METAR AUTO Implementation at
International Airports in New Zealand

Bruce Hartley, Tony Quayle

Meteorological Service of New Zealand Limited

30 Salamanca Road, Kelburn, Wellington 6012, New Zealand

bruce.hartley@metservice.com, tony.quayle@metservice.com

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Abstract:

Due to cost pressures and ever-increasing expectations of METAR reliability, consistency and quality in New Zealand, MetService has implemented fully automated data systems and METAR AUTO to replace manual observations at three international airports. This follows the successful implementation of METAR AUTO at 27 New Zealand domestic airports since 2008.

Implementation of the full system required MetService to meet the stringent requirements of users and the New Zealand Civil Aviation Authority (CAA - in its capacity as the ICAO Meteorological Authority for New Zealand) requirements as prescribed in Annex 3. To achieve this a multi-faceted approach was required including:

- Design and implementation of Automatic Weather Station (AWS) inter-data comparison and quality control;

- On site weather station redundancy (full duplication of AWS);

- Diverse data delivery communications for each AWS with centralised data stream management;

- METAR AUTO store and forward for each AWS;

- Centralised automatic augmentation of METAR AUTO with Runway Visual Range (RVR) data, centralised automatic augmentation of METAR AUTO with TS and VCTS derived from Lightning Detection Network (LDN) data, plus supplementary web camera imagery to forecasters vetting the METAR AUTO during the final level of quality control.

Future plans include investigating the benefits of automatic augmentation of METAR AUTO with present weather precipitation derived from radar data.

This paper describes the project history, technical detail of the multi-faceted approach items implemented and discusses the performance criteria used to monitor the systems.

Introduction

In 2013, due to cost pressures and ever-increasing expectations of METAR reliability, consistency, MetService implemented fully automated data systems and METAR AUTO to replace manual observations at the three main New Zealand International Airports: Auckland (NZAA), Wellington (NZWN) and Christchurch (NZCH).

The project was originally conceived some 10 years ago (in 2004 when a three way AWS-Observer-Observer comparison study was performed) in response to the need to reduce operational costs as purchased manual observations were becoming prohibitively expensive and the catch-phrase "*Plan to can the METAR man*" was coined.

To meet industry and regulatory requirements the METAR AUTO implementation required a combination of highly-reliable (100% data availability) aviation automatic weather stations (AWS), remote sensing systems providing thunderstorm data and other information that supports forecaster situational awareness, forecaster vetting and augmentation to ensure the reports are correctly portraying the prevailing weather, robust IT systems to compile and disseminate the reports, plus ongoing performance monitoring.

This paper provides a description of the thought processes and steps followed during the implementation of METAR AUTO at New Zealand's main International Airports (NZAA, NZWN and NZCH), including: consultation with airlines and other aviation organisations; agreed minimum data sets and reliability criteria; implemented data paths with processing steps, high level algorithms and timing.

Example of Web camera alignment and coverage

Rationale for Automating METAR Reports

The primary drivers for automating the International Airports METAR centred around performance and cost savings:

- **Missed Manual Reports**   Contract arrangements with ATC observers generally worked well, however because ATC first priority is air traffic management, METAR and SPECI are sometimes missed during periods of heavy workload. This resulted in:

  1) very few SPECI reports being issued and, as a result, conditions of operational importance were sometimes unreported until the next standard METAR hourly observation (up to 55 minutes later), and

  2) a small number (typically 5 to 20 at each site every month) of scheduled manual METARs being missed.

- **METAR AUTO 100% Availability**   Duplicating the AWS systems at NZAA, NZWN and NZCH, and employing diverse communications, would effectively reduce the number of missed reports to zero. Furthermore, with 30 minute METAR AUTO eliminating the requirement for SPECI reports[1], the users of METAR observations will be assured timely reporting of changing weather conditions.

- **Manual Visual Observations Weaknesses**   A well-trained and experienced human observer is able to produce representative METAR observations at an airport – at least during daylight. However through no fault of the observer there are some observation limitations due to site practicalities:

  Not all sites have well located height and visibility reference points. e.g., when the nearest hills are too far away to be valid height references for cloud at the airport, and excessive lighting makes it difficult to observe full sky cloud amounts and heights accurately.

  ATC observations are normally made from tall towers which sometimes places them above the fog for which they need to estimate visibility through the layer. This problem becomes worse at night, when extensive airport lighting and in adjacent parking and commercial areas makes it almost impossible to accurately determine visibility.

- **Manual Reports having Less Value**   It is evident that, because of the sorts of challenges described above, ATC tends to utilise the MetService AWS state of sky and visibility data (particularly at night or in difficult conditions) which is provided to them. Accordingly, ATC is adding rather less value in manual METAR reports than might be intuitively expected.

- **Improved METAR Quality**   The implementation model (described in detail below) of 30 minute AWS reports, automatically augmented with other remote sensing data, and vetted by experienced aviation meteorologists, ensures METAR AUTO at least match the quality of daytime manual observations and considerably improves night time observations.

