The Evolution in Aviation Forecasting in Canada (1995-2012)

Introduction[1]

The two Canadian Meteorological Aviation Centres based in Montréal and Edmonton recently celebrated their 20th anniversary. Under an agreement between Environment Canada and NAV CANADA, they supply a variety of aviation weather info supporting the safe and efficient movement of air traffic across Canada.

Many of today's staff in the Meteorological Service of Canada, in NAV CANADA, and in air carrier operations don't know how and why they were created.

This is an overview of the evolution (nay, revolution) of aviation forecasting in Canada from the mid-1990s through 2012. That was a period of significant change, driven by a reduction in funding from the federal government (including Environment Canada) and the creation of NAV CANADA (spun off from Transport Canada in 1996). It's a tale of challenges, upheaval, uncertainty, vision, ingenuity… and success.

People have asked me why I wrote this and who the target audience is. It's partially for me, to remind myself that I was part of and helped lead a huge change. It's for colleagues with whom I worked and for staff who went through it so they too can remember the role that they played (these events happened between 15-30 years ago, and many of the people who were part of have since retired). Finally, it's for current managers and staff for them to see what can be done when one is presented with a challenge and has a vision.

Let's begin…

Steve Ricketts
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[1] This document is based on my experience as the Manager of the Northern Alberta Environmental Services Centre (NAEnSC) in 1995, of the Prairie Aviation and Arctic Weather Centre (PAAWC) in 1998, of Prediction, Prairie and Northern Region (PNR) in 2004 and then as the Lead, Aviation Weather Services in 2006 before retiring in 2012. It has a focus on PNR and on civilian aviation services, not military aviation. I am open to adding information covering other units and regions. Please email them to me: stevericketts1@gmail.com

Background

There is a lot of detail here but it's useful to help understand how the Meteorological Service of Canada adapted to address NAV CANADA's needs. Thanks to Ken Macdonald who supplied much of the information.

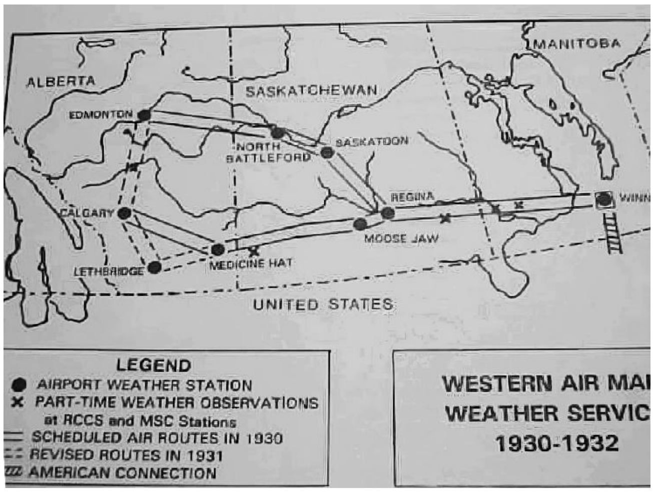


Figure 1 from Morley Thomas's excellent book "Forecasts for Flying: Meteorology in Canada 1918-1939"

The Meteorological Service of Canada (MSC) was created in 1871, partially in response to marine tragedies on the Great Lakes. The 1920s and 30s saw a huge growth in aviation, esp. in western Canada, and which necessitated weather services (i.e. observations, forecasts, briefings to support it). In 1938, the MSC was merged into the new Department of Transport as the Meteorological Branch.

In 1971, a new department—Environment Canada (EC)—was formed. Within it, the Atmospheric Environment Service (AES) assumed responsibility for the provision of public and marine forecasts (and warnings). However, under the Aeronautics Act, responsibility for aviation weather remained with the Minister of Transport. Transport Canada (TC) and EC entered into an interdepartmental arrangement that entailed both the sharing of some activities (e.g. weather observations and briefing services) and the cost recovery of other activities (aviation weather forecasting).

The AES operated a network of approximately 65 weather offices and weather stations; the latter were staffed by weather observers who took weather observations, recorded weather info on automated telephone answering systems, did media interviews, answered calls from the public, while the former were staffed by presentation technicians who also did aviation weather briefings.

TC ran a network of Flight Service Stations (FSS) that were responsible for aviation weather briefings and local communication with pilots, and taking weather observations. The cooperation part of the arrangement between TC and EC was that the departments (at a regional level) negotiated how the observation and briefing programs were run. At some locations, the EC staff provided services for part of the day and FSS did at other times (usually during the quiet hours).

In conformance with International Civil Aviation Organization (ICAO) Annex 3 and MANAIR (a domestic standard maintained by TC), the AES issued a suite of aviation forecasts, including WVs (volcanic ash advisories), FDs (upper wind forecasts), and charts from the Canadian Meteorological Centre (CMC); and FTs and TAFs (forecasts for aerodromes), FAs (area forecasts), AIRMETs (revisions to the FA), and SIGMETs (warnings of severe phenomena affecting aviation) from regional weather centres.

In 1990, there were nine regional weather centres: Vancouver, Whitehorse, two in Edmonton, Winnipeg, Toronto, Montréal, Halifax, and Gander. Some centres ran a 'blended' forecast program in which two or more forecasters looked after all forecasts (including aviation) for a given area. But in most centres, there were separate desks for public, marine and aviation forecasts covering a larger area. Meteorologists didn't specialize in aviation weather, and in some centres the aviation desks were generally staffed by junior and less experienced meteorologists (the public weather forecast program was seen as more important and requiring more experience).

Aviation users (both the air carriers and general aviation) were unhappy. Aviation products were not coordinated between the centres, thus there were major discontinuities at the borders which users had to try to resolve. There was an inability to introduce new services quickly and in a coordinated fashion. Forecasters largely operated in isolation from the end users: there was little contact with the air carriers or briefing centres, and forecasters, despite their desire to produce high-quality forecasts, had little awareness of users' needs and how their forecasts were interpreted. There was little aviation-related training or development for meteorologists.

Weather Service Office (WSO) Concept (late 1980s, early 1990s)

The early 1990s saw the implementation of the AES' Weather Service Office (WSO) Concept, based on the AES's Strategic Plan developed in 1987. This was a major initiative that had been carefully developed over several years and that entailed a restructuring of the AES' network of weather centres and offices, based on advances in technology. The key objective for the transformation was to go from a 3-level system (CMC, regional weather centres, and weather offices and stations) to a 2-level system (CMC, WSOs) with the WSOs assuming both the forecasting and service delivery functions.

The nine weather centres were to be decentralized to 25-ish WSOs, along with the closure of all weather offices and weather stations. The WSOs would do public/marine/aviation forecasting, handle media needs, respond to calls from the public info, and conduct outreach for a smaller area.

Starting in late 1993, the first WSOs opened in Kelowna, Saskatoon, and Thunder Bay.

Concurrent with that change (and required to enable it) was the automation of weather observations funded by EC (it was left for TC to decide if it wanted human observations to continue at airports). Technology was emerging that provided the capability to automate the sampling of weather observation parameters, with dataloggers providing the capacity to process and format the raw signal data into traditional weather observations. In the 1980s, pressure/temperature/wind observations were being made available by systems, and the AES developed an automated system: the Remote Environmental Automatic Data Acquisition Concept (READAC) station that included visibility and cloud height/ceiling information and with the intent to eventually develop the capability to automate the production of full aviation weather observations.

Program Review (1994)

In Feb 1994, the Government of Canada announced its "Program Review" initiative which entailed government-wide reductions in funding and a refocusing of its services. Strategic planning sessions were held to determine the impact on departments and what their priorities would be. Details were released in July 1994.

For the AES, this meant a significant reduction in funding, on the order of 30-40%, which had an immediate impact on the number and staffing levels of the WSOs. The WSO plan was accelerated and rescoped to fewer offices to handle the financial pressures. There was a push to commercialize some weather services such as telephone consultation to raise revenue to offset these reductions; this was the first foray into commercial services for the AES.

The schedule to automate weather observations, including those at airports, was also accelerated. The READAC system had evolved into the Automated Weather Observing System (AWOS) which was certified to produce a full aviation weather observation including cloud layers and heights, ceiling height, visibility, precipitation type and intensity, pressure, temperature, humidity, wind direction and speed and altimeter setting. In 1996, the first aviation AWOS stations were commissioned in airports across the country replacing the human-produced observations, including at Dorval airport in Montreal.

January 1995: the Calgary WSO, labelled the Southern Alberta Environmental Services Centre (SAEnSC) became operational, with the Alberta Weather Centre (AlWC) in Edmonton becoming the NAEnSC.

By early 1995 there were 17 WSOs: in alphabetical order, Calgary, Edmonton (two), Fredericton, Gander, Halifax, Kelowna, Montréal, Ottawa, Quebec City, Rimouski, Saskatoon, Thunder Bay, Toronto, Vancouver, Whitehorse, and Winnipeg.

Other changes

There were significant changes in the relationship with TC between 1993 and 1995. Most important was the move to a business model for the services; that is, rather than TC paying EC lump sums of salary and O&M, a model of costed individual services was introduced, e.g. a price for each FT. This change later became useful for EC moving to a commercial contract with NAV CANADA.

> *January 1995: FTs for major aerodromes were updated every three hours.*
>
> *Prior to 1996, the AES had produced FTs for every aerodrome that TC defined a need for and then translated the ones for international airports into TAF format, the international (ICAO) standard. In 1996, Canada and the US adopted the international standards (TAF and METAR) for all aerodromes after both code formats were extensively modified by ICAO.*

Creation of NAV CANADA (1996)

The major air carriers pushed for changes to the Air Navigation Service (ANS) as they were frustrated by having little say in how TC ran it. In Nov 1996, under the *Civil Air Navigation Services Commercialization Act (CANSCA),* the Government of Canada (GoC) sold the Canadian ANS (lock, stock and barrel) to a new entity, NAV CANADA (NC) for $1.5B. NC became the private, non-share capital corporation responsible for the Air Navigation Service in Canada, including the provision of aviation weather services (observations, forecasts, briefings). TC retained its role as the regulatory body. This was the first example of a country privatizing its ANS. NC would fund its services by collecting user fees, mostly from air carriers.

One requirement of NC's creation under the CANSCA was to continue to provide air navigation services, include aviation weather services, as they had been provided by TC prior to the transfer; thus NC created five-year agreements with several GoC departments for services, including with EC for aviation forecasts, data feeds, weather observations, and equipment maintenance. Any subsequent changes to the provision and type of services would have to go through a user consultation process (an "Aeronautical Review").[2]

NC senior executives mostly came from the private sector and harboured an inherent distrust of government; they viewed it as inherently inefficient (and thus they believed that cost saving efficiencies could be found), and they also believed that it was slow to respond to user needs. They demanded more transparency regarding how its funding was being used.

The AES desired to stay involved in aviation weather activities because of synergies with its publicly funded weather programs (e.g. in weather observing, forecast operations, weather science and modelling, training, software), and because it saw that its forecasts would contribute to the safety of the flying public.

In setting up the initial five-year agreement, the AES had done a rough analysis of its costs. These included the direct costs of forecasting (e.g. the number of forecasters engaged in aviation forecasting, IT staff supporting their operation, furniture, software, travel, office supplies) and also indirect costs (e.g. HR support, finance support, accommodation, ab initio training for new meteorologists). It also included the "as-is-where-is" aviation weather observations, i.e. the provision and maintenance of observation equipment and the training of observers, performance measurement of forecasts, data feeds, and the licensing of software used in NAV CANADA operations. It was based on the incremental cost required to support aviation weather efforts (i.e. tapping a fully funded and functioning public weather program), not on a sharing of the total cost.

The total value of the services was determined to be on the order of $26M. NC accepted this analysis, but to reflect its desire for the AES to find cost efficiencies, the parties agreed to a $1M per year reduction in the value of the 5-year contract for years 2 through 5.

> NAV CANADA's challenge to us: "*how do we fit into NC's vision of being a world-class supplier of ANS?*"

While senior managers within AES viewed the relationship with NC as collaborative, NC senior managers saw it strictly as a business one (i.e. client-supplier). NC was committed to reducing its user fees and to provide improved services to its clients to help them reduce their operating costs. NC made it clear to EC that it was expecting to see changes or else it would seek other solutions for aviation weather services.

A few NC managers wanted to see the AES pay more attention paid to aviation, as they knew about its users' dissatisfaction with the quality of aviation forecasts. The AES wanted to demonstrate that

[2] In the following years, NC took over all or outsourced all these services but the ones with EC

it could do a better job of aviation weather and be a trusted service provider. This led to interesting discussions at times.

NC consulted with its users and involved them in decision-making. They used a business case analysis to make decisions and would invest in an initiative if it felt confident of a return on its investment.

Responding to the NAV CANADA challenge

Clearly, the AES had to review its aviation services, including forecasting. At least the challenge was well defined, as we had a single client—NAV CANADA—which in turn represented its clients (the end users... air carriers, general aviation) to understand their needs and priorities, and turned to us to address them.

Soon after the agreement was signed, the AES created the Aviation Weather Management Board (AWMB) comprising directors that provided internal governance for the program, and the NAV CANADA Account Team (NCAT) comprising managers directly involved in delivering a portion of the aviation weather services, to coordinate the delivery of services. As the AES' regions held much of the line authority; i.e. how to set up units and people to deliver services, there was a Client Services and Market Management Unit, based in Ottawa, whose role was in financial planning and reporting, liaising with NC, and coordinating efforts across the AES. The Client Services Unit (staffed over the years by Joanne St-Coeur, Mike Crowe, Mario Ouellet, Peter Kimbell, Joanne Lancaster, Ron Huibers, Merv Jamieson, Daniel Chrétien, Gilles Ratté, and others) played a pivotal role in managing the relationship with NAV CANADA.

For forecasting issues, we worked closely with John Foottit, NC's Manager, Aviation Weather Services.

He was careful not to tell us how we should run our business (e.g. the number and locations of forecast centres, which software tools to use); he focused on results.

John was truly appreciative of our staff's efforts to address his needs and emphasized that the forecaster's role should not be just to supply weather info, but to be part of the team (including ANS and air carrier operations centres and airport authorities).

John Foottit to staff: "*You're part of the ANS! How safely/efficiently is the ANS going to run today?*"

As he would say: "*Busted" forecasts cause broken plans, increased costs, and lost revenue - the frustration of users is understandable*," and he would often tell us that we needed to manage aviation forecast production in a business-like fashion so that accuracy gradually improved.

For several years, we had a meteorologist seconded to NC. Mario Ouellet (1998-2000) was the first, followed by Joanne Lancaster (Volk) (2000-04), who took a leave of absence and briefly became a

NAV CANADA employee, and then by Daniel Chrétien (2004-07). This position helped to bridge the gap between the two organizations, ensuring that meteorological aspects were being considered in NC's planning, and representing MSC's capabilities. The AES also had a meteorologist seconded to TC (Joanne St-Coeur and Bill Maynard) who played a similar role. These were good developmental opportunities for staff.

