CMO Terminal Aerodrome Forecast (TAF) Verification Programme (CMOTafV)

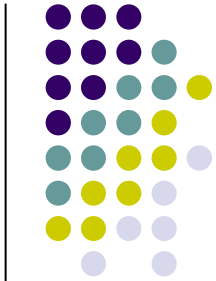
Kathy-Ann Caesar

Meteorologist

Caribbean Meteorological Council - 47

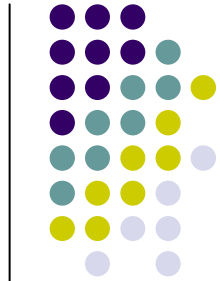
St. Vincent, 2007

CMOTafV
TAF Verification Programme



- **Project:**
  - The development of a Terminal Aerodrome Forecast (TAF) Verification Procedure for the Member States of the Caribbean Meteorological Organisation (CMO)
- **Purpose**
  - WMO and the International Civil Aviation Organization (ICAO) in "*WMO – No. 49 Technical Regulations* and *Annex 3 - Meteorological Service for International Air Navigation,"* respectively states the "*Operational-Desirable Accuracy of Forecast*" is a necessary requirement (DeSouza, 2007).
  - *A TAF verification procedure is necessary to keep in line with WMO/ICAO guidelines and to comply with the WMO requirements on qualifications and training of meteorological personnel*.
  - Taf Verification procedure will become a manidatory procedure for ALL Aerodrome forecast offices.

Why a TAF Verification?



- A TAF verification procedure measures the accuracy of forecasts of specific conditions which may affect aircraft safety;
- The scheme can be used to develop statistics which can be used to:
  - to aid the improvement TAFs generally and thus ensure safe aerodrome operations;
  - to determine the risk of forecast error on aerodrome operations;
  - to evaluate the forecast performance of the various forecast offices;
  - to evaluate the individual performance of the forecasters.

Aeronautical Meteorological Forecasts knowledge

Types, theory, diagnosis, operational impacts of, and forecasting techniques for:

- Aircraft Icing

- Turbulence

- Other hazardous phenomena
  - reduced surface visibility
  - low-level clouds
  - Thunderstorms and hail
  - wind shear
  - tropical cyclones and volcanic ash.

TAF Verification Procedures

- Three Verification methods from *the UK Met Service; the USA National Weather Service and the NavCanada* were reviewed in an effort to develop a procedure for the region;
- All the programmes were very similar in methodology, in that they measure the accuracy of forecasts (TAFS) of specific conditions (ceiling, visibility, flight categories and weather conditions) which may affect aircraft safety.
- The algorithms to the UK **TAF (Terminal Aerodrome Forecast) verification scheme** and the Canadian **Performance Measurement Aviation (PMA) Metrics and Methodology** were unavailable,
- However, they provided good methods on the use of the resulting statistics to quantitative measure over time of the improvement of the forecasting skill of the forecasts and regional model output in the future.

UK TAF (Terminal Aerodrome Forecast) verification scheme

- Figures 1 and 2 show recent trends in overall reliability achieved by The Met. Office TAFs forecasts.
- The steady rise in score to a peak in April 1997 is associated with a reduction in the observed frequencies of these low visibility/low cloud-base events (high scores are generally expected for rarer events since the verification scheme not only penalises incorrect forecasts, but also rewards correct forecasts of the non-event).
- Following the fall in scores from this peak in 1997, defence TAF reliability gradually increases, while for the civil TAFs since 1998 it is less obvious to discern any upward or downward trend in reliability.
- ***Since 1995 they have exceeded their targets, which are currently 0.84 for the civil TAF score and 0.88 for the defence TAF score.***

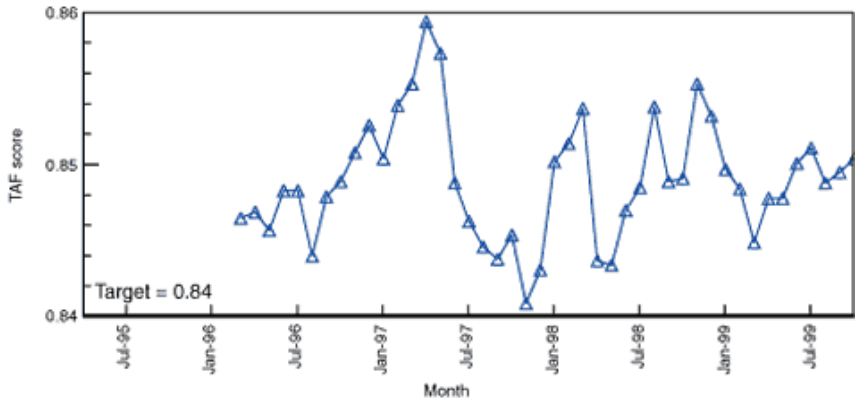


Figure 1. Composite TAF score for civil aerodromes.

