMTIP. Thanks also go to NAV CANADA, Air Canada and Jazz Aviation for giving their staff time to participate in the development of the PMTIP performance metrics and reports. I would also like to thank the following individuals who were involved in the development and implementation of PMTIP and in the preparation of this manuscript; Jeff Thatcher (MSC), Craig MacLaren (MSC), Joanne Volk (MSC/NAV CANADA), Rob Honch (MSC), Bill Woolverton (MSC, retired), Serge Desormeaux (MSC), Nicolas Major (MSC), Peter Kimbell (MSC), Merv Jamieson (MSC), Fabio Esposito (CSB), James Fricker (CSB), Dan Shea (CSB), Chris Wong (CSB), Daniel Chretien (MSC/NAV CANADA), John Footit (NAV CANADA, retired), Eric Dupuis (NAV CANADA), Julie Mailhot (Air Canada), Richard Sowden (Air Canada), and Martin Kothbauer (Jazz).

9. REFERENCES

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