FLYSAFE – meteorological hazard nowcasting driven by the needs of the pilot

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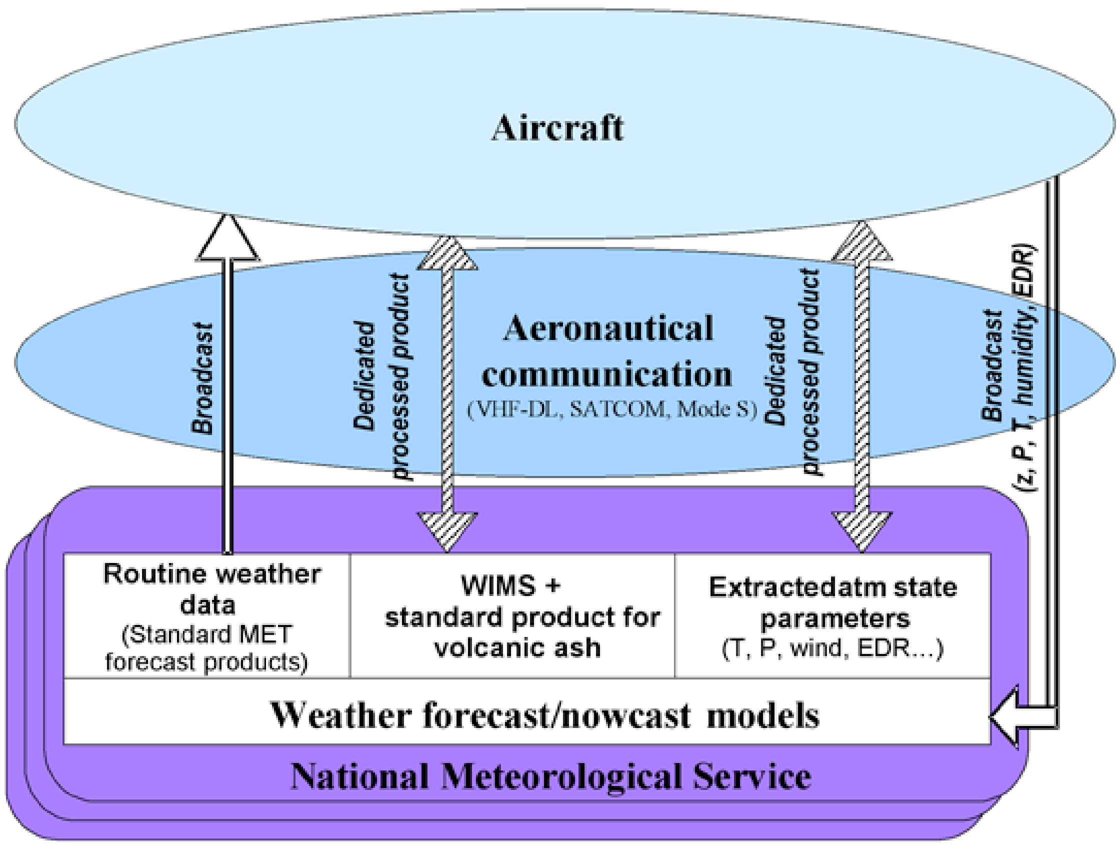
1. Introduction

The FLYSAFE project is a European Commission funded project aiming at improving flight safety through the development of a Next Generation Integrated Surveillance System (ISS). The ISS will provide information to the pilot on a number of external hazards, with particular emphasis on weather, traffic (including both air traffic when airborne and ground traffic when on the runway) and terrain. In many current aircraft information about these three hazards is provided on independent warning systems and there can be considerable difficulty in, for example, avoiding turbulence without increasing the risk of an encounter with terrain. The NGISS will have the capability of displaying information about all three hazards on a single screen, facilitating rapid pilot appreciation of the situation and the instigation of avoiding action.