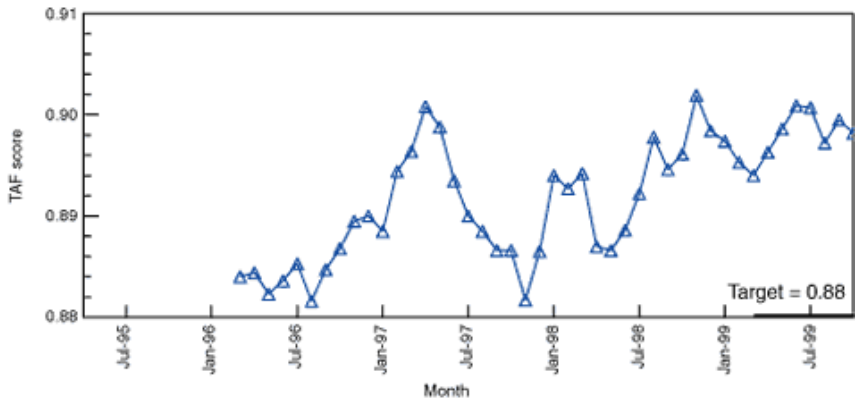


Figure 2. Composite TAF score for defence airfields.

Aviation Verify- TafVer 2.0

- The *Aviation Verify*/Tafver 2.0 programme from the NWS for the United States was readily available and one that could be easily retooled for use in the Caribbean region.
- Written by Andrew Rorke (NWS LOX) **Aviation Verify** and its upgrade **Tafver 2.0** evaluate the TAFs with respect to the observed conditions, available from the hourly METAR reports and model output statistics (MOS).
- It is an Microsoft® Excel based platform, thus is readily useable on COROBOR system or any other Windows base computer.
- The model output statistics (MOS) are currently not available for the regional meteorological centres; however the programme can operate without MOS data.

Additional Programmes

- It was necessary to develop additional programmes to extract and format the data;
- The following are the programs needed to run CMOTafV.
  - ***Extract Data*** was written to extract and sort the TAF and METAR data from the COROBOR database.
  - ***COROBOR-Convert*** (Kim Whitehall) - converts the downloaded data into a form to be read by the TafVer programmes.
  - ***Compactor_2-c*** - a part of the TafVer package processes the raw TAF, MTR, (and MOS files) and aligns the data for the verification procedure.
  - ***AVNVerify_2_MOS*** –the statistical programme generates verification statistics on a monthly basis.

How does it work…

- **Aviation Verify** breaks each TAF and corresponding METAR/SPECI observations into 288 discrete 5-minute blocks.
- Observations are compared to TAFs, and each 5-minute block is verified separately for *ceiling, visibility, flight category, wind direction, wind speed, wind gusts, and weather.*
- Forecasts within the PROB and TEMPO groups are also verified.
  - Verification statistics are stratified by projection (*0-3, 3-6, 6-12, 12-18, and 18-24 hours*) and
  - TAF initiation times (*0000, 0600, 1200, and 1800 UTC*).
  - TAF amendments are not verified.
- During any single 5-minute interval, one or two forecasts may be in effect, depending upon whether or not a TEMPO or PROB group is in effect.
- If neither a TEMPO nor PROB group is in effect, verification is done by simply comparing the prevailing forecast (FM or BECMG group) to the observation.

General Ceiling, Visibility, and Flight Category definitions/statistics

- **Ceiling (CIG)**
- Ceilings are verified by category. A forecast hit occurs if the TAF ceiling category equals the observation ceiling category.
  1. < 200 feet
  2. 200 to 400 feet
  3. 500 to 900 feet
  4. 1000 to 1900 feet
  5. 2000 to 3000 feet
  6. 3100 to 6500 feet
  7. 6600 to 12000 feet
  8. > 12000 feet or no ceiling

- **Visibility (VIS)**
- Visibilities are verified by category. A forecast hit occurs if the TAF visibility category equals the surface observation visibility category.
  1. < 0.5 statute mile
  2. 0.5 to < 1 statute mile
  3. 1 to < 2 statute miles
  4. 2 to < 3 statute miles
  5. 3 to 5 statute miles
  6. > 5 statute miles

Flight categories

•There are four FAA flight categories which are defined in the following table.