After Daniel's secondment ended, we couldn't find anyone interested and whom NC found suitable. This had a negative impact on the working relationship.

Rather than funding R&D as an overhead cost, NC's preference was to fund initiatives on a project-by-project basis by developing a business case, and it expected that any investment would be recouped in the following years via a reduction in costs. This was a challenging process for the MSC as it could not easily borrow money upfront and recoup its costs down the road.

Changes in forecasting

To improve its services and retain the NC contract, the AES initiated discussions at the regional level on consolidating regional aviation forecasting into fewer WSOs rather than having every WSO with a small aviation forecasting responsibility.

July 1996: Kent Johnson, manager of the Mountain Weather Services Office (MWSO) in Kelowna, shared a paper titled "Pacific and Yukon Region Aviation Weather Forecast Unit." In it, he wrote "*In order to remain competitive and client-focused in the field of aviation meteorology, Environment Canada must make significant changes to the manner in which aviation forecasts are delivered*. *One means of accomplishing this is through the creation of aviation weather forecast units, staffed with specialists in aviation meteorology*." This is the first instance that I can recall of such an idea being floated.

October 1996: all aviation forecast production for the southern 2/3rds of BC was consolidated in Kelowna at the MWSO, and it created a dedicated aviation desk. This was the first consolidation of aviation forecasting. Other WSOs had aviation desks, but the MWSO also implemented an enhanced focus on aviation, did training in aviation weather and conducted outreach to aviation users and at NC facilities. It started producing a Visual Flight Rules (VFR) Route Forecast for a few popular VFR flight routes through the BC interior.

1996: the MWSO, utilizing Transport Canada's Search and Rescue New Initiatives Fund (SAR-NIF), produced a manual titled "Aviation Weather Hazards of BC and Yukon". Users found it useful.

February 1997: I shared a note on a "Prairie Aviation Centre". I said that "*I thought it would be worthwhile to sketch out what the "regional aviation weather centre" would look like and what would be the impact on the current offices and their staffing levels*. *I am not trying to convince everyone that this is a better way of doing things (I am not 100% sure myself) but at least this is something more concrete to debate around.*"

Changes in observing

Meanwhile, dissatisfaction was brewing with the AWOS aviation weather observations. Within a few weeks of installation, the AWOS at Dorval was under extreme scrutiny from NC and airlines alike.

Nobody was happy with the quality of the observations, and it was not long before TC implemented a moratorium on AWOS. AES was forced to return human weather observers to Dorval and other sites, and to backtrack and rethink its roll-out of the AWOS technology.

NAV CANADA was supportive of the implementation of a cost-effective AWOS that would be acceptable to users, and they aggressively pursued ways to make this happen. Leading these efforts was the Aviation AWOS Performance Evaluation Group (AAPEG) which has been formed by TC in 1994 and comprising representatives from NC, AES, TC, employee associations (for AES, ATC, and FSS), and user groups. It was tasked with doing what needed to be done to improve the AWOS performance and gain the acceptance of aviation users and approval of TC.

A formal AWOS Performance Evaluation program was implemented that saw human observers collocated with AWOS at seven sites across the country chosen to represent the widely varying climates across the country for a full year to capture the four seasons. All data were logged and analyzed in side-by-side comparisons to understand where the AWOS performed well, where it didn’t, and how the processing could be improved to come closer to mimicking the human observer.

Program Review II (1997)

August 1997: it became clear the commercial revenue was not enough to replace the reduction in EC’s A-base funding. This meant that more staff reductions would be needed, and that it was becoming less viable to operate 17 WSOs in Canada, including five in PNR.

AES regions took different approaches to handle the reductions. Some regions reduced staffing levels at their WSOs; however, PNR senior managers felt that that approach would lead to centres that would be unsustainable (I.e. lacking a critical mass) and unable to accommodate any further reductions, and thus they looked down the road to where they thought we needed to be. And thus it made the difficult decision to close the recently opened Saskatchewan Environmental Services Centre (SEnSC) in Saskatoon, and to rejig the roles for the remaining centres. It was about implementing a regional Centres of Expertise model.

A small contingent would remain in Saskatoon doing local liaison and commercial services. Most forecasting would be removed from the SAEnSC in Calgary, and it would lead commercialization efforts for the region. All regional aviation forecasting would be done in Edmonton, including for the prairies. The Prairie Storm Prediction Centre (PSPC) would look after public and marine forecasting for the region from two locations: in Winnipeg, looking after the prairies, and in Edmonton, responsible for the Arctic.

Two other regions consolidated aviation forecasting into one centre (Atlantic Region into Gander, and Ontario Region, first into Thunder Bay and then Ottawa) while Québec Region stayed with three centres (Montréal, Québec City, Rimouski) which would have separate aviation desks but be staffed in rotation by all forecasters. Pacific Region had previously consolidated it into two locations (Kelowna and Whitehorse). Thus the number of centres doing aviation forecasting was reduced to seven.

Prairie Aviation and Arctic Weather Centre (1998)

Note: from here on, the paper focusses on Prairie and Northern Region, specifically Edmonton. This is because it's based on personal memory, it's where much of the innovative work began, and I don't know all the details of what transpired in other regions.

Figure 2 Prairie Aviation and Arctic Weather Centre (PAAWC) logo

The Prairie Aviation and Arctic Weather Centre (PAAWC) in Edmonton centre comprised three desks looking after all forecasting for the Arctic and two desks devoted to aviation forecasting for the Prairies. For the first time in AES' history, those desks would be staffed by a separate team of dedicated aviation forecasters.

March 1998: the PAAWC is up and running.

It's important to set the stage for what this entailed as it represented a major shift in operations. Meanwhile, staff morale was extremely low because of the downsizing and closure of centres and many people having to relocate to a different city and/or accept different jobs. The departure of many senior staff resulted in a significant loss of expertise and corporate memory. To address the need to reduce staffing levels, the AES had stopped recruiting new meteorologists. All this at a time when we were implementing huge changes and needed staff to buy into them.

There were no guarantees that the new model for aviation forecasting would work. Nevertheless, I and others felt that we needed to do it to keep the contract with NC.

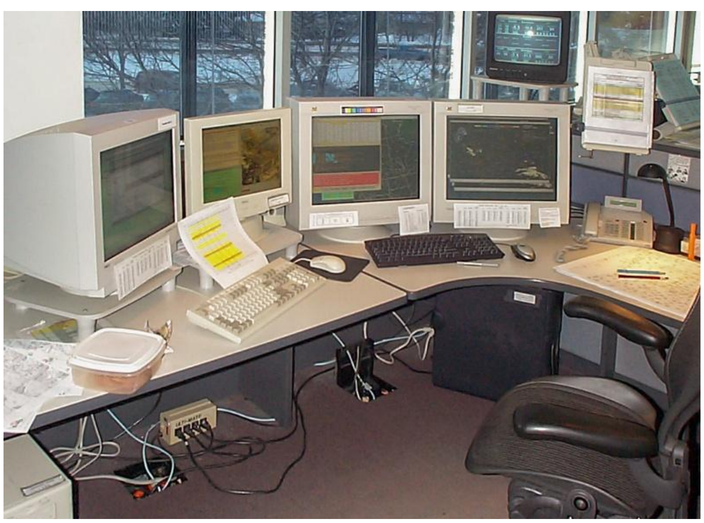


Figure 3 Prairie Aviation and Arctic Weather Centre forecast desk

We needed 12 meteorologists to staff the two prairies aviation desks. I asked for volunteers to make a one-year commitment and said that we'd then accommodate requests to transfer out. We got precisely 12 volunteers. One year later, no one wanted to transfer out, something I would never have predicted. It turned out that they genuinely enjoyed aviation forecasting. Also, public weather forecasting was undergoing a major shift, with the introduction of Scribe (a graphically based tool to modify statistical predictions of individual weather elements that would then generate a plain text product) to produce forecasts, a change that most forecasters disliked.

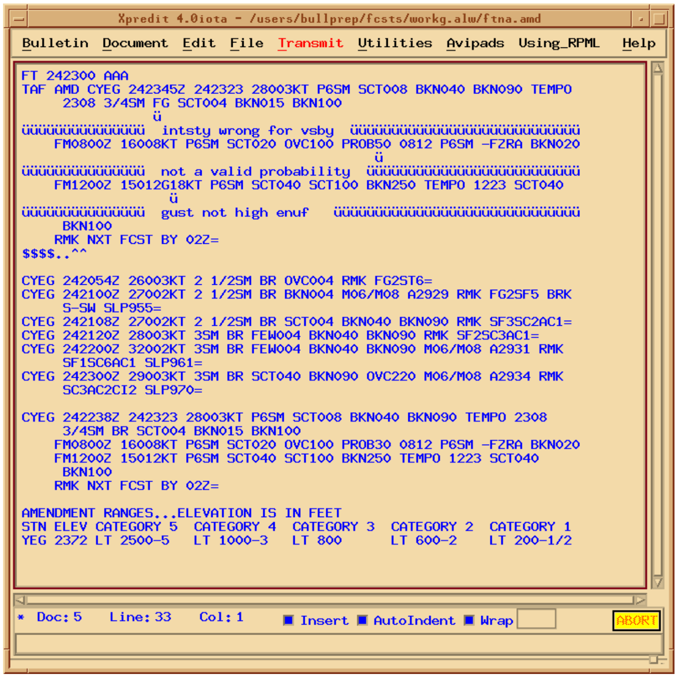


Figure 4 BullPrep

Setting the stage also includes knowing how forecasters worked in 1998. Leading up to the early 1990s, forecasters hand-analysed a surface map on which weather observations were plotted. They used a terminal connected to an HP1000 minicomputer which was limited to displaying alphanumeric text; this was used to access weather observations and bulletins, and to prepare forecasts. There was access to weather satellite, weather radar and lightning data on separate displays. PCs were installed in weather centres around 1993 and David Patrick's BullPrep software was installed on them which made it much easier to produce alphanumeric forecasts.

Through the mid- and late-90s, more capable workstations with graphics capabilities came online, and software was developed to display charts and gridded binary (GriB) data and allowed the forecaster to analyze and explore it; e.g. WADS, RAPID, xTephi, AM, IM, AMX, MetManager. The new Forecast Production Assistant (FPA) and Edigraf tools aided immensely in chart production.

And now throw in Y2K planning, which had a significant impact on resources and led to a freeze in software development.

There were far fewer people doing aviation forecasting for the prairies than in the past as we adjusted staffing levels to reflect NC funding. There had been 3.5 desks in the three prairies EnSCes doing aviation forecasting; in the PAAWC, there were only two. Aviation forecasting, with its six-hour cycle, has a highly variable workload; it is very busy for 2-3 hours leading up to the issuance of TAFs and FAs, then it is much quieter with the forecasters monitoring the weather and issuing amendments as needed. This was hard to accommodate in an aviation-only model.

There was a myriad of info in various formats. Forecasters flipped through reams of paper on the desk, combed through info on their workstations. They desperately needed better software tools to make it easier to monitor and analyse the weather and to produce forecasts; i.e. to compile, sort, filter, and present weather data so that they could more quickly compose forecasts.

And here's where the ingenuity and resourcefulness of staff came into play. There was little funding in the agreement with NC for development activities, so most of this work was done by carving out time from operations to support project time (i.e. done "out of hide") or done during quiet time on the forecast desk.

We needed better software tools to support aviation forecasters. But how could we fit this within the AES's rules and processes? The AES had a formal process to develop and support software, but it was elaborate and lengthy; i.e. not responsive enough. We needed a way to develop, deliver and test prototype solutions within a few months—that is, Rapid Application Development (RAD) or "skunkworks"—and then develop the more formal and approved solution later.

We received approval from the AES' Software Management Board (SMB) to set up separate servers on which to host install software prototypes, with the understanding that they were not supported and thus not guaranteed to always be available, and with the understanding that after one year we would then either decommission these prototypes or go through the formal software development process (using approved tools, coding, documentation) so that they could be installed on operating systems and be supported on a 24/7 basis. We had great support from local IT managers.

With this system in place, staff response to this challenge was wonderful! Creative people developed software to help monitor the weather over a large area, to focus on aviation-specific weather parameters, and to develop reference material. We found that forecasters were very pragmatic and open to change: they were receptive to use tools that made their jobs easier.

Simply put, the PAAWC would not have worked without everyone's efforts. There were many challenges to overcome, but we showed that an aviation-only centre was not only viable but that it could result in an improvement in service. We got favourable reviews from our users (e.g. from NC and end users), and staff liked doing aviation forecasting.

