



**Met Office**

*Airborne Integrated Systems for Safety Improvement,  
Flight Hazard Protection and All Weather Operations*

# **FLYSAFE Final Forum**

## **Weather Information Management Systems (WIMS) and Onboard Applications I**

### **Clear Air Turbulence and Icing**

**25-26 March 2009, NLR, Amsterdam**

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Page 1



# Introduction to this and following talk



- **Weather Information Management Systems (WIMs) are the heart of the ground-based systems developed in FLYSAFE**
- **WIMs covered**
  - **Clear Air Turbulence**
  - **Icing**
  - **Wake Vortices**
  - **Thunderstorms (Cumulonimbus clouds)**
- **My talk covers CAT and Icing**
- **Thomas Gerz's talk covers Wake Vortices and thunderstorms**



## Summary of this talk



- **Safety versus capacity**
- **Clear Air Turbulence**
  - **Weather Information Management System (WIMS)**
  - **On board instrumentation**
- **Icing**
  - **Weather Information Management System (WIMS)**
- **Routine weather data**
- **Airport Delay studies**
- **Looking forward to SESAR**



## Safety vs Capacity



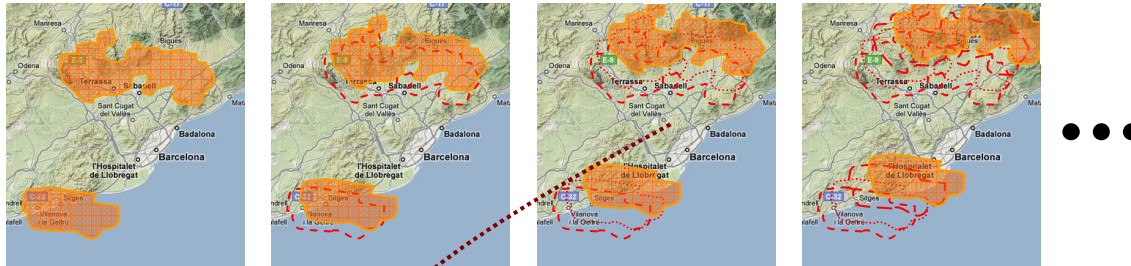
- **The main thrust of FLYSAFE has been to improve aircraft safety**
- **A significant driver for SESAR is improving capacity (although safety is important in its own right)**
- **In the US, much en-route capacity is lost as a result of aircraft seeking to avoid potentially hazardous airspace, due to thunderstorms**
- **In Europe and elsewhere, as air traffic increases and climate change increases risk of thunderstorms, the situation will become increasingly similar to that in US**
- **Both Clear Air Turbulence and Icing can affect aircraft separations**
- **At top level, safety and capacity are mutually dependent**



# Time evolution of forecasts



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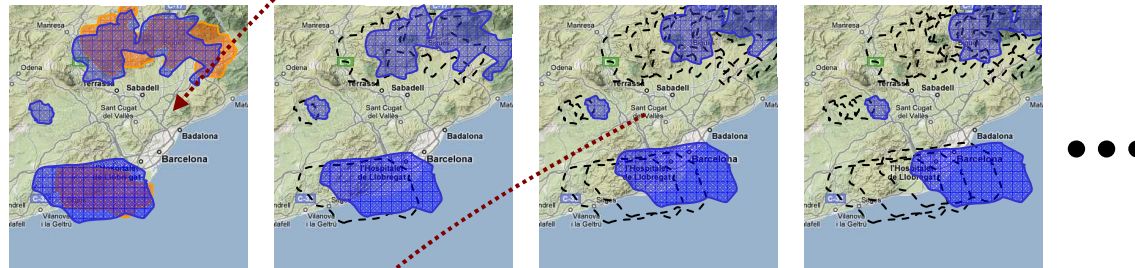
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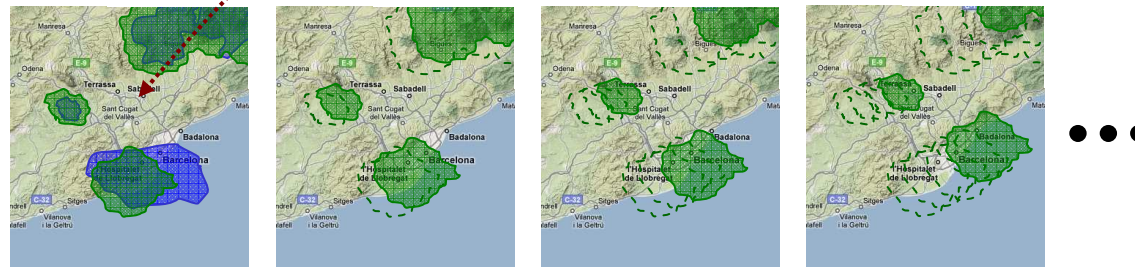
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**CAT**