One particularly innovative feature of the NGISS is that it is coupled to ground facilities which are being designed to provide the best possible nowcast of the most dangerous meteorological hazards. This is made possible by the development of so-called Weather Information Management Systems (WIMSs). The WIMSs are best thought of as expert systems which bring together all available information about the hazard under consideration and provide an optimised nowcast for aircraft at risk. In addition, information concerning hazards which fall outside the scope of the WIMSs will be made available to aircraft in flight through routine weather information.

2. Air/ground Architecture

The proposed air/ground architecture is summarised quite well in the following diagram.



What the diagram shows is that three data flows are envisaged – so-called routine weather data, WIMS products (plus volcanic ash) and atmospheric state parameters.

2.1 Routine Weather Data

This data flow includes all current internationally agreed products, including TAFs, METARs, SIGMETs, AIRMETs. These are well established products which are readily available on the ground and are commonly used for flight planning. Many are made available to aircraft in flight through a variety of mechanisms.

2.2 WIMS products (plus volcanic ash)

The WIMS will be described in more detail below. Volcanic ash is being dealt with in FLYSAFE as a special case. This is partly because the aviation community have difficulty in regarding volcanic ash products as routine weather data (as far as Volcanic Ash Advisory Centres, such as the UK Met Office and Meteo France are concerned, volcanic ash products are routine), but also because it may be possible to provide improved display of volcanic ash products to the pilot.

2.3 Atmospheric State Parameters

These are a subset of the standard output products from Numerical Weather Prediction models. They include wind, temperature, height of pressure surfaces and, ideally, turbulence products such as Eddy Dissipation Rate (EDR). However, in comparison with the other products, EDR is in an early state of development and further work is required before it can be considered as reliable as the more mature products. However, products such as these can be very useful in allowing the risk of hazardous conditions to be calculated. For example, temperature can be used to assist in the interpretation of on-board radar data.

3. WIMS products in more detail

Four WIMSs are being developed, covering Clear Air Turbulence, Icing, Thunderstorms and Wake Vortices. This selection of the most severe hazards was not without debate, and at various stages WIMSs addressing volcanic ash and poor visibility have also been considered. However as mentioned earlier, information concerning these hazards will be made available without specialised processing on the ground.

The WIMSs will generate products on three scales – the global scale, the European scale and the Terminal Manoeuvring Area (TMA) scale. For the global scale, considerable reliance will be placed on products from the London World Area Forecast Centre, which will generate gridded products which will also support flight planning.

The update rate of forecasts from the WIMS will be scale and product dependent and have not been finalised but update rates for TMA scale forecasts of 10 minutes are under consideration. Similarly the length of forecasts is scale and product dependent.

The input are meteorological data from observations (SYNOP, radar, satellite, lightning sensors, aircraft etc) and numerical models.

3.1 CAT WIMS

The CAT WIMS will address shear induced CAT, mountain wave induced CAT and CAT caused by severe thunderstorms. For the latter cause, considerable reliance will be placed on the thunderstorm WIMS. Accurate nowcasts of both shear induced CAT and mountain wave induced CAT are critically dependent on accurate nowcasts of wind and temperature and for this purpose the WAFTAGE nowcasting tool will be further developed.

3.2 ICE WIMS

As mentioned earlier, the global icing information will be derived from the existing WAFC icing product, for European scale information it is planned to use the German ADWICE system (Leifeld, 2004). Icing information on the local scale (TMA) will be produced by the French system SIGMA (LeBot, 2004) incorporating locally available high-resolution observational data sets (e.g. for Paris and other locations).

Output are meteorologically relevant parameters describing the icing situation, like estimate for super-cooled liquid water content (SLWC), temperature and icing type.