Software tools included:

amalert.. to alert the forecaster to changes in the weather, and also when a TAF has gone bust

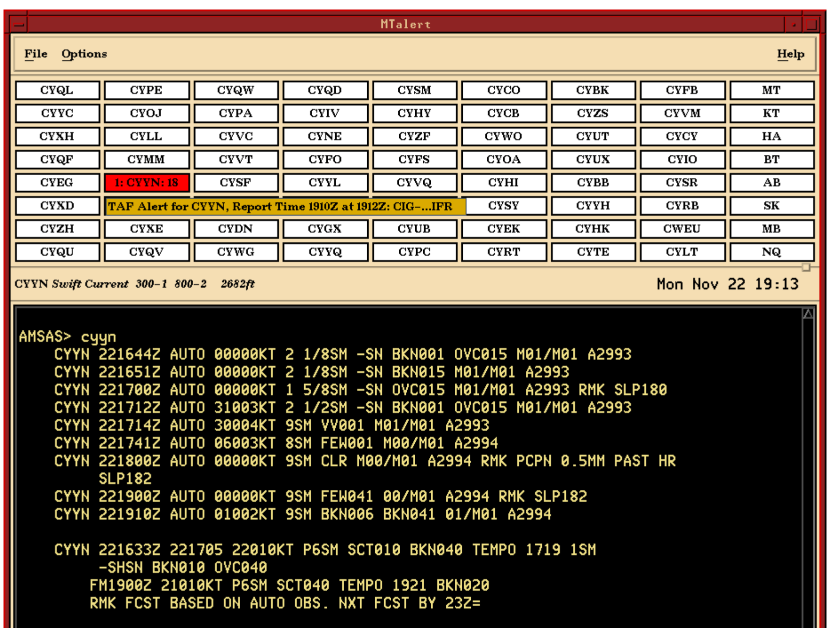


Figure 5 MTalert

MTalert (Jim Murtha)... a graphical interface to amalert and a more effective way to monitor the status of the weather and TAFs at many airports

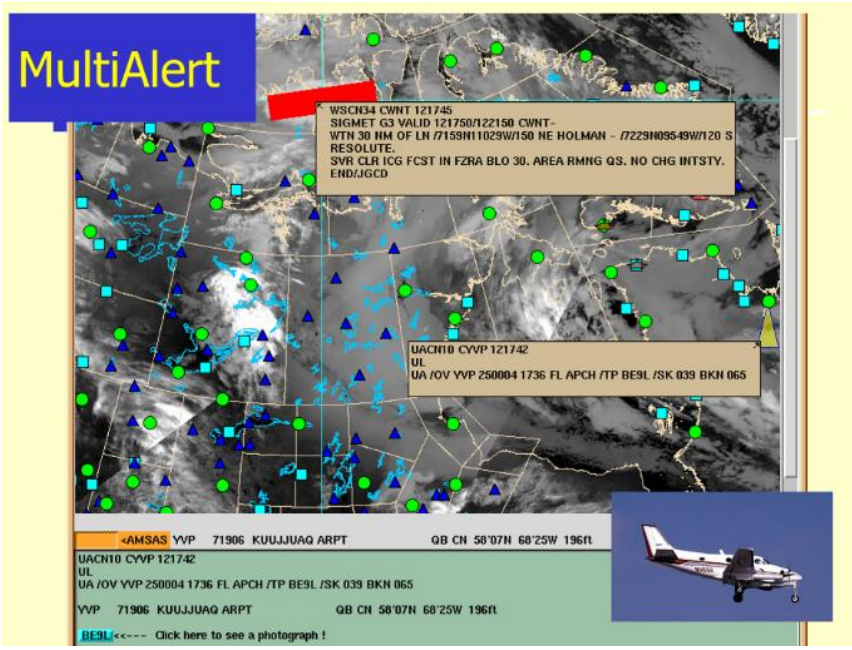


Figure 6 MultiAlert

1998: PIREPAlert (Jack Dunnigan) for maintaining situational awareness, to graphically display and provide access to PIREPs, display tickets from the National Monitoring Desk such as station/radar problems/outages, and which evolved into a more powerful tool (MultiAlert)

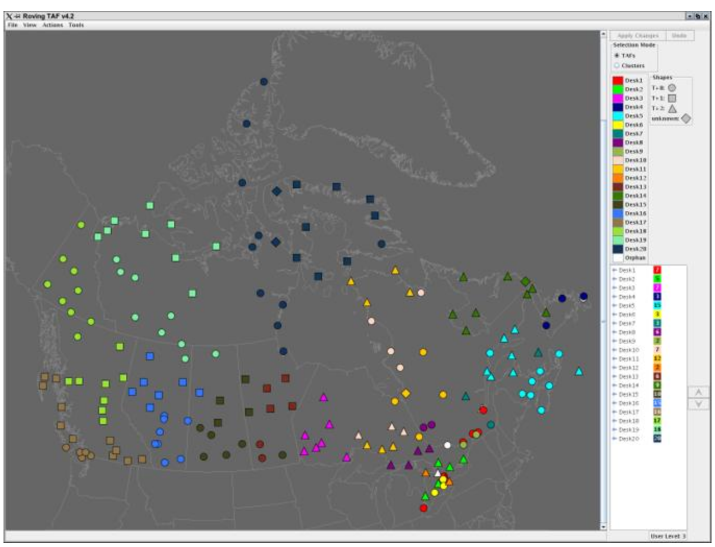


Figure 7 RovingTaf

2002: RovingTaf (Jack Dunnigan)… adjustable desk duties to balance workload.

Edigraf underlays of GRiB data and many other widgets to expedite chart production (Michael Schaffer). CMC was helpful in providing GRiB data to the CMAC, in particular the vertical profiles.

1999: TAFTools… to develop and validate automated forecast guidance products for the weather elements needed in the preparation of TAFs, for eventual use in a “first guess TAF” (FGT) forecast system; e.g. CIG/VSBY guidance.

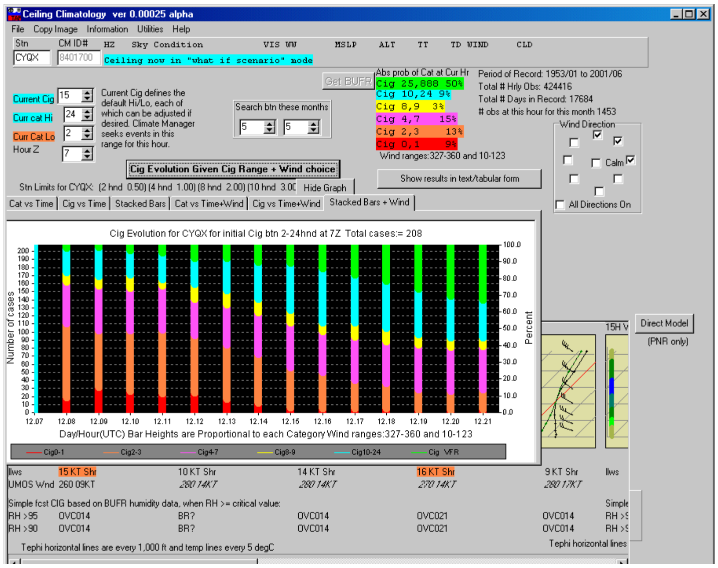


Figure 8 TafAid

2000: TafAid (Alister Ling), for graphically displaying conditional ceiling climatology

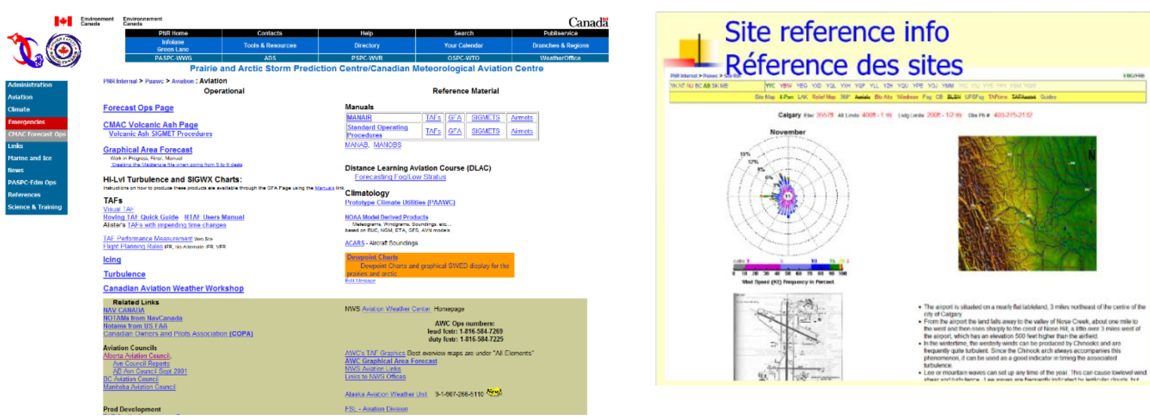


Figure 9/10 : PAAWC intranet

2001: PAAWC intranet (Lisa Scheie[3], Steve Knott). A single website to host relevant information (e.g. reference material, operational material, emergency manuals/plans, news items)

2002: TAF assistant (MtnWC)

[3] Lisa Scheie (now Torneby) was a co-op student who became a meteorologist and now manages CMAC-West

(there were tools developed elsewhere; e.g. Québec Region's Veille (Viateur Turcotte))

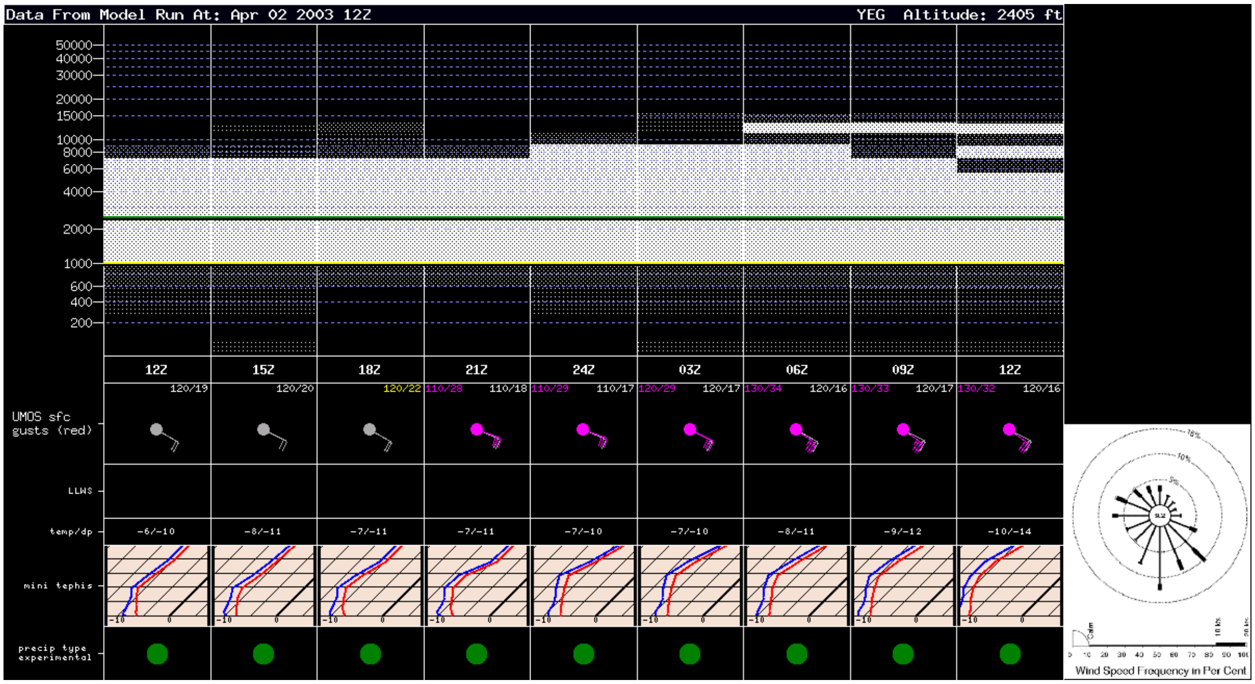


Figure 10 TafTime

While these tools helped operational forecasters deal with increased workload, it was the introduction in 2003 of TafTime (developed by Bruno Larochelle and Steven Laroche, with input from Alister Ling, Steve Knott and others) that presented a quantum lead forward: it was the visualization of GRiB and other data relevant to aviation forecasting as an x-t diagram for TAF sites that helped forecasters to more quickly compose TAFs.

Figure 11 Alberta Aviation Council meeting

The PAAWC started doing more aviation outreach to NC and air carriers.

In the late 1990s, aviation managers from the AES had started attending annual meetings involving aviation companies, provincial aviation councils and users to make presentations on weather and to get feedback on its services. We received puzzled looks when we started doing this, as we had been invisible up until then, but our effort was well received.

Forecasters routinely visited NC's operational facilities such as the Edmonton FSS and Area Control Centre (ACC), and air carrier dispatch operations, and in turn we invited their operational staff to visit our facilities. This increased contact improved the working relationship and user satisfaction with aviation weather services.

TAF Performance Measurement

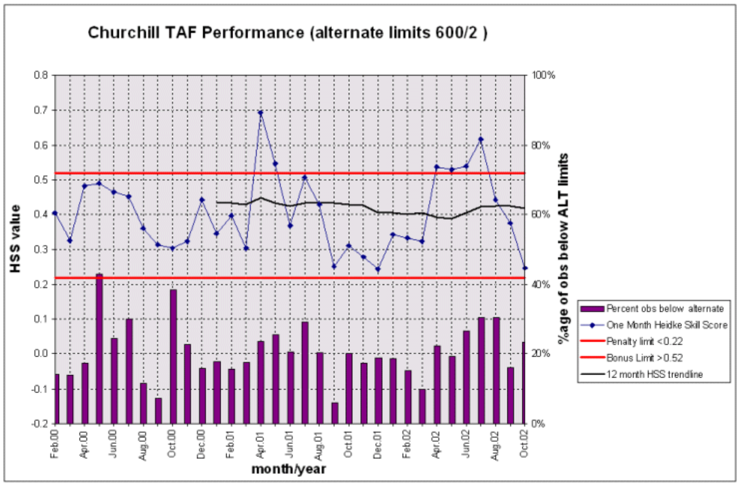


Figure 12 Example of TAF performance measurement output

In1998, the AES implemented a TAF measurement program which measured and tracked aspects of TAF performance, including the on-time delivery of TAFs, the reliability of TAFs for VFR weather and for Instrument Flight Rules (IFR) alternate weather, the false alarm ratio for below alternate IFR weather, and TAF amendment response time

This was one of the first such systems in the world. It included penalties/rewards based on quality. The amounts were small, but it was the principle that mattered; i.e. forecasters knowing that people were paying attention to the quality of their work.

The AES became the Meteorological Service of Canada (MSC) in 1999[4].

Graphic Area Forecast (1999)

The AES and TC had for years contemplated moving from a textual FA to a graphical (chart) version, the Graphic Area Forecast (GFA), something that would be much easier for users to understand and use. There were some trials held, but they never resulted in a decision to move forward.

This is an example of how NC works: once it heard that the users liked the idea, it pushed the MSC to put together a plan for a GFA. There were additional trials in 1998, but progress remained slow, and NC grew impatient.

February 1999: a national meeting of aviation managers (client services, forecast centres, IT, CMC, and Meteorological Research Branch (MRB), standards) was convened in the basement of a hotel in Ottawa. Ken Macdonald, the Chief of Client Services and Market Management was blunt: NC had declared that it wanted to see a GFA and that we need to come up with a plan to implement it by the end of the year or else "*we can kiss the contract goodbye.*" (Note: Ken is very polite and soft-spoken and doesn't talk like this, but this is what I recall him saying.)

So, eleven months to deliver a completely new product, in the midst of Y2K planning and no existing product elsewhere in the world to emulate. We needed to develop a standard for the GFA, create software to produce it, conduct training for forecasters and end users, and ensure that NC could handle it. Daunting. Nevertheless, we accepted the challenge—we had no choice—and work commenced immediately.

[4] It's interesting that we returned to the name that was used between 1871 and 1936.

We had to develop a process to get input for the GFA from all seven centres involved in aviation forecasting and then merge it. The final product needed to be seamless; i.e. no discontinuities at borders. This required close coordination between the centres during the GFA production.