• If the ceiling and visibility values disagree on flight category, the flight category is defined as the worst of the two

Category	Designation	Ceiling	Visibility
9	VFR	None	Greater than 6 miles
8	VFR	6500 - 12000	
7	VFR	3000 - 6000	6
6	MVFR	2000 - 3000	3 -5
5	MVFR	1000 - 1900	
4	IFR	500 - 900	2.0 - 2 3/4
3	IFR		1.0 - 1 3/4
2	LIFR	200 - 400	1/2 or 3/4
1	VLIFR	Lower than 200 Feet	Lower than 1/2 mile

FAA

Statistics

- **Hrs -** Hours (Hrs) are the number of hours a phenomenon was observed during TAF verification.
- **% C -** The percentage of total forecasts issued that were correct.
- **POD -** Probability of detection (POD) is the number of times the TAF matched the corresponding observation divided by the total number of times the element was observed.
  - It is similar to **% C**, but POD is used for evaluating a single category or threshold (e.g., ceilings below 200 feet), whereas **% C** is used for evaluating all categories of a given element.
- **FAR -** False alarm ratio (FAR) is equal to the number of times element was forecast but not observed divided by the total number of times it was forecast.
- **FA Hr -** False Alarm Hours (FA Hr) is the actual number of hours an element was forecast but not observed.
- **T busts -** The percentage of time the hours the TAF was two or more ceiling or visibility categories different from the observed category.

Statistical analysis

	Forecast Yes	Forecast **No**	**Totals**
Observation Yes	Hits	Misses	(H + M) Total Observed
Observation No	**False Alarm**	Null	(FA + N) Total Not Observed
Totals	(H + FA) Total Forecasted	(M + N) Total Not Forecasted	

POD = 100* H/(H + M) -the probability of detection

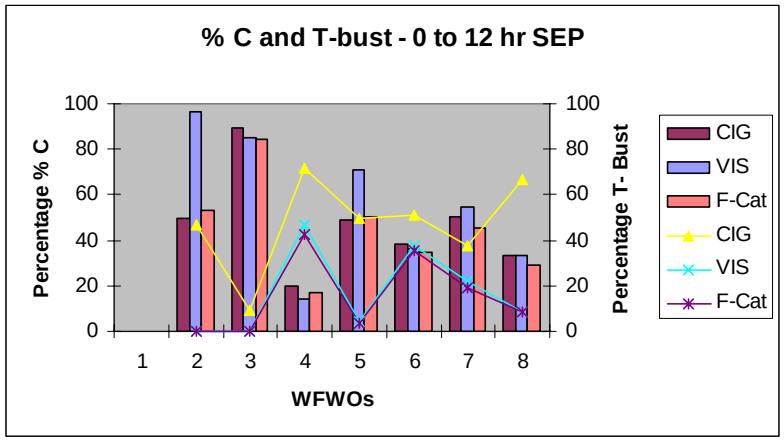
FAR = 100* FA/(FA + H) -the false alarm rate

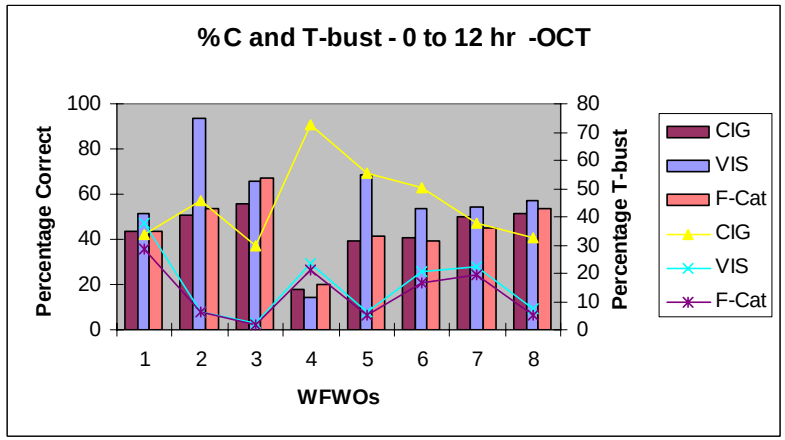
CSI = 100* H/(H + M + FA) -the critical success index AKA "the threat score"

