Creating a Scalable Solution for Producing Quality Terminal Aerodrome Forecasts

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1. Introduction

Telvent DTN has been providing Terminal Aerodrome Forecasts (TAF) to a wide variety of Aviation clients since 1981. Until recently, all TAFs were written manually by individual forecasters, since automated guidance was non-existent for most TAF parameters, and because no guidance has been available at the timeliness required to produce and maintain a quality forecast for aviation end users. Consequently, TAFs require a heavy dose of manual editing which can produce significant scalability issues when a large number of sites require forecasts. Recent new model guidance additions now provide hourly updating datasets that make it feasible to produce automated TAFs, with some editing. An approach to incorporate these datasets into an automated TAF engine is discussed along with the integration of other forecast data sets, including a common precipitation forecast, an interface for aviation forecasters to edit and override unacceptable forecasts when needed, and verification statistics on the performance of the automated TAF engine. Telvent DTN issues TAFs (which are called RAMTAF's [Real-time Atmospheric Monitoring Terminal Area Forecast] to distinguish them from regular TAF forecasts) for global locations on both a scheduled and unscheduled basis. RAMTAFs are identical in format and function to government issued TAFs, and are used by aviation clients just as TAFs are. RAMTAF forecasts are issued for clients who need a TAF forecast for a locations where no government issued TAF is available, or where government issued TAFs are unreliable or not timely enough for flight operations.

2. Automated TAF Engine

The automated TAF engine has been designed to produce TAF forecasts and amendments automatically and run unattended, but includes the ability for manual editing and override. To insure accuracy, hourly updated data is needed, particularly for the first few hours of the forecast. The data available at the frequency required include METAR/SPECI observations, NLDN (National Lightning Detection Network) data, models such as the RUC/RR (Rapid Update Cycle), and MOS LAMP ([GFS based] Localized Aviation MOS Product). An independently produced and frequently updated precipitation forecast is also used.

2.1 Datasets

The first essential component needed for a good TAF is a clean METAR observation. Next, the best hourly updated guidance is used to create a forecast where the first few hours of the forecast need as little editing as possible. The evolution of the LAMP dataset has been impressive in handling most weather events with its forward error correction using METAR observations and GFS MOS guidance. The RUC/Rapid Refresh is a model data resource that is beneficial for rapidly changing weather events that LAMP cannot pick up in as timely a manner. Another key component is a frequently updated precipitation forecast to get the timing of precipitation events as close as possible, and to provide a further correction to the guidance where necessary. Lightning data is also used to pick up thunderstorms before the observations to make thunderstorm forecasting within the TAFs as proactive as possible.

2.2 Integration of datasets into a TAF

The datasets above are then integrated into a cohesive TAF forecast. This begins with the METAR (or an aliased observation if the site does not report observations. Thunderstorms are inserted into the first hour of the TAF if lightning from the NLDN network is detected within 20km of the site. Then the observation is blended with the latest guidance. The blend is done with parameter dependent set of rules to blend the two together. Some blending can be done through interpolation but the rest need to be abruptly cut over from observation to forecast. For example, ceilings and visibility can be interpolated but weather conditions cannot. The result is an hourly forecast of all TAF parameters for each of the next 21 hours. Finally, the precipitation forecast is integrated into the hourly forecast. This precipitation forecast is prepared by Telvent DTN's World-Class Meteorological Operations Center with 50 degreed and experienced meteorologists. The precipitation forecast consists of the precipitation type, intensity, and probability of occurrence. The probability of occurrence drives the decision to display the precipitation in the main body, both the main body and conditional, or just in the conditional portion of the TAF. To finish the precipitation forecast integration, a set of rules is applied to the ceilings and visibilities that synchronize the forecast of those values to acceptable aviation industry standards given a certain precipitation event. Non-precipitation events such as fog or low stratus are purely handled by the guidance.

2.3 Building the TAF

Integrating the hourly data into TAF components results in an hourly representation of what is forecast to occur during the entire forecast period of the TAF. For a TAF, the only forecast information to display are the initial conditions and changes that are important to aviation operations, so that the TAF only contains lines that have changes of operational significance. These thresholds are defined in industry standard categories for visibility, ceilings, significant wind speed and direction changes, precipitation type changes, precipitation intensity changes, and probability of precipitation changes.

Taking all these thresholds into consideration takes a set of very complex rules that limit the number of lines without sacrificing key forecast events within the valid forecast period. The complexity evolved over an extended period where refinements to tune the rules were made to insure that the rules perform desirably. This tuning process extended from warm season to cold season to capture the full spectrum of forecasts that are possible throughout the year, as well as across a good spatial diversity of locations to insure that a wide variety of climate regimes were included.