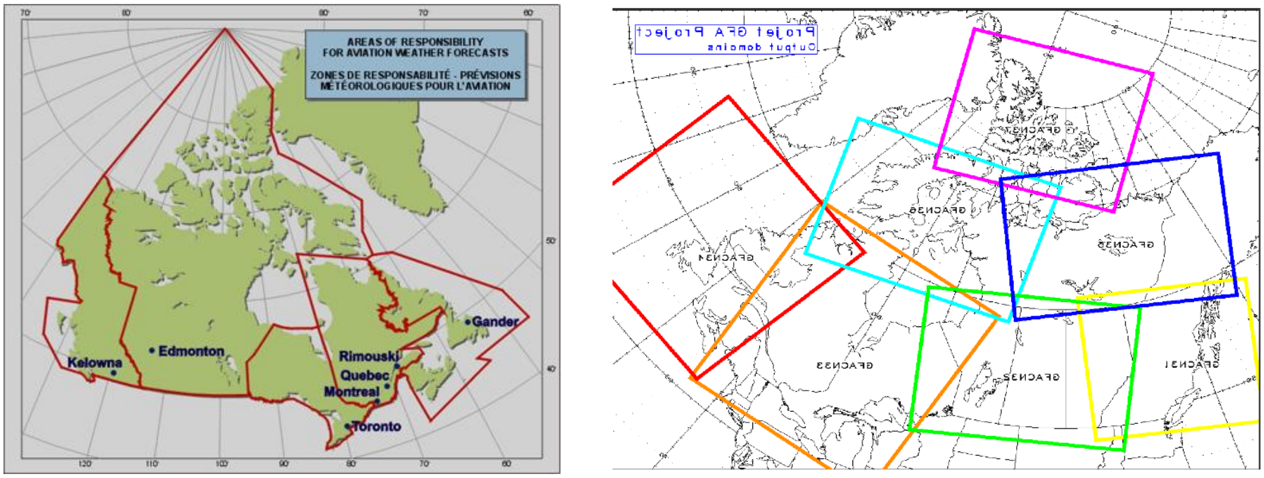


Figure 13 Aviation centre locations and areas of responsibility, and GFA domains

Four of the centres involved in aviation forecasting (Gander, Toronto, Edmonton, Kelowna) would send their input for their areas to the Meteorological Coordinating Centre (MCC) in Montréal which would also use the input from Québec City and Rimouski, and “stitch” the various inputs into a national product, from which the charts covering the seven GFA domains would be automatically extracted and sent to users.

The GFA comprised two types of charts (Clouds & Weather, and Icing, Turbulence & Freezing level), each issued for three time steps (T_{zero}, $T_{zero + 6\ hours}$, and $T_{zero + 12\ hours}$ with a 12 hour outlook), and issued four times a day: 0000, 0600, 1200, and 1800 UTC.

A key question: what tool would be used to produce the GFA? The FPA and Edigraf were the two obvious choices. The former was already being used in PNR; the latter, in CMC, QR and elsewhere. The FPA was seen as more powerful and would support other needs in the long run, but Edigraf required less effort to get ready, was supported nationally[5], and was already Y2K compliant, and so it was chosen.

Many units (forecast centres, standards, CMC, CSU, IT) had to collaborate to pull this off. Daniel Chrétien was heavily involved.

[5] Much of the success of the early years was the in-house innovation and creation of tools. But this approach was becoming unsustainable in the long run, and national standardized approaches were becoming essential

We were ready to implement the GFA by the end of the year as promised but it was delayed because of Y2K concerns. The GFA was officially implemented in April 2000—it was one of the first of its kind in the world—and the textual FAs were discontinued.[6]

Other Changes

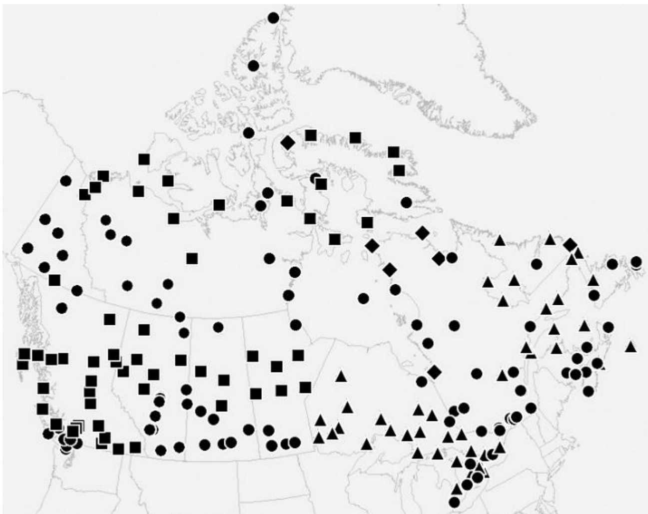


Figure 14 Aerodromes with TAFs

A concern that was mentioned already: aviation forecasting had a highly variable workload, and we wanted to balance it. Before the GFA was introduced, there were ~185 TAFs that were updated at the same time, followed one hour later by the FAs.

April 2000: we got approval from NC and TC to do TAFs in two batches: all international TAFs with a 24-hour valid period would be issued on the synoptic hours (i.e. 0000, 0600, 1200, and 1800 UTC), and the remainder of the TAFs would issued one or two hours later.

2000: NAV CANADA, wanting to see improvements in TAFs, hired a consultant (Pierre Belisle) to gather input from aviation users. The MSC conducted several TAF improvement workshops across the country, to which clients (NAV CANADA FSS staff, dispatchers, pilots) were invited for discussions on how to best word TAFs. This culminated in a TAF workshop in Aug 2002, and the feedback gained was shared with forecasters.

We heard that TAFs are a particular challenge, and there were several themes, some contradictory…

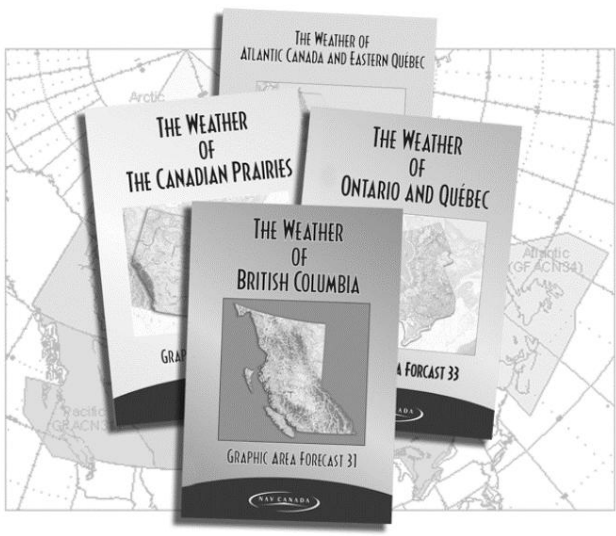
- some wanted short TAFs; others wanted more detail
- some wanted us to focus on the short-term; others were concerned about the 18–24 hour timeframe
- some wanted weather mentioned even if the likelihood of it happening was low; others didn't
- most disliked "hedges" such as TEMPO
- many complained about the high frequency of amendments; they felt we're "chasing the weather"

Clearly it was going to be challenging to please everyone!

Another challenge: forecasters were forecasting for places they weren't familiar with and there was a general lack of knowledge regarding how users used aviation forecasts. Meanwhile, NC operated

[6] Afterward, we costed our resources that went into developing the GFA and shared it with NC, which elicited a strong reaction, as a project of this magnitude should have been approved and funded before it began. Both organizations adopted a better approval process.

a network of Flight Service Stations that were responsible for flight briefings and local communication with pilots. A NC Level of Services review that started in 2000 resulted in the decision to close all the FSSes and to centralize their services into several Flight Information Centres (FIC); this was similar to what had happened with aviation forecasting and presented a similar challenge of getting its staff familiar with the climatology of many locations.



2001: to address both needs, NC funded the creation of a series of aviation manuals based on the MWSO's initial work and covering the rest of Canada: this was the MSC's Local Area Knowledge Project. It was led by John Mullock, involved several MSC forecasters from across the country, and was completed in 2003.

Figure 15 Aviation manuals

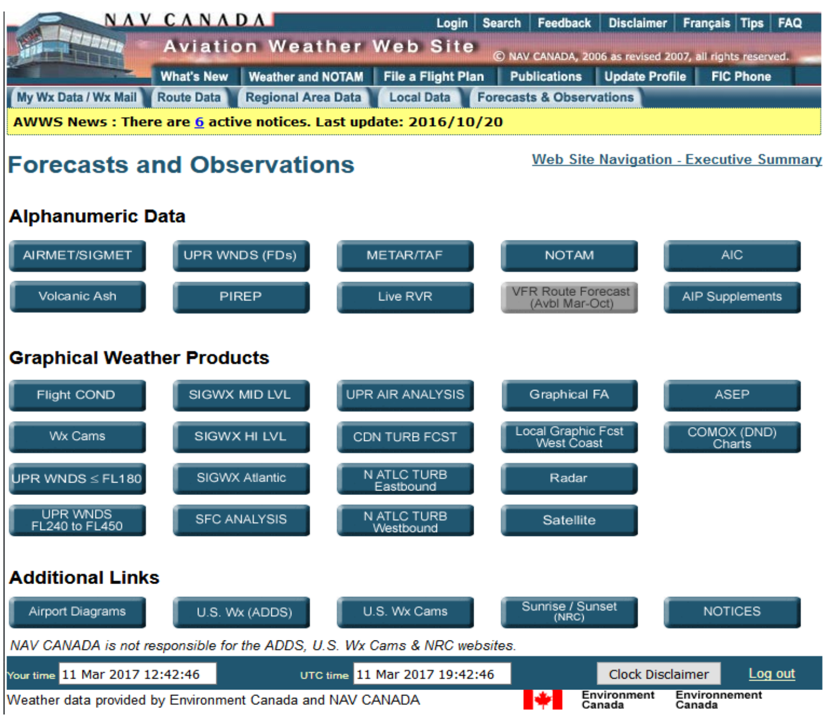


Figure 16 AWWS

2001: the MSC, via the Canadian Meteorological Centre (CMC), launched the Aviation Weather Web Site (AWWS). This was a development project funded by NC and the ongoing service was cost recovered. The AWWS provided online access by aviation users to aviation observations and forecasts, both text bulletins and charts. It was one of the first aviation-oriented weather websites in the world.

2004: the Automated Supplementary Enroute weather Predictions (ASEP) component was added to AWWS. It provided users with a way to view weather parameters graphically, in three dimensions, in support of flight planning.

AWOS Implementation

Meanwhile, the AWOS Performance Evaluation had successfully achieved its goal to improve AWOS performance and gain the acceptance of users. The side-by-side comparisons of human vs AWOS observations at the seven test sites had resulted in a valuable dataset that illustrated some of the more obvious short-comings of AWOS processing algorithms. These data were studied by the engineering team in Downsview led by Earle Robinson and supported by Len Szarko, Ken Wu, Dave MacKay, and others. Algorithms—particularly those that produced ceiling and precipitation information—were tweaked and testing of the new systems demonstrated to users that AWOS observations could be used in their operations.

The result was that the TC moratorium was lifted in 2000 and stand-alone AWOS were deployed at many smaller airports across the country. Observations at the busier international airports would continue to be produced by human observers—either FSS staff or contract observers—in some cases simply by Quality Controlling and supplementing the AWOS observations.

2nd NC agreement (2001)

In 2001, with the initial 5-year agreement ending, EC and NC entered into negotiations for a 2nd agreement. Both organizations desired a longer-term agreement that would ensure stability. NC had looked elsewhere for aviation services, but had not find a viable alternative. For the MSC's part, we realized that we had not fully costed all services the first time around and conducted a more thorough analysis of all costs which resulted in a higher quote for our services.

Recall that aviation activities within the MSC were costed based on being built onto or beside a system for delivering on its mandated responsibilities of public forecasts and warnings; i.e. it considered the incremental cost, not a sharing of infrastructure and effort. This applied to aviation forecasting efforts; i.e. they were costed as being incremental to a fully functioning and funded weather centre doing public, marine and other forecasts, also the additional support needed from IT, HR, Finance, etc. That is, it's not a standalone model, like the Department of National Defence (DND) aviation and oceanographic weather services model. The forecasting component was based on the number of FTEs that had previously been funded by TC and on which the PAAWC's costs had been based.

To aid in the discussions, the MSC developed a detailed costing analysis of three models for delivering aviation forecasting services, comprising one, two, and five aviation centres. In the end, the two-centre model was deemed the best solution (while a one-centre model was slightly cheaper, it presented challenges with staffing and handling contingencies).

The two-centre model was based on six full-term equivalents (FTEs, or people) per 24/7 desk, and resulted in three GFA desks (also doing the SIGWX chart, SIGMETs, AIRMETs), six TAF desks (based on roughly 24 TAFs/desk), and a supervisor desk that would pick up remaining TAFs and other duties, especially during the spin-up and spin-down periods (shoulder periods) around shift change.

In the aftermath of 9/11, NC was hurting financially as flights and resulting revenue had dropped significantly. NC chose to delete some contracted services (that it would take on itself); these were mostly in monitoring (e.g. the training of weather observers, looking after contracts for weather observing sites). In the end, NC accepted our costing analysis but deleted some items (e.g. science R&D) and got agreement to ramp up the costs over a three-year period, and we signed a 10-year, ~$20M/year contract that would run until 2011.

It's important to note that while NC funding was based on a two-centre model, it did not (could not) require the MSC to operate that way. The MSC chose to not make any changes in its structure (i.e. it continued doing aviation forecasting out of seven centres); it thus made the conscious decision to subsidize aviation forecasting operations, at least for the time being.

June 2001: I wrote a position paper proposing a different way to do aviation forecast production. At the time, seven weather centres were involved in aviation. My paper outlined a graphic centre concept; i.e. two centres doing GFA and other charts for all of Canada, while all seven centres looking after SIGMETs, AIRMETs, and route forecasts for their area of responsibility (i.e. the products which have a local, mesoscale component) and providing input on their area to the graphic centres. I included an option for a two-centre model for doing all aviation products.

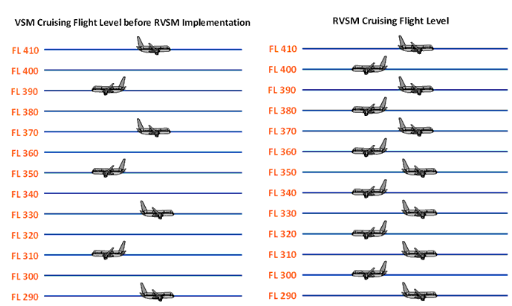


Figure 17 RVSM

2002: the MSC started producing turbulence charts covering northern Canada in support of Reduced Vertical Separation Minima (RVSM) procedures that NC was implementing, and which supported the tight spacing of aircraft and thus improved flight planning and reduced air carriers' costs.