- **Manual METARs were expensive**   And costs continued to rise to reflect ATC increasing business costs. There was no realistic opportunity to reduce the cost of manual METARs through negotiation or competition. Automation would therefore help MetService minimise future cost increases in its observations programme.

- **High Capital Cost - Long Term Lower Costs**   Although the capital cost of establishing the infrastructure required to create METAR AUTO was high, particularly where additional system redundancy was necessary (see later text), the lifetime cost of automation remains much lower than manual observation programmes.

- **Standardisation and Future Proofing**   Automation supports the New Zealand National Airspace and Air Navigation Plan - Meteorological Requirements for integrating

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[1] Annex 3, Chapter 4, para 4.4.2 b) includes provision for SPECI to be replaced by routine METAR/METAR AUTO issued at 30-minute intervals.

real time meteorological information into Flight Management Systems (FMS) and ATM Decision Support Tools (DSTs) to mitigate risk and support safe and efficient flight operations, and to replace individual and potentially conflicting meteorological products with consistent weather information.

The implementation of METAR AUTO supports future requirements for more automated machine readable meteorological information products e.g. extensible markup language (XML) and geography markup language (GML) formats for integration into FMS and ATM decision support systems.

Summary of Key Differences Between Manual and Automated METAR:

	Manual	Auto
Cost	—	Typical saving of 50% including capital, depreciation and operating costs
Interval	60 minutes	30 minutes
SPECI reports	When specified weather conditions or changes occur Off-hour reports infrequent	Not required for 30 minute METAR reporting interval
Reliability	Typically 98% of scheduled	100% (dual AWS and AWS diverse communications)
Timeliness	Within 10-15 minutes either side of the hour (subject to ATC workload)	AWS METAR AUTO are created and sent at T-8 (to allow sufficient time for data augmentation and forecaster vetting) Guaranteed customer delivery by T+7
Represent-ativeness	Well trained, experienced observers are able to accurately report airport and vicinity weather	State of the sky, visibility and present weather observations created from single instruments and proven algorithms AWS sensors cannot detect VC weather Forecaster vetting supported by 1 minute AWS data, web cam, radar and satellite imagery allows some VC additions
	Observation quality is affected by darkness	Observation quality is not affected by darkness
	Thunderstorm location reporting by visual and listening methods is very subjective	Thunderstorm location data obtained from MetService's lightning detection network

Some Background

The idea of full METAR AUTO automation is not new and MetService and other organisations have been working towards this system for well in excess of 5 years. Some of the pre-cursors paving the way for this project have included the following:

Regulatory Environment Since November 2007 ICAO Annex 3 Chapter 4, paragraph 4.7.1 (Amendment 74) has allowed for METAR and SPECI to be provided from automatic observing systems during both non-operational and operational hours of an airport as determined by the Meteorological Authority in consultation with users based on the availability and efficient use of personnel.

International Precedence A number of significant international airports around the world have fully automated METAR programmes. These include Rotterdam, Luxembourg, Helsinki and – in the Australia-Pacific region - Noumea, Pago Pago, Avalon and Gold Coast (Coolangatta) airports.

Previous Studies   MetService's intercomparisons between manual METARs and AWS data show good agreement, and a three way comparison from April – June 2004 between Air Traffic Control (ATC) METARs, AWS observations and an independent highly-experienced former MetService observer, has demonstrated that the difference between human and AWS observations is about the same as the difference between two observers at the same location.

Proven METAR AUTO   During 2008 and 2009, MetService introduced automated METARs (METAR AUTO) at 26 New Zealand domestic airports, including 12 locations where manual METARS were formerly provided. Chatham Island METAR AUTO also commenced in 2012, taking the total number of New Zealand METAR AUTO locations to 27.

The domestic airport implementation included METAR with 1 minute data diversity, and present weather thunderstorm data augmentation with information from the MetService operated New Zealand automated real time Lightning Detection Network (LDN). The implementation did not include dual station redundancy, dual 1 minute data diversity, or forecaster vetting.

The introduction of METAR AUTO at domestic airports had been well-accepted by pilots and forecasters alike. Users have appreciated the improved temporal coverage (AUTO METAR issued every 30 minutes, 24 hours a day), and the improved measurement accuracy and consistency (compared with human influences particularly with visual estimates).

Proven AWS Reliability   MetService currently operates a nominal network (the number is continually changing) of ~180 AWS, ~100 to support its own forecasting and business requirements and a further ~80 on behalf of specific customers. The customer stations are mostly in high-value, operationally-critical applications, including road transport, aviation, energy, marine and local government sectors, where users place importance on system robustness, accurate measurements and excellent supplier support. A Network availability of ≥ 98% has been achieved for the last 5 years.

Proven AWS Data Quality   All AWS operations and associated activities are to the standards by MetService's ISO9001 certification, and aviation AWS also conform to Civil Aviation Rule Part 174 certifications. MetService operates internationally traceable calibration systems, preventative maintenance as well as prioritised fault handling, and monitors equipment MTBF and MMTR on all sensors and major system components. All implemented algorithms are industry recognised and are trialled and soak tested before implementation. Important examples include the adoption of the internationally-accepted United States ASOS state of the sky-of-the-sky algorithm, the deconstruction of present weather sensor codes for quality control against other data parameters, the implementation of WMO standard data conversion, data range and lost data vetting. The use of sensor redundancy, for example, triple cell pressure sensors ensure any erroneous pressure values are immediately identified and removed. All MetService AWS implement status metadata reporting so that central alerting can quickly identify current and potential faults.