2.4 TAF Quality Monitoring and Editing

In order to ensure that the TAF forecasts have the quality required, the final step is a manual check by a meteorologist. The TAF system is integrated into a meteorologist's workstation, in a system called MetConsole which provides a convenient way for meteorologists to interact with the TAF data stream and approve or edit the automated TAFs. We have employed a web-based interface to perform this task (Figure 1).

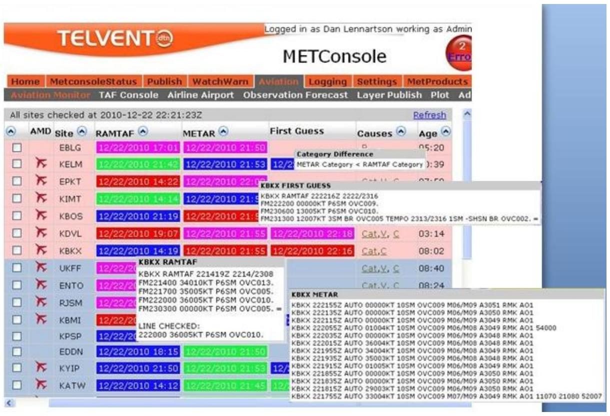

Figure 1: *Web-based Aviation Monitor within the larger program MetConsole that is used for a wide variety of function to support weather forecasting operations.*

The interface is designed to organize the TAFs so that it clearly shows the TAFs that are in most need of attention to streamline workflow. This is accomplished by making a set of priority rules that order the initial TAFs from highest operational significance to lowest in the Initial RAMTAF Manager to the right of the Aviation Monitor (Figure 2).

Figure 2: *The IRM is activated on a schedule where a forecaster can mouse over a first guess automated initial forecast and either send it directly with the button or click the ICAO to launch TAFConsole to perform an edit and send.*

For amending TAFs, we further refine the rules so that out of category TAFs rise to the top maintaining their order from highest to lowest significance. TAFs are continuously compared with observations evaluating their categorical compliance.
From the AviationMonitor, another web-based tool, TAFConsole, can edit TAFs in need of overriding (Figure 3).

Figure 3: *The web-based TAF editor called TAFConsole features the editing box in the lower left with METARs (upper left) and National Weather Service TAFs (upper right) as guidance for editing. Buttons are provided for loading first guesses, previous forecast, and for getting back to the monitor with/without sending a TAF.*

The tool pops up by clicking on the site in need of editing where it automatically loads in the amended TAF into an editing window with the latest METAR, NLDN indicated thunderstorm (if detected) (Figure 4), and forecast guidance as reference for ease of editing.

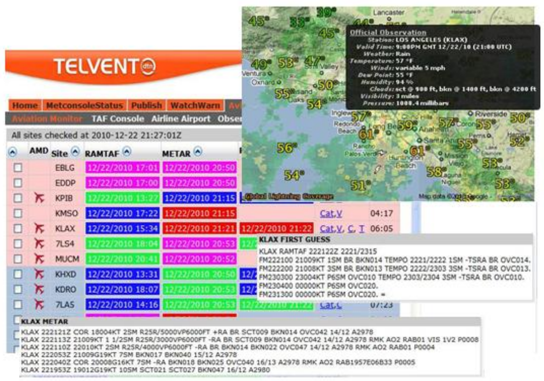

Figure 4: *This figure shows an example of the NDLN data alerting the aviation forecaster of potential thunderstorms approaching LAX. The first guess amendment proactively adds thunder to the first line of the TAF.*

Once the forecaster is satisfied with the TAF, the forecast is sent from the editor. This entire TAF system is integrated into an automated workflow stream, so there is a schedule set around the TAF engine where automated TAFs are generated and distributed whether they are edited or not to make sure the aviation end users get their forecasts in a timely manner.

3 Forecast Performance

The forecasts produced by the Automated TAF engine not only streamlines the workflow creating the TAFs but are also more accurate than the purely manual TAF workflow of the past. Figure 5 shows the verification results over a three month period from late summer to late fall where TAFs verified VFR to demonstrate how the VFR TAFs can be sent unedited. It also shows TAFs verifying as LIFR where the automated TAFs have a decisive edge on the forecasters. This discrepancy is largely because the automated TAF production keeps up with the changing conditions of all TAFs far more efficiently. The more TAFs a forecaster is responsible for the wider this gap in quality becomes.