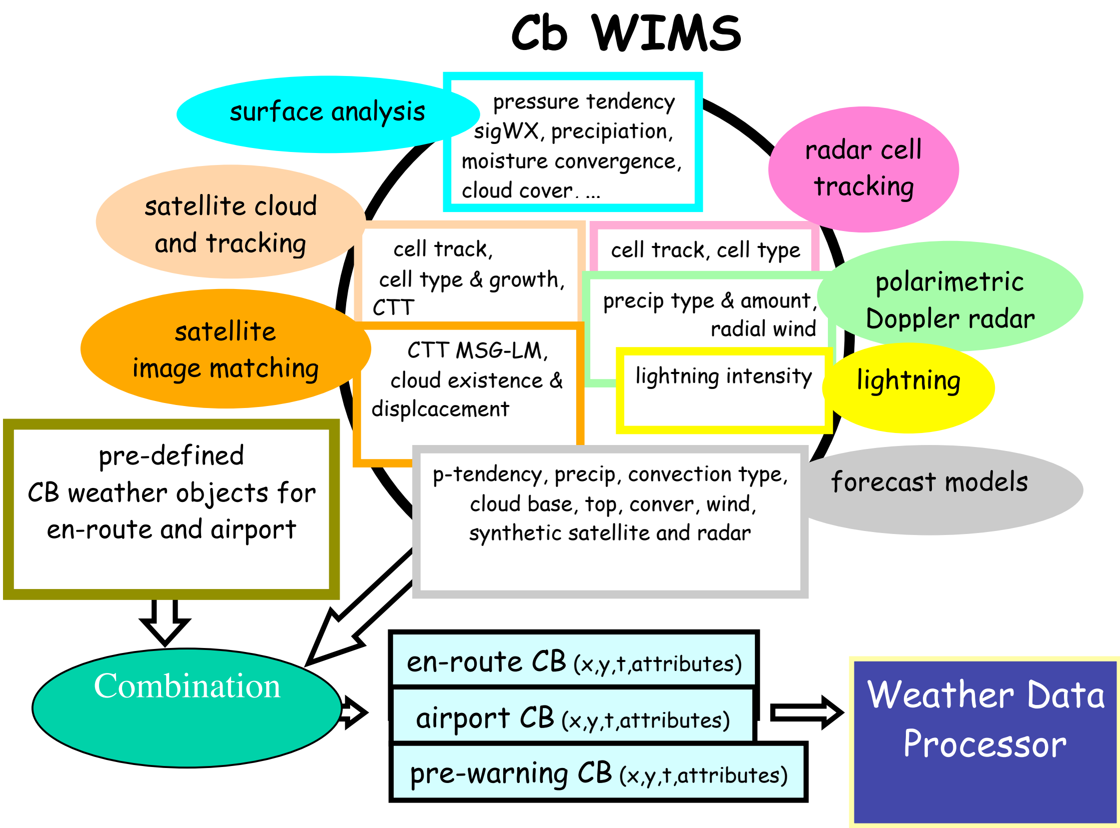
3.3 Cb WIMS

For the TMA, the Cb properties like location, size, track, its meteorological characterisation like rain, hail, wind, turbulence, lightning, and its future evolution are described in terms of Cb objects. For the European scale, object-oriented data or meteorological parameters on grids may be used. As mentioned earlier, for the global scale (over areas with low data density), simple Cb measures are provided on a grid by the London WAFC.

The thunderstorm WIMS will be developed from a number of existing systems including ASPOC (automatic thunderstorm identification and nowcasting product based on radar data, operational at Air Traffic Control for French main approaches)(Autones et al, 1999), RDT (Rapidly Developing Thunderstorm product based on METEOSAT Second Generation data providing convective cloud identification and tracking) and CONOO (Convection NOwcasting Objects: automated identification and tracking of convective cells and systems by fusion of satellite, radar and lightning data).

The thunderstorm WIMS uses meteorological data from sensors installed at the airport, in addition to the data sources available to all WIMSs.

A figure illustrating the data which is expected to be used is given below.



3.4 Wake Vortex WIMS

The Wake Vortex (WV) WIMS provides forecast meteorological parameters used for WV predictions in RVSM airspace and in the TMA (approach and take-off/climbing). For the TMA the WIMS further produces predictions of WV trajectories and strength and minimum safe time separations for two consecutive aircraft classes between the Final Approach Fix and the runway threshold or – for departures – for the take-off and climb phases. The WV WIMS uses local meteorological measurements from equipment installed at the airport, and ground-based WV monitoring data in addition to the data sources available to all WIMSs. It computes the future meteorological parameters in the RVSM airspace. It also computes the future meteorological parameters, the resulting WV behaviour, and the required safe aircraft separations in the TMA.