Purpose of International Airport METAR AUTO Observations

The first step in implementation was to have a clear definition of what the deliverable goal and scope of the METAR AUTO system had to be.

ICAO Annex 3 Chapter 4 section 4.3 "Routine observations and reports" prescribes the role of METAR observations in aviation weather services, with 4.3.2 b) stating that METAR are "… for dissemination beyond the airport of origin (mainly intended for flight planning, VOLMET broadcasts and D-VOLMET)", whereas information for arriving and departing aircraft is provided by way of "local routine reports", delivered by ATIS broadcasts and ATC voice communications.

Implicitly, METAR reports are also an essential input for production of TAFs and other aviation weather products.

Importantly, METARs are not intended for use as landing reports.

The pre METAR AUTO requirement for New Zealand international airports was to produce hourly METARS (every hour, on the hour) plus between-hour SPECI reports[2] whenever certain prescribed weather conditions exist and when significant deteriorations and improvements occur.

CAA and Industry Buy-in

The second step was to achieve the approval of the New Zealand Civil Aviation Authority (CAA) and to get the buy-in of Industry. This included thorough consultation and definition of all minimum requirements to meet regulatory requirements and industry/customer expectations.

CAA Regulatory Approval MetService had to gain the approval from CAA (in its capacity as the ICAO Meteorological Authority for New Zealand) to automate the METAR programmes at Auckland, Wellington and Christchurch international airports. The MetService proposal to CAA demonstrated its systems robustness with the ability to deliver high quality observations that fully meet the requirements of ICAO accuracy standards prescribed in Annex 3, Attachment A. The expectation was that a delivery performance of METAR AUTO would exceed that of manual METAR reporting at the time.

Industry Consultation Consultation with the main international airlines servicing New Zealand was undertaken by correspondence and user meetings. Without exception the Industry groups accepted MetService's demonstrated ability to operate an effective and reliable METAR AUTO programme at the international airports. Feedback from consultation with industry groups was also passed to CAA. Consultations involved the following groups:

Industry associations:

    International Federation of Air Line Pilots' Associations (IFALPA)

    International Air Transport Association (IATA)

    Board of Airline Representatives New Zealand (BARNZ)

    Aviation Industry Association New Zealand (AIA);

New Zealand Airlines Operators:

    Air New Zealand, Jetconnect, Jetstar, Qantas, Virgin Australia,

    Royal New Zealand Air Force.

Summary of Implementation Requirements An outcome of the CAA and Industry consultation was a definition of the minimum data and performance requirements for implementation of the full system required MetService which can be summarised as follows:

- ✓ 100% METAR AUTO delivery
- ✓ METAR AUTO delivery timeliness (onto the GTS By T+7)
- ✓ Automated quality control at the weather station (Data Validity Cross Checking)
- ✓ Automated data cross-filling using backup AWS
- ✓ Automated RVR augmentation where available
- ✓ TS, VCTS, RETS and ///CB augmentation stations with LDN data

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[2] The requirement for METAR and SPECI in NZ is included in the Asia/Pacific Regional Air Navigation Plan and Agreement.

- ✓ Forecaster vetting of automated reports including SHRA and VCSH augmentation and CAVOK supported by:
    - o Multiple web cameras at all sites
    - o ATC-generated ATIS where available
    - o Satellite imagery
    - o Radar imagery
    - o LDN strike maps
- ✓ Performance monitoring and reporting

Implementation

Each AWS-created METAR AUTO is sent first to MetService, where a TREND forecast (derived from the current TAF) is automatically added to meet ICAO requirements for international METARs. The METAR is then directed to the aviation forecaster for vetting of the data content and to check that the TREND correctly reflects the latest predictions for the airport and is correct in terms of the conditions reported in the METAR. Where necessary, the METAR AUTO and/or the TREND is manually corrected by the forecaster.

The implementation project is described in detail here and is presented under topics that match the *Summary of Implementation Requirements* above.

- ✓ **100% METAR AUTO Delivery**

    The existing domestic airport METAR AUTO has achieved delivery in excess of 99%[3],achieved through the following processes:

    - o METAR AUTO are created and sent by email from the AWS every 30 minutes with backup store and forward for up to 28 days.
    - o The 1 minute data path uses a two-try transfer protocol to allow for lost and corrupted messages.
    - o The 1 min data received at the central servers is used to create a backup METAR AUTO in real time.
    - o Message delivery is monitored with hourly alerting to quickly identify any faults and enable high priority remedial action.

    To achieve 100% METAR AUTO delivery for the International AWS additional system redundancy was established. This involved:

    - o Installing a fully-equipped and independent duplicate weather station at each of Auckland, Wellington and Christchurch international airports.
    - o Implementing diverse (independent communications providers and paths) dual 1 minute data paths for each of the main and backup AWS to the central servers.
    - o Each AWS has local batteries and is connected to airport generator backed-up power supplies to ensure that at a bare minimum wind, QNH, temperature and humidity data will be available in the extremely unlikely event of a major local power outage.