- **The problem**
- **Design of Weather Information Management System**
- **Results**
- **On board instrumentation**
- **Recommendations**



## CAT- the problem



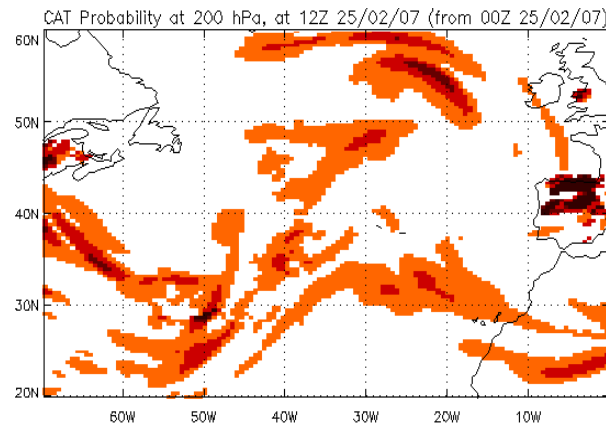
- **CAT is undetectable in aircraft weather radar**
- **Cost of a severe turbulence encounter is hundreds of K€'s**
- **Less severe turbulence can cause injuries to passengers and cabin crew**
- **Turbulence can cause autopilot drop-out leading to temporary loss of control**



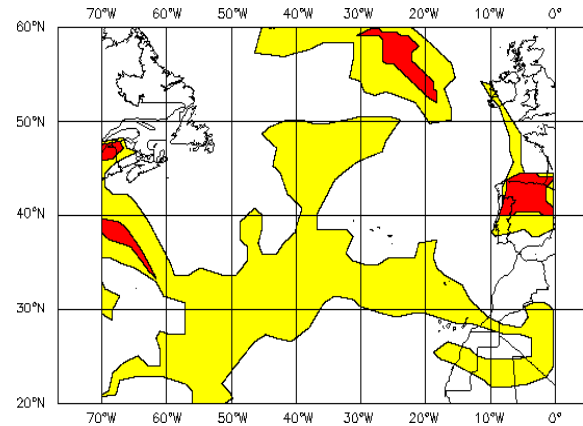
# CAT WIMS design



- 1. Global scale WIMS – based on service provided by World Area Forecast Centre based in UK, but converted to CAT objects



CAT probability per 100 km flight track



CAT severity classes

- Class 1 "light":  $3.5\% \leq \text{CAT prob} \leq 6\%$
- Class 2 "mod/severe": CAT prob  $> 6\%$





## CAT - on board instrumentation



- In FLYSAFE we realised that a LIDAR [Laser Radar] could be developed to identify areas of CAT up to 30 kilometres ahead of the aircraft
- It works by measuring variations of temperature and density ahead of the aircraft which are associated with CAT
- A data gathering instrument (pointing sideways) was flown on SAFIRE aircraft during FLYSAFE flight trials – see presentation tomorrow on flight trials
- A specifically designed LIDAR is being developed within the DELICAT project in EU Framework Programme 7
  - [DELICAT=DEtection using a LIDAR of CAT]



## CAT - recommendations



- **Need to recognise all three causes of CAT, i.e.**
  - **Shear induced CAT**
  - **Mountain wave induced CAT**
  - **Convectively Induced CAT (above or around thunderstorms)**
- **In the US there is an “artificial intelligence” system for predicting CAT – it would be good to have similar system based in Europe**
- **New algorithms for predicting CAT (e.g. Knox, McCann and Williams, 2008) should be investigated**
- **Methods for ingesting measurements of turbulence into short range forecasting packages (e.g. WAFTAGE - see later) should be developed**
- **Concepts in on-board detection, e.g. DELICAT, should be pursued**



## Icing



- **The problem**
- **Design of Weather Information Management System**
- **Results**
- **Recommendations**