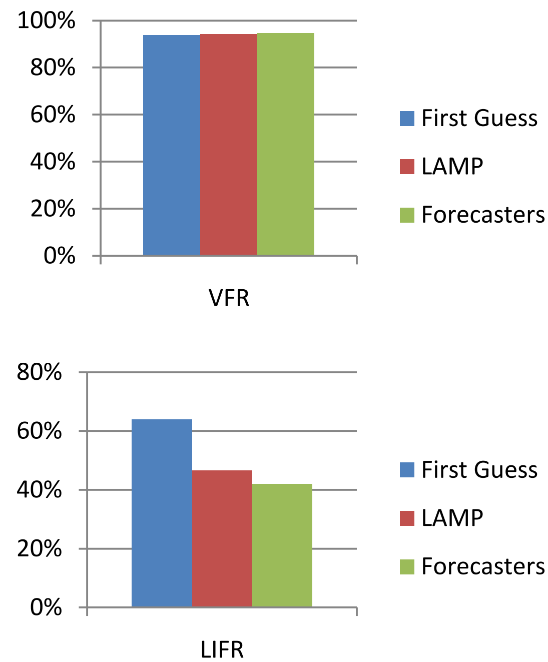

Figure 5: *The top graph shows the comparison of the automated first guess over the forecasters with LAMP verification as reference to show relative quality where the TAF forecast verifies VFR over all 18 hours of the TAF. The bottom shows the verification over the first 6 hours of the TAF where the TAF verifies LIFR.*

The multiple updates within an hour for every hour for every site provide a forecast quality that cannot be reliably matched by the manual editing process. The fact that the automated process does not forget to update nor care about the volume of sites are the two primary reasons for the superior quality of the automated process. This quality discrepancy between the automated and manual process, therefore, is proportional to the number of TAFs maintained. Amendments also benefit greatly in performance in not only quality as mentioned but also in response time from having a first guess which was not available in the manual process.

4 Aviation Forecaster Workflow

RAMTAFs are just one of a number of functions that Telvent DTN aviation meteorologists are responsible for. Therefore, an important consideration in the design of the TAF engine was to make sure that the new system enhanced workflow. Even more importantly, the transition from the old, manually edited TAFs to the new automated TAFs had to be seamless and transparent to end users. For this reason, the TAF quality monitoring and editing discussed in section 2.4 was included as an integral part of the system design.
With the new automated TAF engine, the infrastructure is designed to be a 24/7 automated system where the new focus of the aviation forecaster has changed to a quality control role, instead of one of ownership of the entire TAF production. The shift in focus requires that forecasters have to have confidence in the automated process. For this reason, the manual override and editing functions were maintained in the TAF engine. The building of forecaster confidence is shown in Figure 6 where the first months of statistics showing use of the unedited automated TAFs has steadily increased from less than 25% to over 60%.

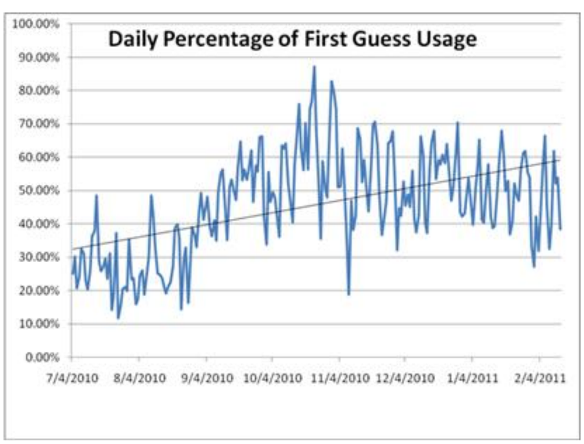

Figure 6: *Percentage of automated forecasts released without further editing. Since the introduction of the new TAF Engine, The number of automated TAFs that forecasters pass along with no further edits has steadily increased.*

To sustain a reliable environment to run the automated TAF engine, it is integrated into a datacenter infrastructure where the TAF engine is equipped with a redundant production engine that can be rolled to if the primary system fails. This is also true for the handling of input dataset processing. The design of the engine also allows us to handle outages of one or more data inputs to maintain a constant production of TAFs albeit in a somewhat degraded state depending on the forecast impact from the data missing. For data outages, the forecasters are alerted so they are prepared to step up their quality control duties to field any undesirable degradation of forecast quality as needed.

5 Summary

Telvent DTN has developed an automated first guess forecast of all TAF components, using LAMP and model guidance products combined with METAR and NLDN observations. This automated forecast has been shown to have accuracy equal to or better than the manual forecasts they replace. The automated forecast has been integrated into the workflow of Telvent DTN aviation meteorologists via a system called TAFConsole that enables the interaction with the automated scalable production of TAF forecasts. This system maximizes the incorporation of skill and experience provided by a meteorologist, while minimizing the manual labor and associated costs.