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[3] based on MetService monitoring statistics for AWS used to generate METAR AUTO.

Christchurch International Airport Dual AWS

✓ **METAR AUTO Delivery Timeliness (onto the GTS By T+7)**

Timing definition: T means hh:00 and hh:30 i.e. the METAR AUTO zero time is on the hour and at 30 minutes past the hour. T+x means x minutes after T, and T-y means y minutes before T.

To ensure guaranteed sending of the fully augmented and vetted METAR AUTO onto the GTS by T+7 there must be enough time for the AWS message creation, the telecommunications, message augmentation and forecaster vetting. MetService has implemented the following timing scheme to meet this objective for the international airport METAR AUTO:

- o T-10   TS, VCTS, RETS and ///CB are generated from LDN data in readiness.
- o T-8   AWS creates and sends the METAR AUTO by email.

  Central server creates a backup METAR AUTO from the 1 minute data.

- o T-5   If Primary METAR AUTO is not received then the backup one is filed.

  Any wind RMK[4] are added to the message.

  Any TS, VCTS, RETS and ///CB are added to the message.

  An automated TREND forecast is created and added to the message.

  A forecaster workstation alert is generated.

  The forecaster has reviewed all supplementary data sources.

  The forecaster reviews and "sends" the METAR AUTO message.

- o T+5   Timeout on forecaster vetting.

  If the forecaster has not already "sent" the message then it is sent now.

METAR AUTO for domestic airports are created and sent by AWS at T-2 as these are not subject to forecaster vetting.

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[4] Wind RMK are supplementary data remarks created from data for automated wind systems near the airport.

- ✓ **Automated Quality Control at the Weather Station (Data Validity Cross Checking)**

  During operation of the METAR AUTO programme at domestic airports over the previous 5 years it had become apparent to MetService that present and recent weather reports made in METAR codes by its network sensors (specifically the Vaisala FD12P and PWD22) are occasionally inaccurate under certain conditions. The reasons for this have been attributed to the following:

  - o The weather conditions experienced in New Zealand's maritime climate are at times dis-similar to those experienced in continental locations where the sensors were developed.

  - o The sensor algorithms are limited by the quality, location and number of data parameters built into the sensors.

  - o The sensors have limited present weather discrimination for some conditions e.g. insects.

  - o Some differences in time processing (averaging and time history transitions).

  - o Invalid code combinations can be reported.

  As part of the implementation process for international airport METAR AUTO MetService enhanced its AWS software by deconstructing present weather messages originating from the present weather sensors and then performing inter-data comparison and quality control with information from other AWS sensors. The MetService algorithms generate their own Recent Weather. The full data set used for intercomparison is:

  - o Present weather; Visibility; Rainfall; Air temperature; Relative humidity.

  The implemented algorithms will not be presented in this paper as they are still undergoing operational performance review.

  As a by-product of this project these algorithm enhancements have also been rolled out to all domestic METAR AUTO airports thereby improving all present weather reports from MetService aviation AWS.

- ✓ **Automated Data Cross-filling Using Backup AWS**

  For AWS-A

  - o The duplicate AWS-A one minute messages received at the central server via the dual communications paths are used on a full message replacement basis only i.e. if the primary message does not arrive or is rejected (because of corruption) then the entire backup message is used to replace it.

  - o At T-8 the combined dual AWS-A one minute message path is used create a backup METAR AUTO.

  - o At T-5 the central server checks to see if a primary METAR AUTO (sent directly from the AWS-A) has been filed, if it has not then the one minute data generated backup METAR AUTO is filed instead (this includes extracting all data elements from the message and saving into a database).

  For AWS-B

  - o The same process is performed as above.

  For AWS-A and AWS-B

  - o At this point the central processing creates a new station official METAR AUTO using the data from AWS-A. This includes checking for missing data elements and if any AWS-A data elements are missing then the element, if it is available from AWS-B, will be used instead along with any "associated" data elements to preserve algorithm integrity. The combined data set is then saved as the station official METAR AUTO.

✓ **Automated RVR Augmentation where Available**

The Airways Corporation of New Zealand has 3 sensors (Transmissometers) that measure RVR along the NZAA runway 23L-05R. The sensors are located near the touchdown points of runways 23L and 05R and the runway midpoint. Each of the 3 RVR sensors measures visibility along a 30 metre baseline parallel to the runway and transmits a message every 15 seconds. Runway 23 Left has ICAO Cat 3B status for low-visibility flight operations.

MetService has a live feed of data from all the NZAA RVR sensors and touchdown RVR values for both runways (23L and 05R) are automatically appended to station official METAR AUTO according to the following: On all occasions when the RVR observation at the threshold of RWY05R or RWY23L is less than 1500m, the RVR for both RWY is included in the METAR AUTO reports. This means that sometimes one of the RVR observations may indicate an RVR of less than 1500m and the other more than 1500m, e.g., R23L/1200 R05R/P1500.