## Icing – the problem



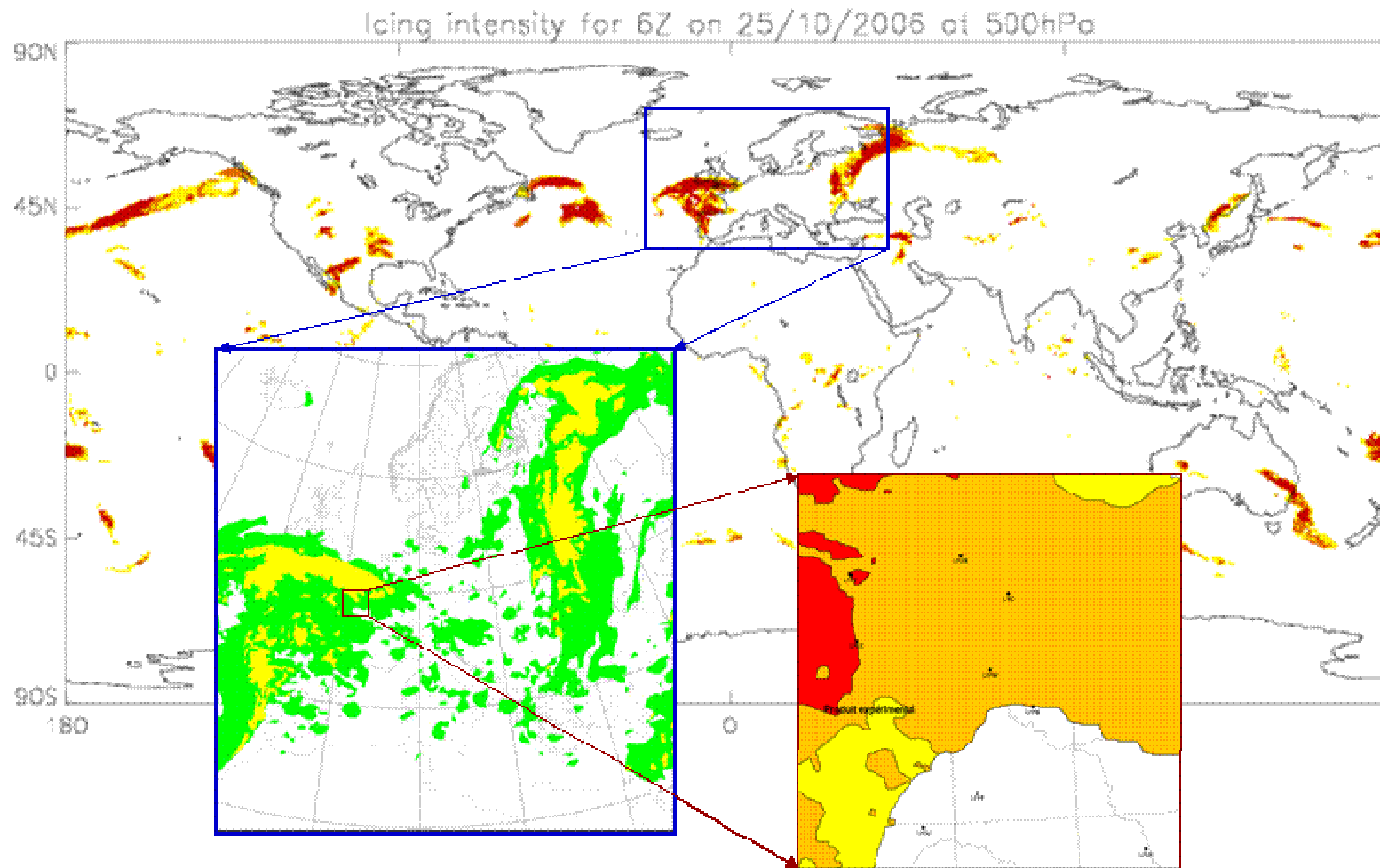
- Icing has been shown to be a factor in a number of transport aircraft accidents
- Turboprops are particularly prone to icing problems
- Flight Planning for ETOPS (Extended Twin-engined Operations) must take icing into account (because have to plan for emergency descent to ~ 14000 feet)
- Anti-icing consumes power and its use can slow aircraft down
- Icing can cause reduced aircraft separations