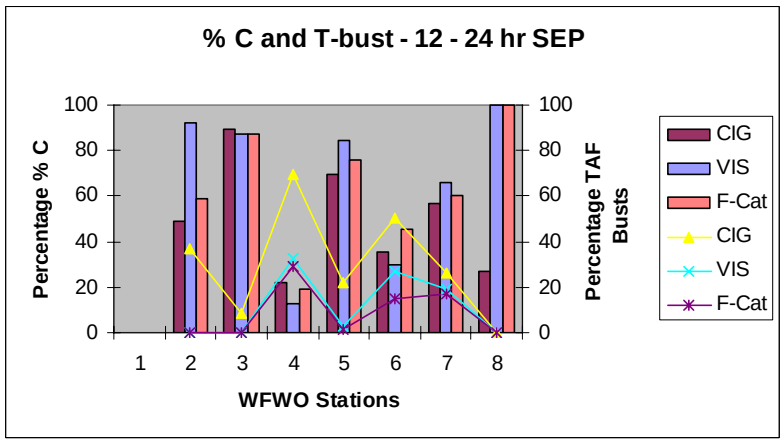
Output Statistics

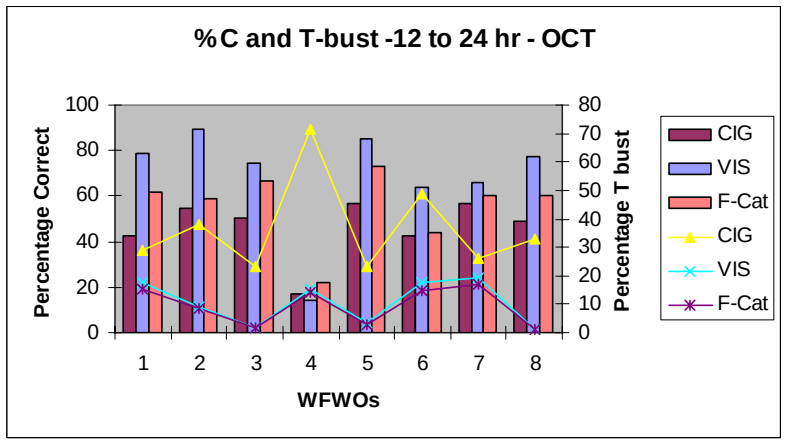
- The programme was run on data from June, July, September and October 2007;
- DEMO
- Basic Statistics
- Combine Statistics
- Flight Impact Statistics

Preliminary Results









Tempo Statistics

In addition to the standard TAF verification statistics, the following specialized statistics are computed for the TEMPO groups.

- **Hrs -** Number of hours (hrs) each element was forecast in TEMPO groups.
- **GT -** Good Tempo (GT) is the percentage of time the element used in the TEMPO group varied enough to justify TEMPO usage.
- **Tempo S/B FM -** Given that the MTRs did not vary enough to justify a TEMPO group, this is the percentage of time the TEMPO group produced a correct forecast, while the prevailing group was incorrect.
- **Tempo Benign -** Of all TEMPO hours for a given element, this the percentage of time:
  - the TEMPO group produced a forecast more in error than the prevailing group, and
  - the TEMPO group forecast better flying conditions than the prevailing group.
- Hence, the more erroneous TEMPO group was benign-it was unnecessary but also not harmful to the TAF.
- **Tempo Hurt TAF -** Of all TEMPO hours for a given element, this the percentage of time.
  - the TEMPO group produced a forecast more in error than the prevailing group, and
  - the TEMPO group forecast worse flying conditions than the prevailing group....
- Hence, the more erroneous TEMPO group hurt the TAF operationally by forcing the pilot to plan for worse conditions that did not happen.

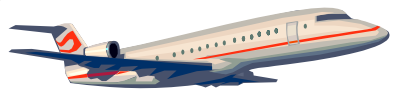
Future CMOTafV Goals

- Meaningful statistics will need to generate over a 3 to 5 year period.
- The programme will be modified for use by CMO members. Further modifications will be made to accomplish the following:
  - Design a user friendly interface;
  - Develop a database of statistics;
  - Modify the system to be flexible for training and management purposes;
  - Implementation of a model verification system for the region.
- Develop a data base from which statistics can be readily produce the following:
  - Timely reports on forecast office performance;
  - The threshold of performance score of TAFs e.g. 70% and track the performance against this threshold;

Special Thanks

- Rohan Brown (Forecaster/student);
- John Peters (Forecaster/student);
- Kim Whitehall (Climatologist);
- Mr. Andrew Rorke (USA NWS programme aurthor); and
- Mr. Michael Graf (Head, US NWS Statistical Office).

Thank You!



Questions/Comments!