This provision currently applies to NZAA only but is likely to be implemented at NZCH when an RVR system is implemented there later this year.

✓ **TS, VCTS, RETS and ///CB Augmentation of All Stations Using LDN**

METAR AUTO are automatically augmented at the central servers with thunderstorm information from the MetService operated New Zealand automated real time Lightning Detection Network (LDN).

The LDN provides close to 100% detection efficiency along with precise and accurate location information for each lightning strike. This process has already proved to be extremely effective and robust since it was introduced as part of the domestic airport METAR AUTO implementation in 2008/2009.
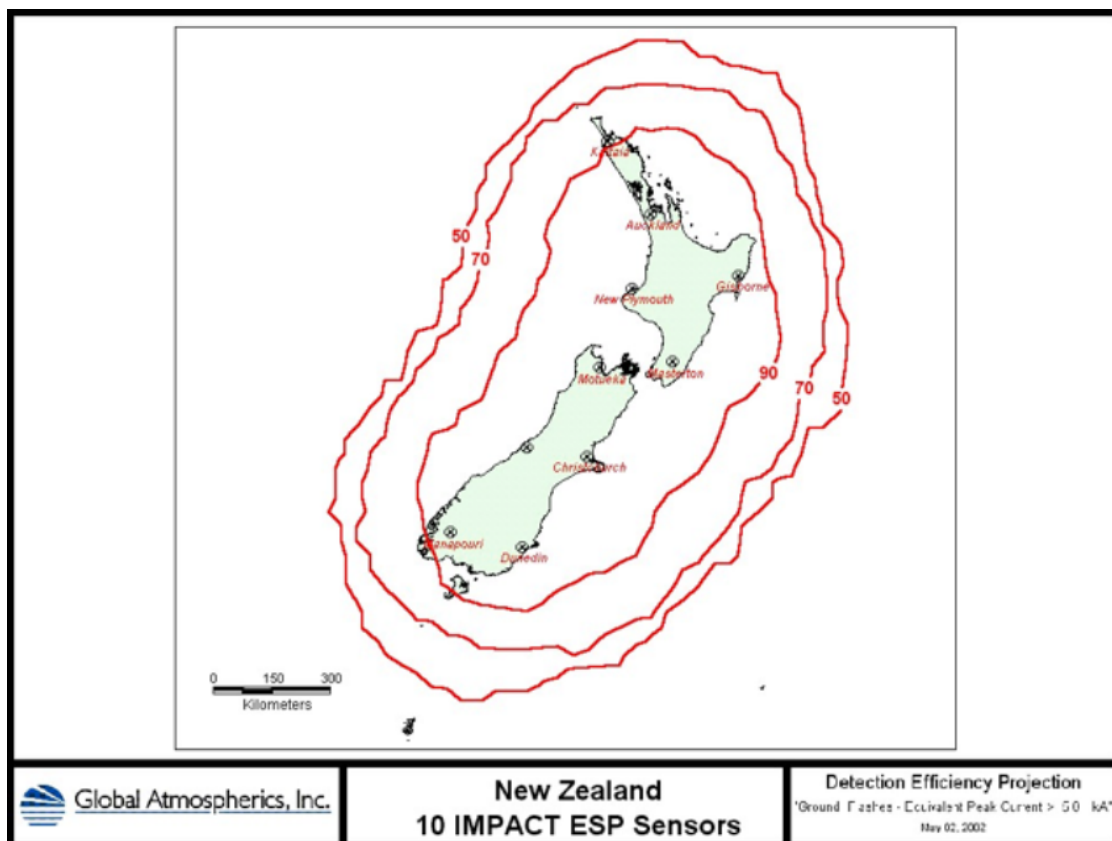
New Zealand LDN Cloud-to-Ground Detection Efficiency Plot

The algorithm implements rules specified in the WMO Manual on Codes FM 15-XIII Ext. METAR, and also the rules and examples in Table A3-2 (Template for METAR and SPECI) of Appendix 3 of ICAO's Annex 3 "Meteorological Service for International Air Navigation". Test suites were developed that the algorithm had to pass.

The algorithm generates and includes present weather reports as follows:

- o The LDN data is scanned for any lightning activity for the period T-10 to T-15.

- o If there are at least two strikes within 21km[5] of the airport in the data period then there is thunderstorm activity to be added.

- o Then if the data period has at least one strike within 8km of the airport, TS and ///CB are added to the report.

- o Otherwise, If the data period has at least one strike within 16km of the airport (but not within 8km) VCTS and ///CB are added to the report.

- o Otherwise, If neither of the previous two cases occurred, but there was TS reported in the previous METAR AUTO report (20-35 minutes ago), RETS is indicated.

- o If the LDN network data is not available or there are any errors or delays or other problems in the system then the text "TS STATUS NOT AVBL" is indicated in the METAR AUTO remarks.

- o If either the present weather field or the RMK were changed by the algorithm, then the METAR AUTO is written back to the database.

- ✓ **Forecaster Vetting of Automated Reports Including SHRA and VCSH Augmentation and CAVOK in TAFs**

MetService has implemented a process of aviation forecaster manual vetting and augmenting where forecasters review, and if necessary edit, all international airport METAR AUTO prior to issue.