Creation of the CMACs (2003)

Ongoing financial pressures, including the lack of sufficient funding to ensure the proper maintenance of infrastructure, led to an MSC-wide examination of all A-base (i.e. government-funded) services in 2003. It was given $75M to restructure itself so that it could "Live Within Its Means." This led to more office closures and a further consolidation of forecast operations into six regional centres in Vancouver, Edmonton, Winnipeg, Thunder Bay, Montréal, and Halifax.

The MSC realized that could no longer afford to subsidize aviation forecasting, and the decision was made to implement the two-centre model; i.e. two dedicated aviation centres (AC), one in the east and the other in the west. This entailed a decoupling from public forecasting. Each AC would be collocated with a weather centre (to be known as a Storm Prediction Centre, or SPC) to save costs.

Where would the ACs be located? Managers in the regions and at the national level put together a list of options, each with its pros and cons. Since Kelowna's public weather forecasting role was to end, Edmonton was the obvious location for the western centre. It was trickier in the east, with Ottawa/Toronto, Montréal and Halifax all vying for the opportunity. In the end, Montréal was selected as the host city (it provided a useful bilingual capability and was close to CMC).

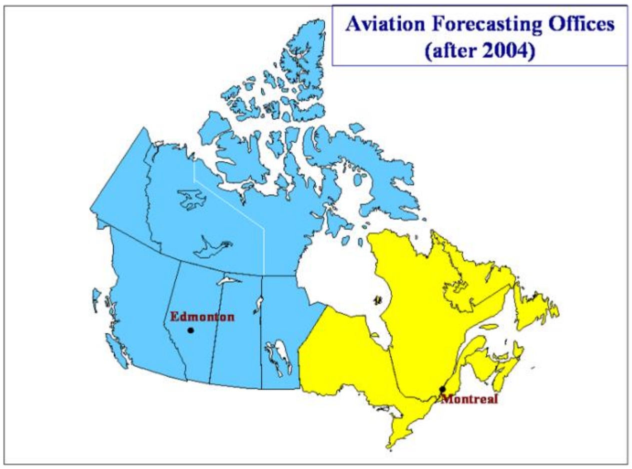


Figure 18 CMAC locations and areas of responsibility

March 2003: the restructuring decisions were announced; i.e. the creation of the SPCs and the ACs, and the closing of the remaining WSOs. Edmonton and Montréal were announced as the locations of the two ACs. They would be tagged onto/beside a SPC and share the infrastructure but have separate staff.

Aviation services for Yukon and northern BC started moving from Kelowna to Edmonton in Oct 2003 and were completed in spring 2004 when there were sufficient trained staff in Edmonton.

April 2004: with the transfer of aviation forecasting duties from Ottawa and Gander to Montréal, and from Kelowna to Edmonton, the two ACs were operational. This change went remarkably smoothly.

We held a contest to select names for the ACs. We needed bilingual names, and we felt that the acronyms for the names should be pronounceable and the same in both official languages. This would help convey the message that the centres would be two parts of a whole.

Fortunately, we could tap the "C" appearing in Canadian and Centre. Thus, the Canadian Meteorological Aviation Centre - East/West (CMAC East/West) or Centre Météorologique Aéronautique du Canada - Est/Ouest (CMAC Est/Ouest).

Together, they had ~92 FTEs and 11-12 operational desks. They looked after ~185 TAFs, SIGMETs/AIRMETs in their area of responsibility, and coordinated on the GFA. Staffing levels were based on six FTEs per 24/7 desk, not seven as in the SPCs (thus there was only ~10% non-operational time for training, projects, etc.). They provided consultation services and did outreach.

Figure 19 CMAC-Est and CMAC-West forecast desks

The two aviation centres were able to transfer work between desks within a centre and also between the centres as needed (based on the staffing situation, the busyness of weather, to allow for training). Forecasts for the entire country could be done from either centre. This capability was exercised (and came in handy during the 2020 pandemic).

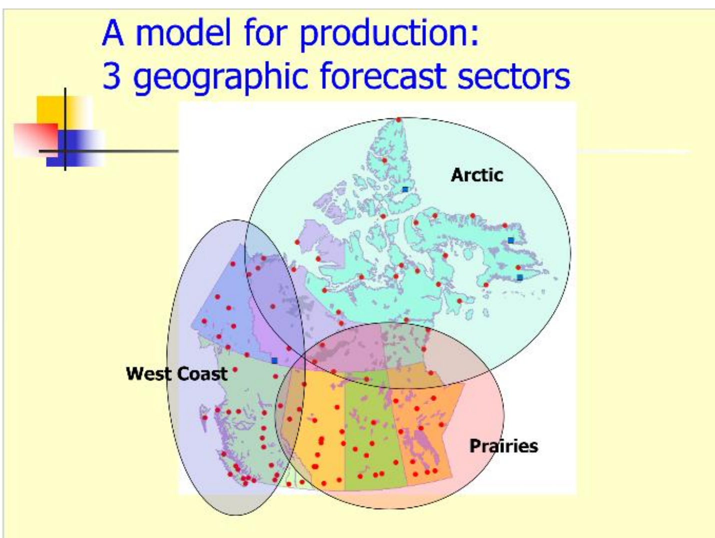


Figure 20 CMAC-West sectors

In CMAC-West, there would be three sectors (West Coast, Prairies, Arctic), each with two 24-hour desks. As the weather typically varies tremendously across Canada, workloads can be highly variable from one day to the next. One advantage of a centre looking after the weather for a large area is that the weather is seldom busy everywhere. RovingTaf was used to shift the area of responsibility between desks and to redistribute the list of TAFs and other work to balance workload, and even to add or subtract desks. CMAC-Est took a different approach but also had the capability to shift duties.

As with the PAAWC, the question was how to make the CMACs work. Again, there were no models around the world to emulate. USA had the AWC in Kansas City but just for the FA and SIGMETs; TAFs were done by the ~118 Weather Forecast Offices (WFO) around the country. Other countries had national or regional weather centres that included aviation forecasting. None had separate aviation centres.

> Rob Honch (CMAC-West Manager): "*how can we make CMAC-West the place where forecasters want to be?*"

To handle a large area of responsibility with many products, and to support a focus on aviation high impact weather (HIW), the aviation forecaster needed a suite of aviation-oriented software to

- monitor weather, be alerted to changes in the weather,
- collect/display a variety of aviation-specific info,
- better tap climatological info and use it effectively, and
- easily and quickly compose many forecasts.

Forecasters again rose to the challenge.

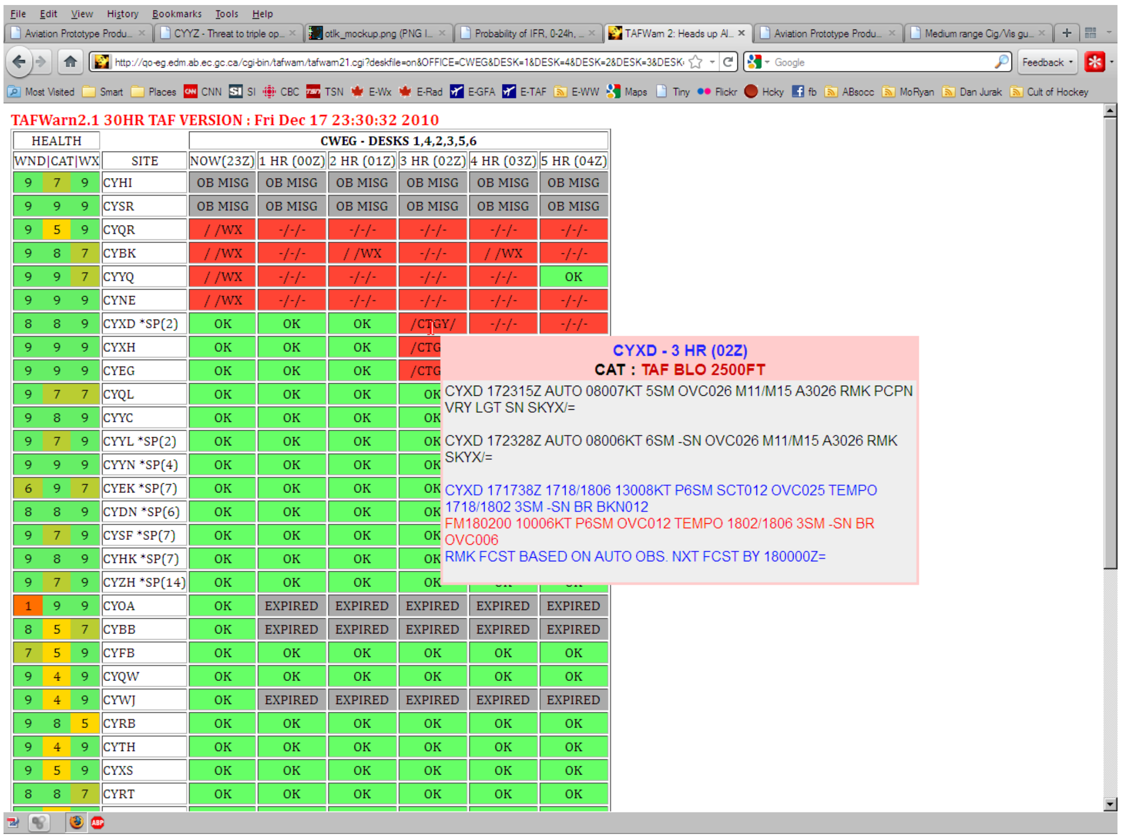


Figure 21 TAFWarn

2004: TAFWarn (Erik de Groot)… for monitoring TAFs and seeing which ones might need attention in the future by comparing the TAFs, hour-by-hour, against weather element guidance.

Overall: the CMACs proved to be very reliable (they never missed more than 1 forecast cycle), and there was generally positive feedback from aviation users. There were concerns about differences in training, in professional development and the career path for aviation forecasters versus public forecasters, but forecasters could transfer between the CMACs and SPCs.

New aviation initiatives and services

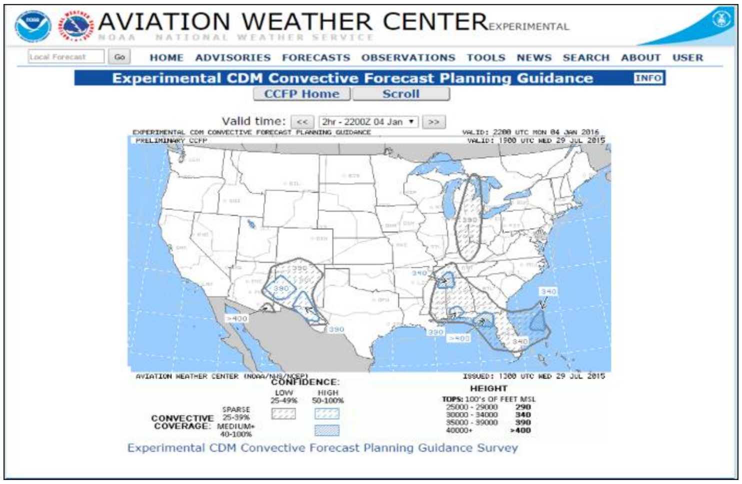


Figure 22 CCFP

In 1999, the United States' National Weather Service (NWS) started experimenting with graphic charts outlining areas of organized convection: this was the Collaborative Convective Forecast Product (CCFP), a graphical depiction of location, intensity, and probability of convective activity. This product was formalized and made operational in 2000. In 2003, CMAC-Est started supplying input covering extreme southern Canada (ON and QB); this was a good example of international collaboration.

NAV CANADA created the Weather Applications Work Group (WAWG) to deal with the application of weather in relation to traffic flow management. It was a sub-group of the Collaborative Routing Work Group, which was a sub-group of the Collaborative Decision Making (CDM) Work Group. It included not just forecasters (in both the USA and Canada) and NC managers but also end users (e.g. Martin Kothbauer from Air Canada Jazz). Collaboration!

Jan 2004: the CMACs took over responsibility for the MIDLVL SIGWX chart from CMC.

May 2004: the Meteorological Watch Office (MWO), responsible for issuing volcanic ash SIGMETs for Canadian domestic airspace and the Gander Oceanic Flight Information Region (FIR), moved from CMC to CMAC-West.

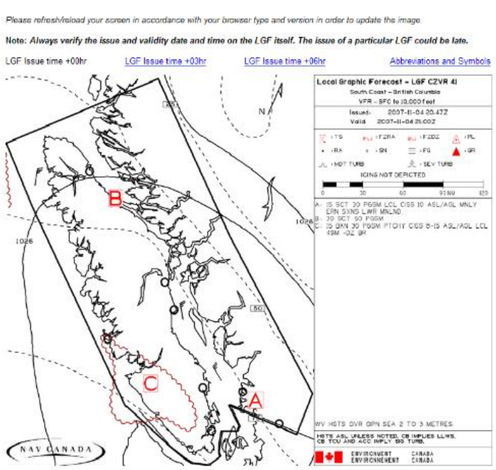


Figure 23 Local Graphic Forecast (LGF)

2006: CMAC-West commenced producing a Local Graphic Forecast (LGF) covering the BC West Coast

2006: a trial was conducted of embedding a forecaster (Daryl Pereira and François Moreau) in NC's National Operations Centre (NOC) in Ottawa to see if they could aid in national operations. This idea had potential, but their roles didn't seem to have been defined well, and it was discontinued. Another missed opportunity?

Figure 24 Canadian Aviation Weather Workshop (CAWW) discussions

In the 1990s, TC had hosted an annual meeting of major organizations involved in aviation: itself, the AES, major airlines and DND. This was the Aviation Weather Services Users Meeting (AWSUM). NC viewed them as unproductive and ended them, but in 2006 the concept was resurrected by the MSC as the annual Canadian Aviation Weather Workshop (CAWW), involving forecasters from both CMACs, NC and TC managers, and end users.

2007: the MSC completed the Performance Measurement TAF Improvement Project (PMTIP), funded by NC, which provided additional statistics on those weather parameters deemed most important to flight planning operations.

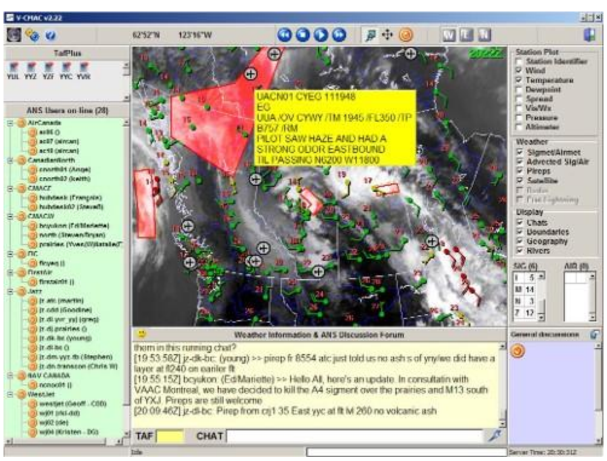


Figure 25 V-CMAC

Figure 26 Martin Kothbauer and Bruno Larochelle

2007: in response to user comments expressed at a CAWW, especially by Martin Kothbauer from Air Canada Jazz, the MSC introduced, on a trial basis, V-CMAC (Virtual CMAC), developed by Bruno Larochelle. Based on MultiAlert (Martin: "I want that!"), this was software that ran on servers that NC and air carrier operations centres could access. It displayed a variety of aviation info, including SIGMETs, in a graphical format. Users and forecasters could use V-CMAC to see the same info, pose questions and get answers. For the first time, forecasters were directly connected to the end users in real-time. This represented a significant leap forward in real-time collaboration.