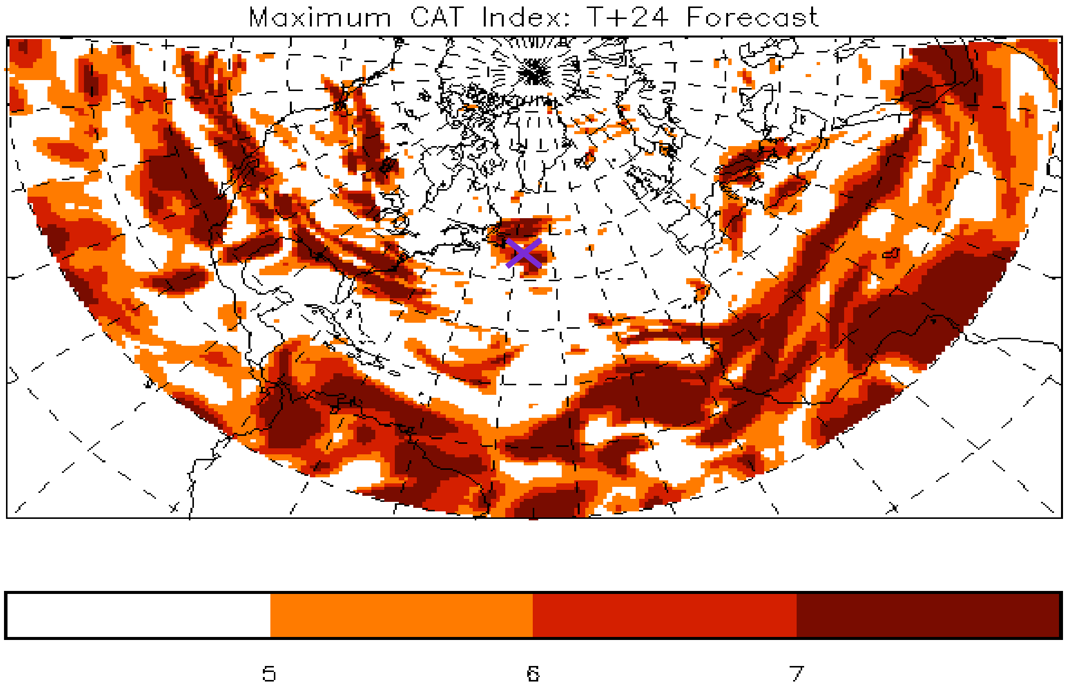
The prediction of position and severity of wake vortices will place considerable reliance on the P2P model (Holzapfel, 2003) and others.

4. Global scale products – the gridded products from WAFC London

As part of our commitments as a World Area Forecast Centre (WAFC), WAFC London is developing a range of global, gridded forecasts of hazards specific to aviation. The hazards addressed are CAT, in cloud turbulence, icing and embedded cumulonimbus clouds. These hazards comprise the full set of hazards represented on an ICAO-standard Significant Weather (SIGWX) chart, and it is anticipated that the development of these products will allow improved, automated flight planning which takes such hazards into account. In addition these products will form the basis of the global products generated by the WIMSs. Although it will be possible to update these products, which are forecasts for up to 36 hours ahead, with current observations, as a baseline solution the WIMS global products will be identical to the

WAFC products. However, there is no WAFC wake vortex product and some work will be needed to define one.

An example of global WAFC hazard product is given below. This is a forecast of the maximum severity of CAT in a vertical column. The product which will be broadcast, will specify the CAT intensity at individual levels in the atmosphere. The product below has been calculated using the Dutton formulation. It is likely that the broadcast product will be calculated using the Elrod formulation. These formulations, and others, were intercompared in Turner and Bysouth (1999).



5. On-board data fusion

After the WIMS products have been uplinked to the aircraft, they are combined with data from on-board sensors where appropriate. For example on-board measurements of turbulence can be combined with data from the CAT WIMS. This process will mean that the information provided to the pilot is the most up-to-date available.

References

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