During vetting the aviation forecaster is considering the METAR AUTO content (including automatic data augmentations), the automatically added TREND, and other information sources, including the prevailing weather situation, LDN, radar, satellite and, webcam imagery, and any ATIS reports available from ATC. Where necessary, the METAR AUTO and/or the TREND is manually edited and corrected.

Forecasters do not append remarks intended for external customers to the METAR AUTO as these are automatically stripped off when the reports are sent out to international customers and users - remarks can be added for internal MetService distribution.

Full detail on the supplementary data sources available to the Aviation Forecaster is as follows:

- o Web Camera at All Sites

   Each international airport has three web cams installed at the AWS site – one looking each way along the main runway(s) and the third looking across the main runway(s) between the other two cameras, so that an approximate 270 degree panorama is available. Near Live imagery (4 minute updates) from the webcams is displayed on the forecasters' workstations.

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[5] The extended 21km is used to ensure single lightning strikes within 8 and/or 16km are corroborated with further strikes in the general area of the airport and enable single, possibly erroneous, strikes to be excluded.

Panorama Style Webcam images from Auckland International Airport

o   ATC Generated ATIS where Available

Manual ATIS reports from ATC staff (Airways Corporation) include information on routine and significant weather conditions.

o   Radar Imagery

High resolution Radar imagery, updated every 7.5 minutes contribute significantly to forecasters' situational awareness and support the forecaster vetting and verification process. Imagery is available as individual radar plots (including airport-centric plots) as well as national and regional multi-radar composites.

Although none of the weather radars are located at the international airports, 8 and 16km airport-centric range ring overlays are available on certain radar views to assist the forecaster with identifying the location of precipitation and thunderstorm events relative to the airports.
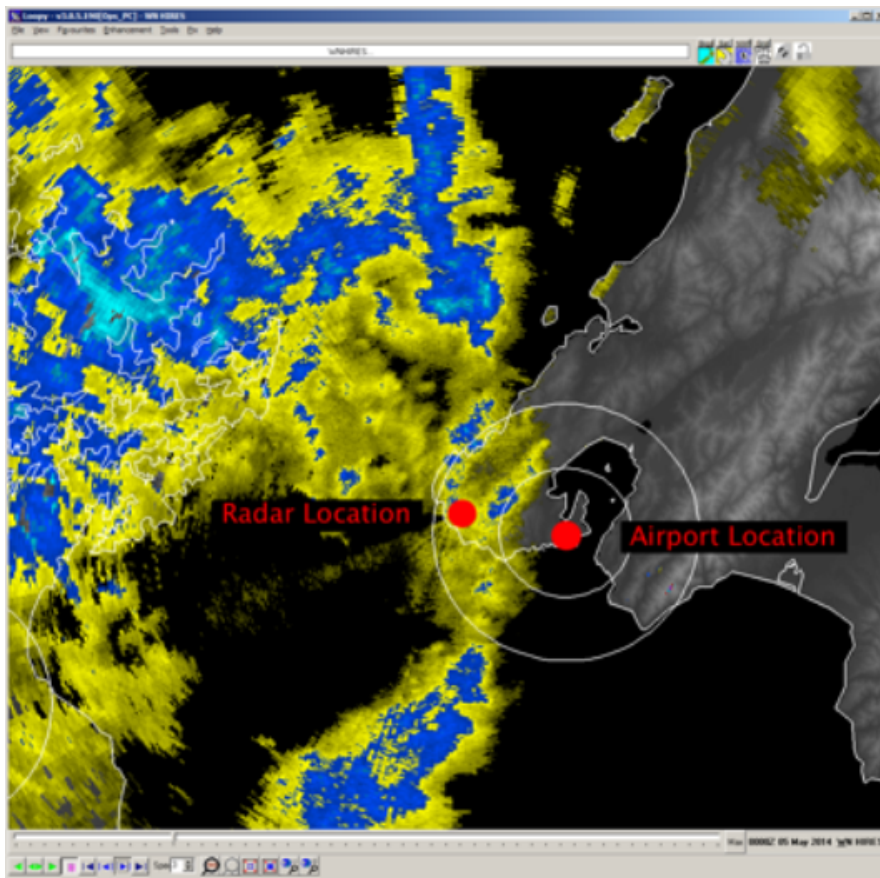
Radar Range Ring Example Indicating likely VCSH

- o Satellite Imagery

  Normally-available high resolution satellite imagery contributes significantly to forecasters' situational awareness and support the forecaster vetting process.

- o LDN Strike Maps

  In addition to the automatic thunderstorm data being added to the METAR AUTO, there is access to full New Zealand coverage Cloud-to-Ground and Inter-Cloud time lapse imagery that is updated in real time.

System and Forecaster Vetting Timing

T-10   TS, VCTS, RETS and ///CB are generated from LDN data in readiness.

T-8   AWS created METAR AUTO is available.