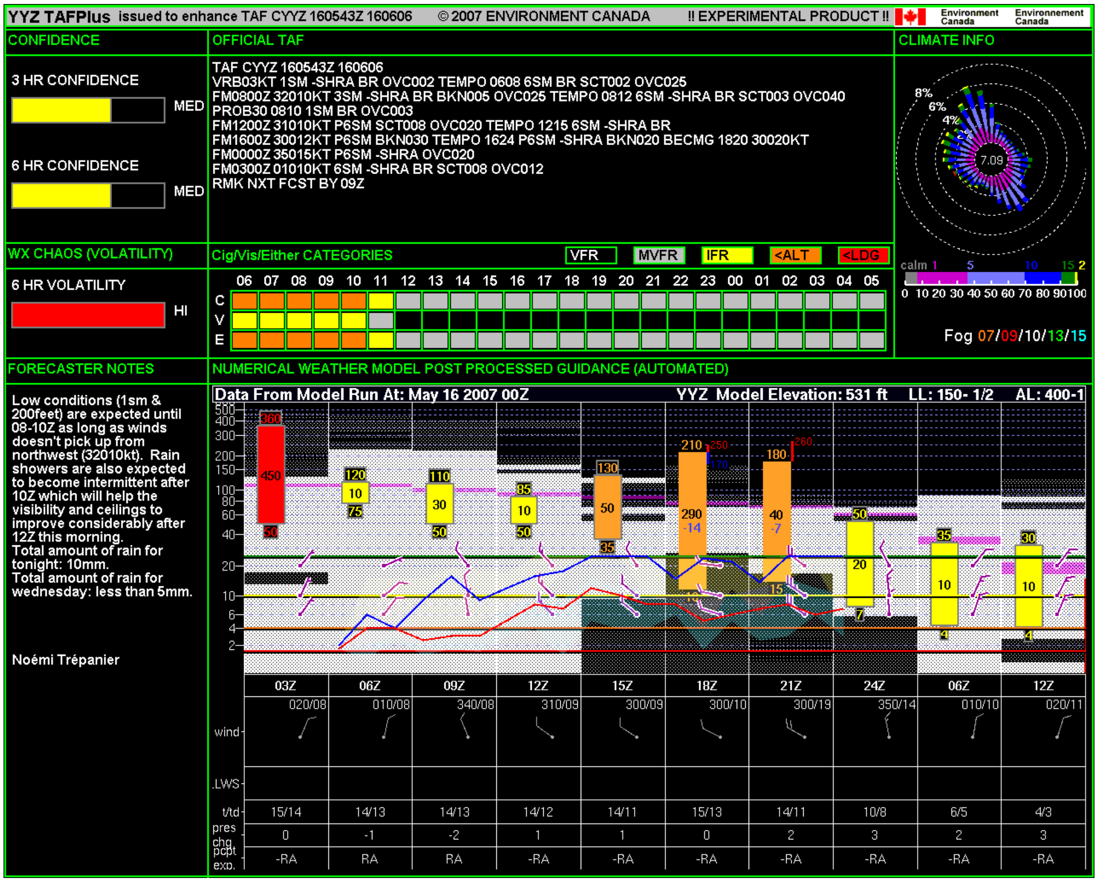


Figure 27 TafPlus

TafPlus (Bruno Larochelle, Steve Laroche) was incorporated into V-CMAC. It was a slimmed-down version of TafTime, using graphical annotations (arrows, circles, ovals) to point out things on the TafTime diagram (e.g. one could add an arrow to indicate a cold frontal passage), climatology (wind roses, fog specs), forecaster confidence and volatility, a forecaster discussion (a summary of their reasoning behind the forecasts), and an hour-by-hour graphical representation of flight categories (IFR, MVFR, VFR)

Aviation-related science and R&D

The weather parameters that are most critical to aviation operations (i.e. cloud ceiling, visibility, wind, icing, turbulence)...

- vary tremendously across short distances and time,
- are the hardest to observe,
- are the hardest to model numerically, and
- are the hardest to forecast.

R&D requires a long-term commitment and a long-term stable investment. This was challenging for the MSC as the agreement contained no specific funding for R&D.

Oct 2005: Stewart Cober proposes creating an Aviation National Lab (ANL), one of several national labs planned for the MSC.

Its role would be to undertake R&D in aviation meteorology with the goal of "*providing more accurate, more relevant and timelier forecasts in order increase the safety and efficiency of aviation operations.*" It included the technical transfer of research to operations. It would involve the Meteorological Research Branch (MRB), the CMACs, and CMC.

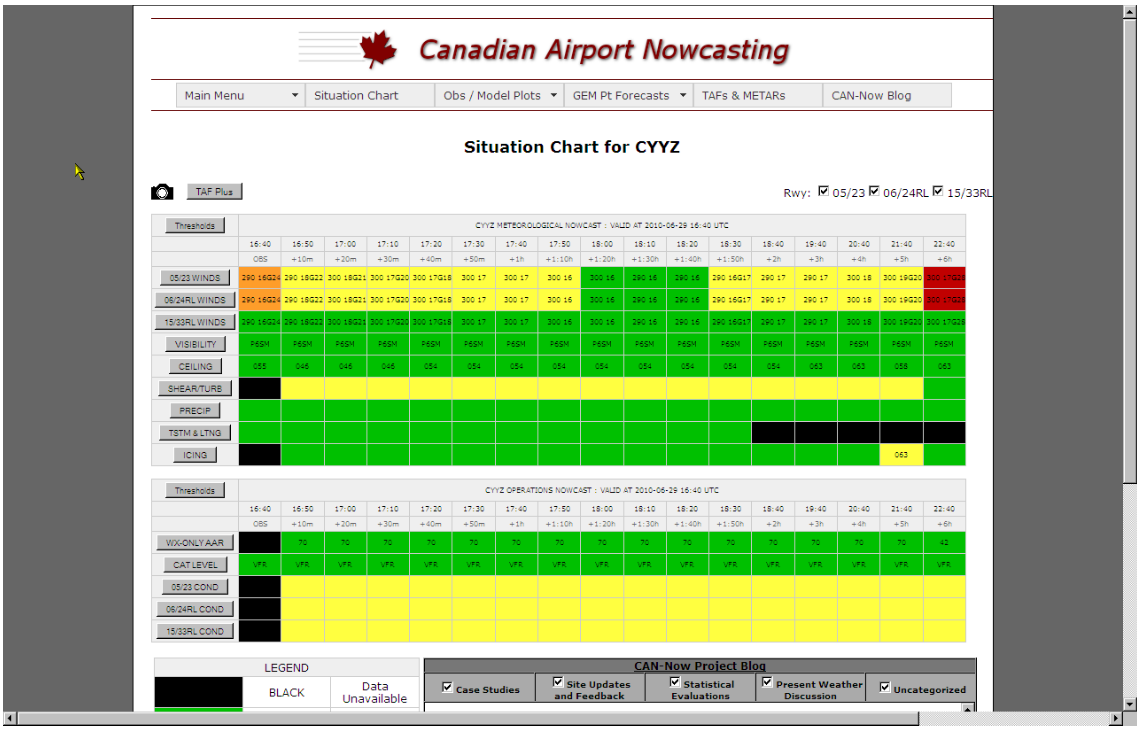


Figure 28 Examples of CAN-Now display

2007: the MRB starts the CAN-Now (Canadian Aviation Nowcasting) project. It tapped funding from the MSC, NC and other agencies to evaluate nowcasting techniques for aviation weather parameters at airports.

Ongoing efforts in aviation weather services: a shift in focus

Sep 2007: a meeting of CMAC managers stressed a few things: NAV CANADA senior managers are pushing harder to reduce costs, to increase quality, to respond to air carrier needs. They are unsure re MSC's commitment to the contract in the long term. The MSC was losing the monitoring portion, and the forecasting portion is also at risk (NAV CANADA was seriously looking at alternatives).

At the annual CAWW in 2007, it was emphasized that the forecast is not the end, in and of itself; it's an assessment of airport, terminal, and enroute capacity, it's all about flow management, flight scheduling, fuel upload decisions (integrating info). This was one of the early steps in getting the MSC to think beyond the basic forecasts.

Martin Kothbauer and other end users were very positive about V-CMAC and TAFPlus. They found them useful, especially seeing the forecaster's insight. They had high-glance value; e.g. colour-coding weather conditions. A success!

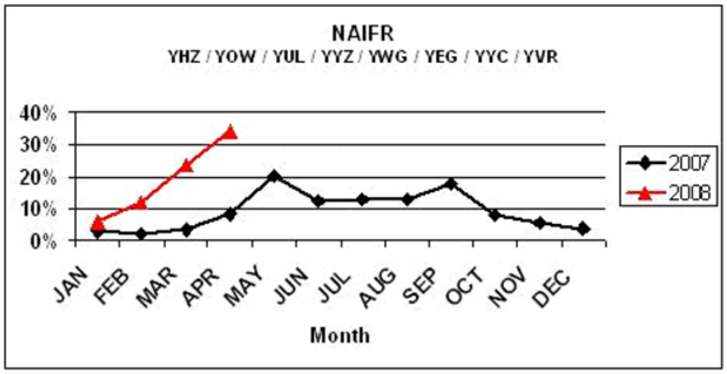


Figure 29 Air Canada Jazz utilization of NAIFR

We learned that air carriers were utilizing No Alternate IFR (NAIFR) more often to reduce the amount of fuel that needed to be carried (thus reducing cost). That is, based on criteria outlined in the Canadian Aviation Regulations (CARs), including the TAF at the flight's destination, a flight may not be required to file an alternate aerodrome.

And while safety is always a concern, today's air carrier operation is about focussing on passenger comfort and convenience and on reducing operating costs, which includes making smarter decisions based on weather (e.g. using NAIFR more frequently and safely), and picking optimal flight routes and levels, based on winds, to save fuel burn enroute and to avoid turbulence.

Many airport operations (e.g. active runway selection, airport capacity, runway maintenance, aircraft de-icing and refueling, baggage handling) are affected by weather. (Paradoxically, even though airports are an integral part of the ANS, NC did not view them as clients as they contributed no revenue to NC.)

Users' approach to decision-making depends on the timeframe (the closeness of the event)

- Tactical (0-2 hours),
- Short-term strategic (2-24 hours), and
- Long-term strategic (24 hours to 3 days in advance).

Plus, the Canadian ANS is different from the States: the skies are less congested, airspace capacity less often reduced by convection. There are enroute weather concerns, but it's more so a matter of the weather at the terminals.

Overall, striving to make the current suite of products more accurate would not address the need.

Clearly, our work was cut out for us, and we needed to rethink our approach. And so we developed a CONOPS (Concept of Operations). Our vision of the future…

- A suite of modern products and services based on an active outreach program identifying needs and educating users
- Grounded in science, supported by a vibrant and sustainable R&D unit developing and transferring knowledge to operations and into products
- Constant prototyping of new ideas
- Delivered by two 24/7 aviation forecast centres
- The increased automation of basic products

- Forecasters in direct contact with users, providing advice
- Supported by a Client Services Unit, liaising with NAV CANADA and end users

Within the MSC, we drafted a vision of the future, which outlined a shift in thinking…

- In **services**… from providing products to providing info,
- In **focus**… from all terminals to greater attention on the hubs,
- In **focus**… from the needs of GA to those of major air carriers,
- In **the types of forecasts**… from deterministic to probabilistic,
- In **scope**… from Canada to North America-wide, and
- In **how we work**… from the forecaster doing manual editing to being "over-the-loop"

> A key message: the current product and service suite falls significantly short of the industry's needs; they are designed to fulfill a regulatory requirement that's designed to ensure safety with little or no consideration for efficiency

2007: the MSC achieved ISO 9001:2000 registration. This is an international benchmark for quality management systems (QMS) that focuses on customer satisfaction and continuous improvement and is required by the World Meteorological Organization (WMO).

Sept 2008: at the annual CAWW, given that we had identified a need to reduce TAF production costs (also to standardize TAF format, make TAFs more useful), Alister Ling talked about his AVGuide initiative, which would focus on where humans add value, take steps towards TAF automation, and conduct research into understanding airport acceptance rates (AAR) and critical wind directions at the hubs. This connected with the Hub Critical Wind Project (Tim Guezen).

March 2009: the AVGuide project idea was shared with NC. We outlined our plan to take the first steps towards TAF automation. This was to reduce the effort spent on writing and maintaining TAFs to enable spending a higher percentage of effort on the more important TAFs (the hubs, and where there is significant weather).

There were also plans to standardize TAFs more; i.e. in a given weather situation, they should look the same, no matter which forecaster prepared them, to provide info on the reliability of the TAFs, and to develop other products based on the info that drives the TAFs… ultimately, to feed the 4-dimensional data cube (4DDC), and to translate weather information into Air Traffic Management (ATM) impacts.

This paralleled the American NextGen Weather (NextGen Wx) initiative that entailed a move toward the automation of basic aviation forecast products and the seamless integration of weather info into users' decision-making processes. It included a 4-D Data Cube (a fully automated, single authoritative source of weather observation information and probabilistic weather forecast products).

Winter 2008: CMAC-Est established a “Toronto desk” to focus on the TAFs in the Windsor to Montreal corridor and to participate in the CAN-Now project at Toronto-Pearson Airport to examine the value of enhanced monitoring and short-term forecasts. It was staffed by experienced forecasters who had gone through a certification process.

This new desk was appreciated by users who saw an improved focus on Pearson. The following April, this focus on Toronto Pearson continued by combining the Toronto desk with the CCFP desk. This resulted in 24/7 coverage, and looked after the TAFs for CYYZ, CYHM, CYXU, the TAF Forecaster Note for CYYZ, and the CCFP.