T-5   Fully augmented METAR AUTO available to the forecaster (including RVR, Thunderstorms, TREND)

T-5   Forecaster alert generated

T+5   If the forecaster hasn't released the METAR AUTO then the unedited report is queued ready for sending

T+7   METAR AUTO distributed via GTS and to customers

Forecaster Vetting Guidelines

The following types of changes (typical examples shown) may be made to the draft METAR AUTO under forecaster discretion:

//   should never be issued as a present weather report. i.e. any report with // for present weather should be investigated and forecasters will decide whether a present weather term should be added (see below) or the // removed when there is no significant present weather to report.

SHRA   is added if a shower of rain is within the 8km range ring and the AWS has not already included it.

VCSH   is added if a shower of rain is within the 16km range and the AWS has not already included it.

NSC   is used to replace all cloud groups if all cloud base are above 10,000ft regardless of the layer extent.

RESH   is added if a recent shower of rain has occurred at the station but the AWS has not already included it.

///CB   group is added automatically when detected by the LDN algorithm. If CB are present but not added by the automatic (TS) process then add them with the coded cloud base or as ///CB if the base is indeterminate.

TCU   will always need to be added manually when detected.

Other   items such as visibility obscuration, precipitation intensities and types, and in fact any present weather phenomena that can be seen using the web cameras is to be added as required.

CAVOK   may be used to replace visibility, present weather and cloud when:

  Visibility is 10km or greater (or coded as 9999) AND

  There is no significant present weather AND

There is no significant cloud. i.e. no cloud at or below: 5000ft for NZAA; 6500ft for NZWN; 7000ft for NZCH, AND there is no CB or TCU at any height.

✓ **Performance Monitoring and Reporting**

MetService maintains, through regular quality systems activity and external audits, full ISO9000 certification and CAA Rule Part 174 Exposition, and all systems within MetService are operated within this regime. MetService's normal network operations include the following monitoring and performance reporting:

Performance monitoring AWS delivery performance statistics (along with weather radar) are long established MetService corporate Key Performance Indicators (KPI) that are reported monthly to our directors, the Minister of Transport and other stakeholders e.g. CAA.

Network Monitoring All MetService data collection systems (AWS, LDN, Radar, Satellite imagery reception, third party data sources), central processing, and delivery systems are supported via a 24 hour helpdesk which directs fault reports to on-call information systems and data collection systems support teams. Information systems experts are on 24/7 callout to respond to critical faults (including METAR AUTO production) and the data collection systems team is on call 0700-1700 daily to attend to AWS, radar, LDN and satellite receiver faults. Any missing RVR or ATIS information is reported to the Airways Corporation technical help desk.

Calibration The minimum requirement for all AWS sensors is an annual in-situ spot check of each sensor data parameter against a travelling calibration reference (an inspector's instrument). For critical measurements sensors are returned to the calibration laboratory for multi-point calibrations under a fully controlled environment. All calibrations and checks are documented and are traceable to international reference standards.

Preventative Maintenance Rigorous data collection station maintenance are in place to ensure the stations operate reliably and that critical measurements are traceable to international reference standards. For critical measurement sites e.g. aviation and reference climatology, the station is visited annually.

For the international airport METAR AUTO implementation MetService has put in place additional monitoring and performance reporting to ensure all performance criteria are maintained. The following were added to MetService's systems:

CAA has performed an unannounced spot audit (and may do so at any time in the future) on the system to ensure that all procedures are being followed.

All changes made by forecasters to any international airport METAR AUTO are recorded in a log that is regularly reviewed to ensure the system is performing to expectations, that work loads are manageable, and to identify areas for improvement.

Monthly reporting of delivery statistics are created, graphed, and reported to the CAA.

Summary of Data Sources and Processing

Automatically generated:

AWS-A	1 minute data (diverse communications)
	METAR AUTO every 30 minutes by email
AWS-B	1 minute data (with diverse communications)
	METAR AUTO every 30 minutes by email
LDN	TS, VCTS, RETS, ///CB using range rings
RVR	NZAA only - Three runway sensors - data at 15 second intervals
TREND	Automated forecast

For Forecaster Review as part of Vetting:

ATIS	ATC staff manual reports that include weather conditions
Radar	High resolution Doppler, 7.5 minute image interval
Satellite	Standard MTSAT and NOAA imagery
WebCamera	4 minute image interval, Daylight & Infrared, each cameras 90˚h x 67˚v
	3 cameras - mosaic view 260˚h x 67˚v (1024h x 768v pixels - XGA)

Data Flow Path:

International Airport AWS-A
1 minute data channel 1 ⟶
1 minute data channel 2 ⟶
T-8 30 minute METAR ⟶

International Airport AWS-B
1 minute data channel 1 ⟶
1 minute data channel 2 ⟶
T-8 30 minute METAR ⟶