> *2008: based on a request from NC, the MSC implemented 30-hour TAFs for a few aerodromes (an ICAO initiative)*

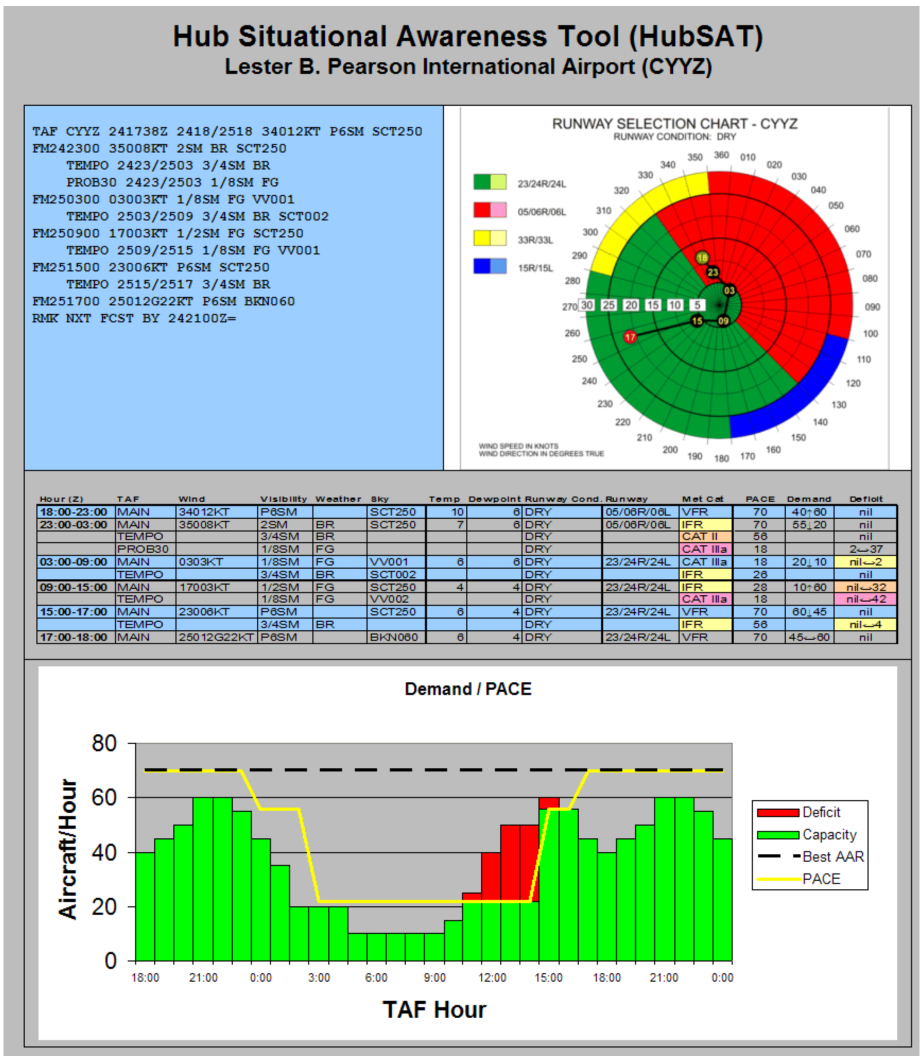


Figure 30 HubSAT

2009: HubSAT (Tim Guezen) is developed. It extracts info from the TAF (esp. wind and precipitation) to determine its impact on an airport's Airport Acceptance Rate (AAR) and the number of arrivals per hour. This was an important first step to move from standalone forecasts to applying them in the ATM world.

2009: DND's new Joint Meteorological Centre (JMC) is operational in Gagetown, NB. This entailed the transfer of people and responsibilities from several smaller centres across the country, similar to the CMACs. It looks after most aviation (and other) forecasting in support of the military. It and the two CMACs provide mutual backup.

3rd NC agreement (2009)

In Nov 2007, the MSC's response to the annual NC supplier review highlighted a few aspects:

- The GoC enters into relationships with non-GoC organizations, not to make money but because we have something unique to offer, there's a benefit to our organization and ultimately to the people of Canada
- The contract is based on the concept of cost-recovery, including of overhead and indirect costs. This covers a suite of ongoing products and services; there is little specific funding for research and development
- We're being contracted for a specific list (of services), but are being measured against another list (of expectations)
- Ideas for improving quality, developing new products, creating efficiencies are funded through projects
- CAN-Now project at YYZ to examine the value of enhanced monitoring and short-term forecasts (now has funding from NAV CANADA), looking to expand it to YVR

NAV CANADA indicated that it was unsure of EC's commitment to a contract. We committed to present a going-forward strategy to NAV CANADA senior managers by end of 2007.

In 2008, as we neared the end of the 2nd agreement, the mood was quite different, as neither NC nor EC assumed that it was a given that we would be able to come to a new agreement. The 2008 worldwide recession had severely affected aviation and NC's budget (100% of its revenue comes from user fees), so it was looking hard at every facet of its organization to cut costs, including for services supplied by the MSC.

NAV CANADA had started a procurement process for selecting a contractor for aviation forecast services and was examining all its options, as it knew that there were private companies who would be interested.

While the MSC had stated that it wanted to remain in a relationship with NC for the provision of services, it was becoming firmer in its stance, feeling that it needed to not simply recoup its costs but also see a tangible benefit to its other programs and mandate. Some senior MSC managers no longer perceived a benefit of being in the contract and did not want to renew it at any cost.

If NC decided to contract with someone else or the MSC chose to not supply services, time would be needed by both organizations for an orderly transition, so contract discussions started in 2008. NC had already told EC that it would be taking over almost all monitoring activities (including installing and maintaining the 2nd generation AWOS, which it had developed, and other observing equipment).

NC issued a formal Request for Information (RFI) asking potential vendors to describe their capabilities and how they would provide aviation weather forecast services. MSC responded with its proposal. Negotiations were… "interesting."

May 2009: a new agreement was reached; it had a 12.5-year term through November 2021. NC got what it wanted (a significant decrease in the value of the contract, mainly accomplished by getting a credit for the EC's use of its surface weather observations and to which it held the IP), while the MSC got a long-term contract that allowed it to plan for the future.

The agreement provided for a collaborative approach to the modernization of the aviation forecasting system: the Joint Aviation Forecast Modernization Initiative (JAFMI) to be led by a joint management team co-chaired by a senior manager from each party. It included investigating the partial automation of TAF forecasts, the development of a new aerodrome forecast to supplement or replace the TAF, and the development of specialized services to improve the effectiveness and efficiency of Air Traffic Management (ATM) operations especially at high-volume airports.

The pricing for aviation forecasts was adjusted to better reflect the level of effort (e.g. a greater focus on forecasts for principal airports).

Implementing a new CONOPS

Nov 2009: John Foottit, the Manager, Aviation Weather Services for NC, retires. John had pushed us hard and was hard to please at times, but he also was complementary when we earned it. We viewed him as an ally and, by attending workshops and talking with our staff, he helped to lay out NC's needs and reinforce our plans. His departure left a huge gap as there no one left in NC with a background in weather.

Nov 2009: to address NC's needs and address the problem of the lack of funding for R&D, the MSC created an Aviation Innovation Fund (AIF). It would fund initiatives that would:

- Support synergies between the aviation and public forecast programs
- Improve efficiencies and performance in the aviation program
- Support work to meet international obligations or capitalize on advancements made in other countries
- Support goals to retire legacy software and enable efficient and effective IM-IT solutions
- Accelerate and enable S&T advancements which support a future vision for the aviation program

Specifically, the AIF could be tapped for

- Streamlining TAF production
- Supporting the development of Aviation Warning Event Manager (AWEM)
- Developing a tool to connect forecasters with end users
- Supporting nowcasting development
- Building an aviation R&D capacity

- Pursuing advances in performance measurement
- Improving our monitoring and alerting capabilities
- Upgrading the performance measurement system

This would include work being done in the ANL:

- Canadian Airport Nowcasting Project (CAN-Now)
- Aerodrome Vicinity Guidance Project (AVGuide)
- Ceiling and Visibility Forecast Tool (WIND III)
- Fog Research and Modeling Project (FRAM)
- High Ice Water Content Project (HIWC)

The CAN-Now project was deemed important, but we were not (yet?!) seeing the impact and value. For it to continue it needed be more focussed and operationally relevant.

The MSC was a member of an international consortium building the next-generation forecast production system: NinJo. The first operational version had been installed in CMAC operations in 2008; it mainly did data visualization.

Aviation needs for NinJo included a graphical editing tool for producing the GFA and other graphical charts. The forecaster would work with objects, editable trial fields (as generated from numerical weather models) and, once finalized, these objects would be importable/exportable so that they could be shared with other aviation weather centres (including the AWC) and used to generate secondary products (such as SIGWX charts). The forecaster-adjusted fields and values would be saved in an aviation digital weather element database for use by external users and third parties (needed for NextGen Wx).

New products in support of terminal operations (especially the hubs) could include a probabilistic "TAF" (tables of numbers, with probabilities of ceilings, visibilities, winds), data (numbers, probabilities) that others could embed into their systems, an AAR product for Pearson and other major hubs. There were two aspects: a very-short-term forecast based on nowcasting techniques, and a longer-term one based on the TAF.

Products in support of enroute operations included the Corridor Integrated Weather System (CIWS), CCFP, and an LGF-type product covering Toronto Pearson, southern Ontario, and extending across the border. Its production would be coordinated with the AWC in Kansas City. There would be a variety of info available online, with users having the ability to interact with it. We would focus our effort on uniquely Canadian needs: winter weather, data-sparse areas, boundary layer, icing potential in the low-mid levels.

> *2009: in support of the 2010 Olympics in Vancouver/Whistler, specialized weather observations and forecast services (TAFs for Squamish, Whistler, and Pemberton), and a Route Forecast were supplied to NC*
>
> *2010: responsibility for hosting and maintaining AWWS was transferred to NAV CANADA.*

Oct 2010: NAV CANADA created the Canadian Weather Evaluation Team (CWET), of which we were a member. A key goal would be to extend the CIWS domain to encompass the entire Canadian weather radar network. Other potential tasks would be to investigate the potential use of graphical AIRMETs and SIGMETs, to investigate the impact of NEXTGEN weather developments, and to improve TAF accuracy.

Dec 2010: "Project Pearson" is pitched by the MSC. This would be a two-year project centred on an enhanced level of aviation weather forecast services for the Toronto/Pearson International Airport (PIA) area. It would focus on improving existing aviation products, experiment with more detailed and higher-resolution products, providing consultation, and work closely with NAV CANADA and end users to evaluate the usefulness of this approach.

Apr 2011: a strategy for aviation R&D is launched. The aviation R&D program had been primarily funded through external sources (NAV CANADA, Transport Canada SAR-NIF, FAA) for the past several years; however, most of that funding was sunsetting. As a result, the long-term viability of the MSC's aviation program was at risk, and without a sustained investment, the MSC would not be able to improve its aviation forecasts, the aviation program would fall behind and be unable to meet NAV CANADA's needs, and this could lead to NAV CANADA and EC going their separate ways.

We now had a good grasp of what was needed in the future and had developed a firm science foundation from which to advance. To support this needed work, the ANL could tap MSC funding... the Aviation Innovation Fund. Also, we knew that NAV CANADA was more willing to invest funding in projects when there are other partners.

It would include research support desks (RSD) in both CMACs where new tools and products could be evaluated and feedback obtained, and intensive operating periods (IOP) in the CMACs to evaluate and provide feedback on experimental tools and products.

These efforts would also serve to alleviate the financial pressure on the MSC. The new agreement with NAV CANADA provided them with a credit (~$3.36M) for the MSC's use of its weather observations, and the aviation program was expected to contribute to covering it.

Modernizing TAF production

In July 2011, discussions started on how to modernize TAF production.

The plan was to implement in CMAC operations, gradually, in stages, and completely by FY2015-16, a semi-automated TAF production system. The TAFs would be supplemented by specialized products in support of operations in the terminal area, and consultation and advice. It would comprise a database of aviation weather element observations and predictions.

By reducing the effort needed to produce TAFs, we could support more non-operational time for staff (i.e. support forecasters' development) and increase the capacity for developmental activities.

We needed to ensure that the system was designed to support, not replace, the forecaster. Forecast production would be heavily streamlined, but with the forecaster actively involved. The forecaster's role would be to monitor the production process, to intercede when necessary to ensure a quality service, and to help users to understand how to interpret and use the data; i.e. a "forecaster in the loop" approach.

These ideas were shared with NC; they were interested but pressed us to evaluate RAMTAF, a TAF production system operated by a private American company (Telvent/DTN) of which they were aware. NC felt that this solution would be available sooner and would be cheaper. Their notion was that they would license the system and have Telvent deliver draft TAFs to us, and they were willing to fund a formal evaluation of RAMTAF. (This was consistent with NC's approach in the past; i.e. that they wanted us to tap existing solutions rather than developing our own.)

This generated a lot of discussion within the MSC. We believed that NC underestimated the effort needed and overestimated the savings to be reaped. We felt that there was room for an increase in efficiency in producing TAFs, but that it wasn't huge. Perhaps a 10-20% reduction in effort was a reasonable target?

Our response to NC made several points. First, CAN-Now and other ANL projects were a foundation on which to build a TAF production system and to develop additional services, and that a third party auto-TAF solution was not compatible with this approach. Telvent/DTN's RAMTAF system would be less applicable in Canada and would need to be re-engineered to operate with Canadian data (the amount of effort to do this was unknown) and would be incompatible with other solutions and tools (CCFP, CIWS).

(This goes to previous comments about NC lacking in-house aviation weather expertise, including a meteorologist, to evaluate solutions.)

Basically, we said that we weren't interested in tapping RAMTAF, and that we would prefer to use a targeted investment from NAV CANADA to accelerate development efforts and for which we were seeking $300K annually for the next 5 years. This would address specific aviation angles, the development of NinJo for aviation forecasting purposes, and software testing and implementation.

The resulting reduction in the cost of aviation forecast services (a portion of the savings, based on the investment) could amount up to 5% of the cost of running the CMACs, or $500K, which would continue over the rest of the contract (through 2021).

2012: TAF Utility Improvement Project (TUIP) was launched. Led by Tim Guezen, this was about developing a more standardized way of writing TAFs based on the weather; i.e. a more consistent approach to TAFs and required to support a FGT.

Figure 31 aviation weather services planning meeting

April 2012: my last aviation weather services planning meeting, where I and others brought everyone up to date and laid out ideas and plans for the future, including developing a strategic vision for the program. We discussed the NAV CANADA Supplier Review Survey results that were much more positive than the last completed review of 2007.

Epilogue

This brings us to 2012, when I retired. There have been many changes to aviation forecasting since then, of which I'm only loosely aware and I am open to others to update the story.

2013: Canadian SIGMETs are made ICAO-compliant and based on FIR regions (as opposed to GFA domains). This entailed developing a new NinJo layer: the Aviation Warning Event Manager (AWEM) led by Gilles Ratté.

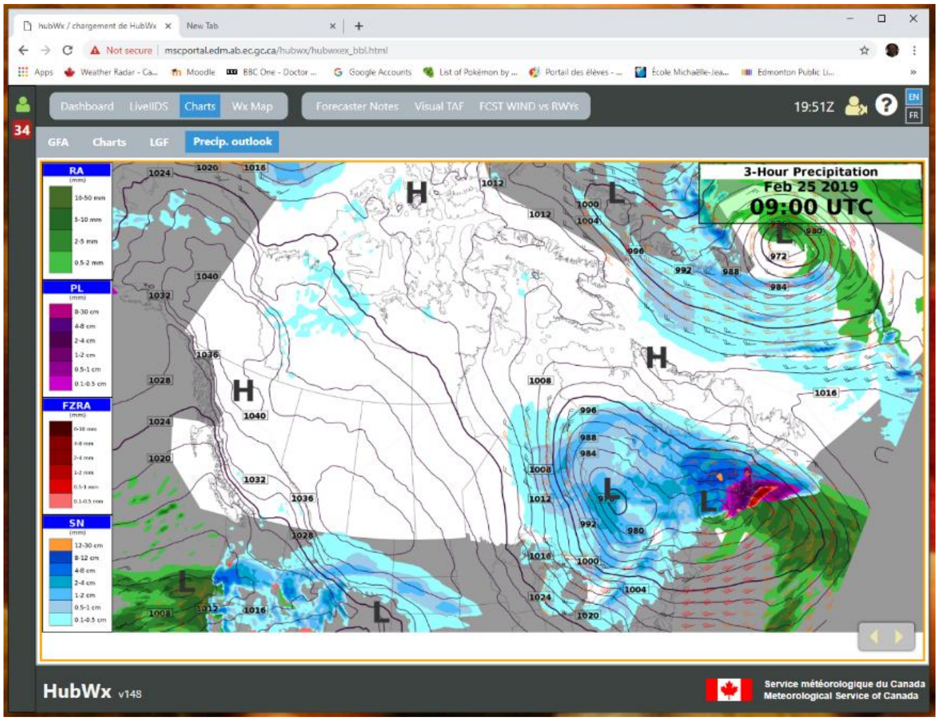


Figure 32 NinJo

NinJo has become much more powerful and has enabled the retirement of old software. There has been ongoing development of better TAF guidance and first-draft TAFs (AutoTaf), and they were added to NinJo, but I understand that only a few forecasters use them. I do not know how the TAF modernization plan and CONOPS unfolded, or whether the strategic vision ever saw the light of day. Stewart Cober left MRB as he was frustrated by the lack of support and progress.

2014: while V-CMAC was considered extremely useful by the users, agreement could not be reached on funding a permanent solution, and it was shut down. However, one component (TAFPlus for four major airports) remained.

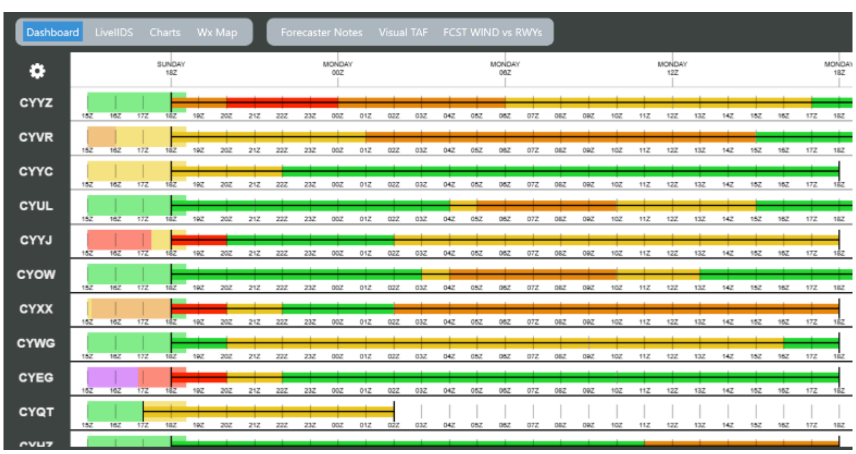


Figure 33 TafTime

2016: using modern technologies, Steven Laroche redeveloped TafTime as a web application. It is interactive, integrated with other data sets (e.g. RovingTaf, Scribe), and taps the 2.5km numerical weather model with updates every six hours. It incorporates quick reference climatology data (developed by Lindsay Sutton and Anke Kelker), WIND-3 (Bjarne Hansen), and Scribe output. It's become a mainstay in CMAC operations, an all-in-one Swiss Army knife. TafPlus was 'taken apart', and only the forecaster discussion remained.

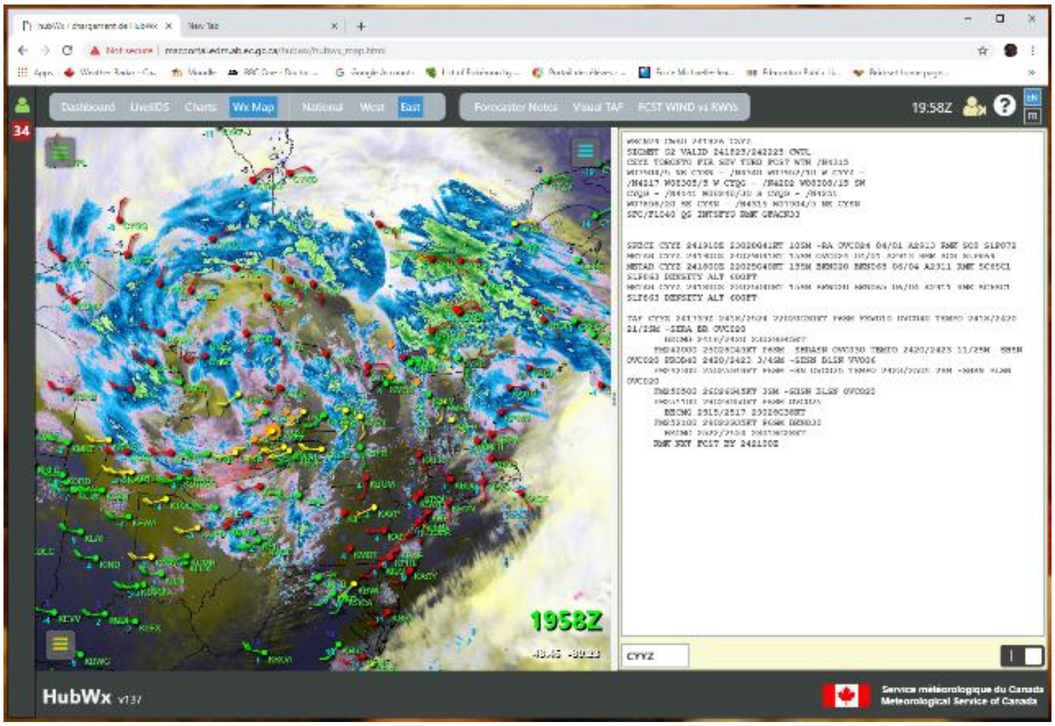


Figure 34 HubWx

2019: Phil Reddish and Steven Laroche, under the guidance of Gilles Ratté and Bruno Larochelle, developed a web-based version of V-CMAC—HubWx—that made it acceptable to users' IT managers for staff to access on their operational systems. It was added to the list of contracted services. HubSAT was incorporated into HubWx as "Live Winds". The forecaster discussion and confidence parameters were ported to the "Forecaster Notes" tab.

2020: COVID tested the entire system, with many staff in both centres affected. CMAC-Est suffered a COVID outbreak amongst a number of staff and had to be closed for 17 straight days, with CMAC-West and the JMC picking up the work.

2021: the 4th agreement between NC and EC was signed. I don't know how the negotiations went as I was not involved. I believe that it was aided by HubWx, an increased focus on hub airports, and a greater client focus.

2024: the CMACs celebrated their 20th anniversary. 20 years of stability and continual evolutionary change.

Looking back

The period between 1995-2012 saw many significant changes in how the AES (then MSC) delivered aviation weather forecasting services. In many ways, it was sailing into uncharted waters and while changes were necessary, success was not guaranteed.

A key point: changes were implemented in stages over several years and at each stage the MSC did not know if further changes would be needed. Could, at any of the stages, have the plan failed? Absolutely, and that thought kept me and others up a few nights.

As we had no endpoint in mind or an established model to follow, I'm glad that we made changes in stages; i.e. we decided on a change, implemented it, got it working, and then considered the next move; i.e. we built on success.

We did our best to create an aviation centre of excellence and a sense of ownership and identity for staff. In doing so, we discovered that forecasters enjoyed aviation weather and users appreciated our efforts. We found out that an aviation-only forecast centre is not only viable, but it can also be attractive to staff and can deliver better aviation services.

We had a singular client: NAV CANADA, and that made it easier as it could define its needs. NC was (is) not the easiest client to please but while they continually challenged us and made it known when they were unhappy, they also saw and acknowledged our efforts.

We had a long-term vision, something that is useful for managers and staff to look at as they deal with short-term challenges (the disruptions, pain, uncertainty).

We had a small, tight-knit management team that was able to make decisions and move quickly. We had great leadership with Ken Macdonald and Diane Campbell (Director-General), support from several people who worked in Client Services (Ron Huibers, Joanne Volk (Lancaster), Mike Crowe, Pete Kimbell, Merv Jamieson, Daniel Chrétien, Gilles Ratté, Mario Ouellet, Gilles Simard). We had open-minded and innovative managers running the CMACs (Rob Honch in Edmonton and Serge Désormeaux and Jennifer Milton in Montréal).

We had great support from other units in EC; e.g. Defence Services (Abdoulaye Harou. Martha Anderson, Wendy Benjamin, Jim Boyd), CMC (Richard Hogue, Nicole Bois, Rick Jones, Pierre Bourgouin, Carol Hopkins, Yves Pelletier, Peter Silva), IT (Susan Wild, Richard Serna), Downsview units (Robert Lefebvre, Luigi Bertolone, Erik Buhler, Jeff Thatcher), MRB (Stewart Cober, George Isaac), HR and Finance. (I know I have left some people out; for that I apologize.)

People in NC (esp. John Foottit and William Estrada) pushed us and helped to make things happened. Martin Kothbauer at Air Canada Jazz was instrumental in getting the users' voices heard.

We were able to get staff onboard. We were open with them: we shared the challenge, the reasons behind decisions, and invited them to come along on a journey. We engaged them in the planning, especially in the initial stages; i.e. we laid out the main goals, timeframes, constraints… and then let them come up with a detailed plan to implement changes.

When I look back, I realize just how much we accomplished in the 17-year period between 1995-2012. It was a period of great personal growth for me, a neophyte manager when it started. We pushed hard, perhaps too hard?! People were stretched to the limit. I now realize that I asked/expected a lot of managers and staff, and I worry that I caused a lot of stress.

At the end of the day, did what we do benefit the client (NC) and the end users? Absolutely.

Did it result in keeping the agreement with NAV CANADA? While no one can say for sure, I believe that it did. Overall, we did well in responding to NC's challenges, and we did not give them cause to end the agreement.

Did it benefit the MSC? I think so, as many of the things that we did are applicable to other programs. (As to what extent they have been adopted, I do not know.)

> Steve Ricketts: "*Good people who feel energized, are supported, and are given ownership and authority can do wondrous things… they can make even flawed systems work.*"

Did it benefit staff? I believe so. Most genuinely enjoy aviation forecasting, and they had (have) an alternative career path.

A side note: in 2020, the Australian Bureau of Meteorology completed a three-year plan to create aviation specialist roles and establish two Aviation Forecasting Centres (AFCs), one in Brisbane and the other in Melbourne. This was largely based on the CMAC model.

--end--

Glossary

Abbreviation	Phrase
AAPEG	Aviation AWOS Performance Evaluation Group
AAR	airport acceptance rate
AC	aviation centre
ACC	Area Control Centre
AES	Atmospheric Environment Service
AIF	Aviation Innovation Fund
AlWC	Alberta Weather Centre
ANL	Aviation National Lab
ANS	Air Navigation Service
ASEP	Automated Supplementary Enroute weather Predictions
ATM	Air Traffic Management
AVGuide	Aerodrome Vicinity Guidance Project
AWEM	Aviation Warning Event Manager
AWMB	Aviation Weather Management Board
AWOS	Automated Weather Observing System
AWSUM	Aviation Weather Services Users Meeting
AWWS	Aviation Weather Web Site
CAN-Now	Canadian Aviation Nowcasting
CARs	Canadian Aviation Regulations
CAWW	Canadian Aviation Weather Workshop
CCFP	Collaborative Convective Forecast Product
CIWS	Corridor Integrated Weather System
CMAC	Canadian Meteorological Aviation Centre
CMC	Canadian Meteorological Centre
CONOPS	Concept of Operations
CWET	Canadian Weather Evaluation Team
DND	Department of National Defence
EC	Environment Canada
FGT	first guess TAF
FIC	Flight Information Centre
FPA	Forecast Production Assistant
FRAM	Fog Research and Modeling Project
FSS	Flight Service Station
FTE	full-term equivalent
GFA	Graphic Area Forecast
GoC	Government of Canada
GriB	gridded binary
HIW	high impact weather
HIWC	High Ice Water Content Project
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules

IOP	intensive operating period
JAFMI	Joint Aviation Forecast Modernization Initiative
JMC	Joint Meteorological Centre
LGF	Local Graphic Forecast
MCC	Meteorological Coordinating Centre
MRB	Meteorological Research Branch
MSC	Meteorological Service of Canada
MWO	Meteorological Watch Office
MWSO	Mountain Weather Services Office
NAEnSC	Northern Alberta Environmental Services Centre
NAIFR	No Alternate IFR
NC	NAV CANADA
NCAT	NAV CANADA Account Team
NOC	National Operations Centre
NWS	National Weather Service
PAAWC	Prairie Aviation and Arctic Weather Centre
PMTIP	Performance Measurement TAF Improvement Project
PNR	Prairie and Northern Region
PSPC	Prairie Storm Prediction Centre
QMS	quality management system
RAD	Rapid Application Development
READAC	Remote Environmental Automatic Data Acquisition Concept
RFP	request for proposal
RSD	research support desk
RVSM	Reduced Vertical Separation Minima
SAEnSC	Southern Alberta Environmental Services Centre
SAR-NIF	Search and Rescue New Initiatives Fund
SEnSC	Saskatchewan Environmental Services Centre
SMB	Software Management Board
SPC	Storm Prediction Centre
TC	Transport Canada
TUIP	TAF Utility Improvement Project
V-CMAC	Virtual CMAC
VFR	Visual Flight Rules
WAWG	Weather Applications Work Group
WFO	Weather Forecast Office
WMO	World Meteorological Organization
WSO	Weather Service Officef