~2000ft winds
1 minute data ⟶

RVR (NZAA: 23L, MID, 05R)
3 sensors: 15 seconds ⟶

Lightning Detection Network
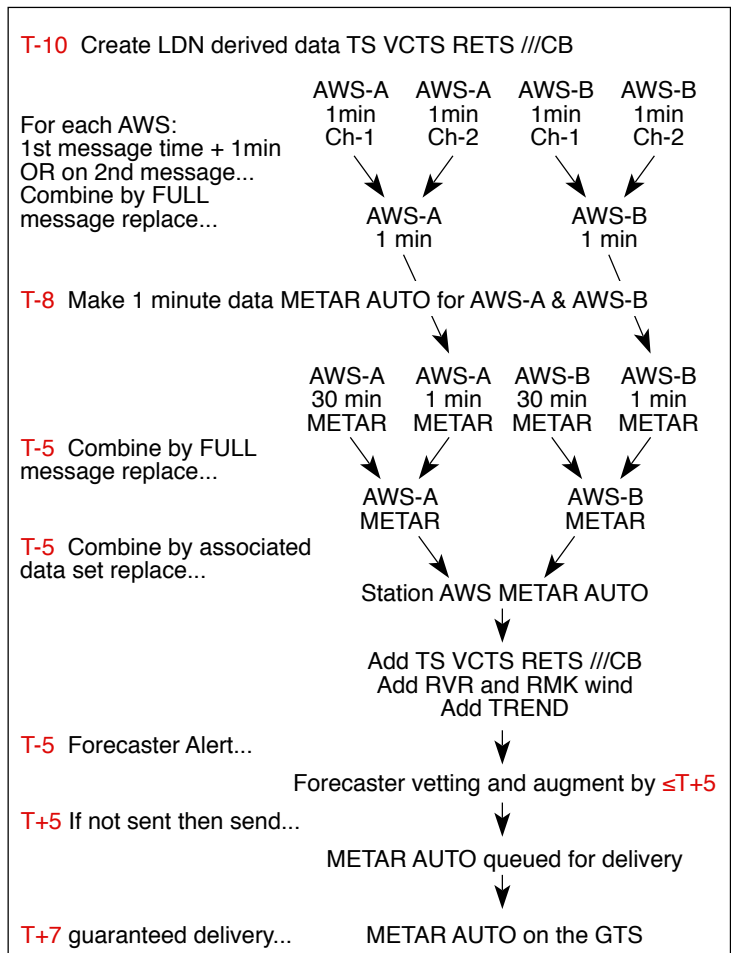Real time: 10 sites ⟶

Manual Reports (ATIS)
Manual: T-10 to T+0 ⟶

Web Cameras
Image file: 4 minutes ⟶

Weather Radar
Image file: 7.5 minutes ⟶

T+0 means hh:00, hh:30

T-10 Create LDN derived data TS VCTS RETS ///CB

AWS-A 1min Ch-1	AWS-A 1min Ch-2	AWS-B 1min Ch-1	AWS-B 1min Ch-2

For each AWS:
1st message time + 1min
OR on 2nd message...
Combine by FULL
message replace...

AWS-A 1 min   AWS-B 1 min

T-8 Make 1 minute data METAR AUTO for AWS-A & AWS-B

AWS-A 30 min METAR	AWS-A 1 min METAR	AWS-B 30 min METAR	AWS-B 1 min METAR

T-5 Combine by FULL message replace...

AWS-A METAR   AWS-B METAR

T-5 Combine by associated data set replace...

Station AWS METAR AUTO

Add TS VCTS RETS ///CB
Add RVR and RMK wind
Add TREND

T-5 Forecaster Alert...

Forecaster vetting and augment by ≤T+5

T+5 If not sent then send...

METAR AUTO queued for delivery

T+7 guaranteed delivery...   METAR AUTO on the GTS

Future plans

To future proof the METAR AUTO system and provide the ability to create more accurate and higher valued forecaster vetting the following are planned:

Fish Eye Web Camera Implementation of a higher resolution web camera with a fish eye lens is nearing roll-out. The full fish-eye view is not planned to be used but rather a crop and zoom is being used to provide imaged comparative to the previous camera style images as this is more palatable for human interpretation. The end result is a slightly distorted view of 170˚h x 80˚v (1547h x 768v pixels - QXGA) with the same angular (degrees/pixel) resolution as the older style camera view.

New Fish-Eye Style Webcam Image *(blue line indicates previous camera view)*

LDN Network Upgrade with new sensors and processors to provide much higher detection efficiencies and greater location accuracy is currently in the planning phase.

Alternate Forecast Centre To address the very low risk of METAR AUTO production being disrupted by a central forecast office outage, AWS will email METAR AUTO reports to the MetService unmanned backup forecast centre.

Central Operations Resilience MetService operates a hardened data centre its head office and is continually improving its central processing resilience by replacing legacy systems with modern solutions. MetService has an established and operationally tested backup forecasting facility located in a secure commercial data centre over 100km from its head office. This facility is not staffed but provides a location for relocated staff to continue providing essential services in the rare event that MetService head office is inoperable.

Possible areas for further future research and development towards enhancing the METAR AUTO system include:

- Automatic augmentation of METAR AUTO with present weather precipitation derived from radar data.

- Establishment of a staffed full time MetService backup data and forecast centre.

- Parallel delivery of all AWS 1 minute data, via Teleco networking independent of MetService operations, to the MetService backup data and forecast centre.

- Operation of a real-time in parallel LDN central processing server at another data centre.

End