# Structure of icing WIMs

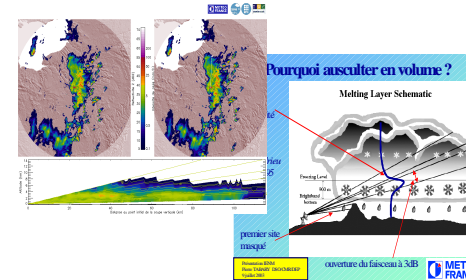
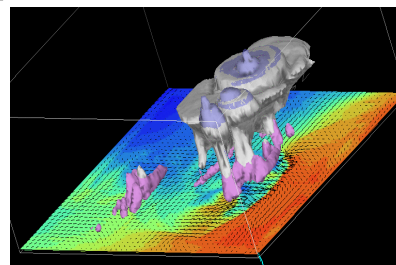
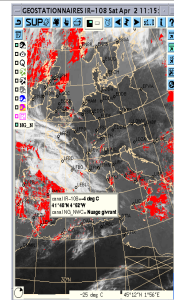
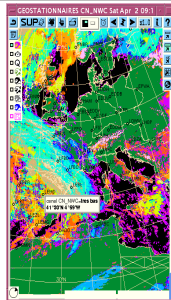
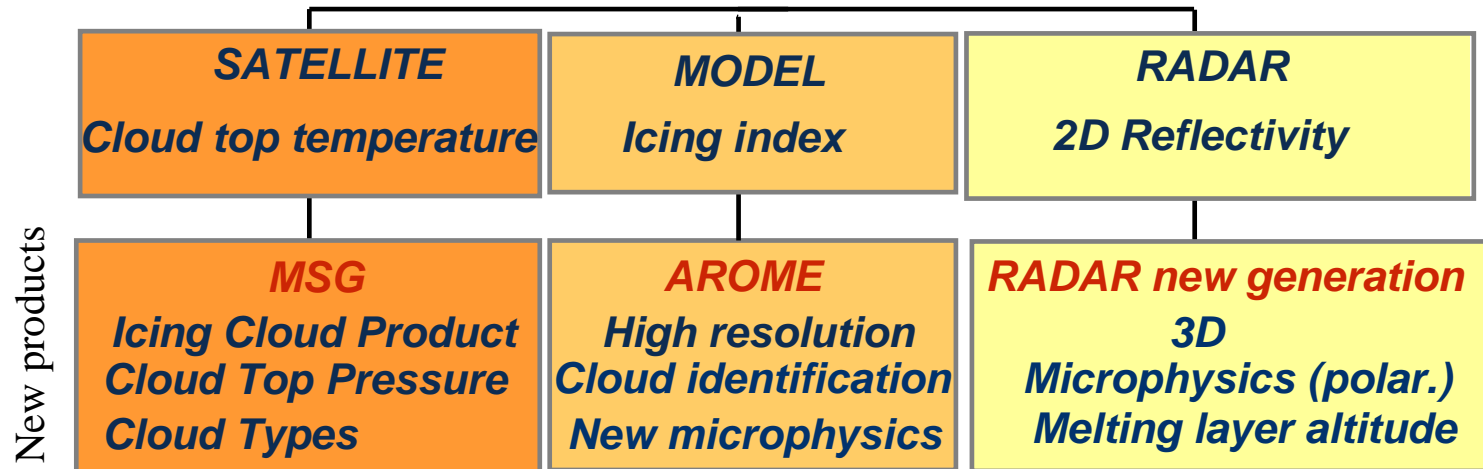


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# Advanced version of ICE WIMS in terminal area





## Icing - recommendations



- **Aircraft specific icing intensity**
  - **Although this has been researched a lot (especially in USA) it is not yet possible to develop an index which relates met conditions to effects on various aircraft types**
  - **We would like to forecast supercooled liquid water content and dropsize**
  - **Software on each aircraft would convert this into aircraft-specific threat**
- **Choice of icing predictor might be refined based on flight trials**
- **Assignment of probability values should be refined, and consistent across WIMS products**
- **Need to identify “patchy” icing areas**
- **Need to develop icing product for ATM**



## Routine weather data



- In addition to WIMS products, there is a lot of other meteorological data which is of value to aircraft in flight, for both safety and economy of flight
- Some of the data is addressed by video of “side display”, created by Meteo France, being shown during Forum
- Full list of routine weather data, prioritised by External Experts Advisory Group:
  - [WIMS data]
  - Volcanic ash warning information
  - METARs/SYNOPs
  - SIGMETs
  - TAFs/TRENDS
  - Atmospheric state information (see next slide)
  - SIGWX charts
  - Satellite imagery
  - Lightning detection system outputs
  - Numerical Weather Prediction outputs
  - Ground based weather radar data



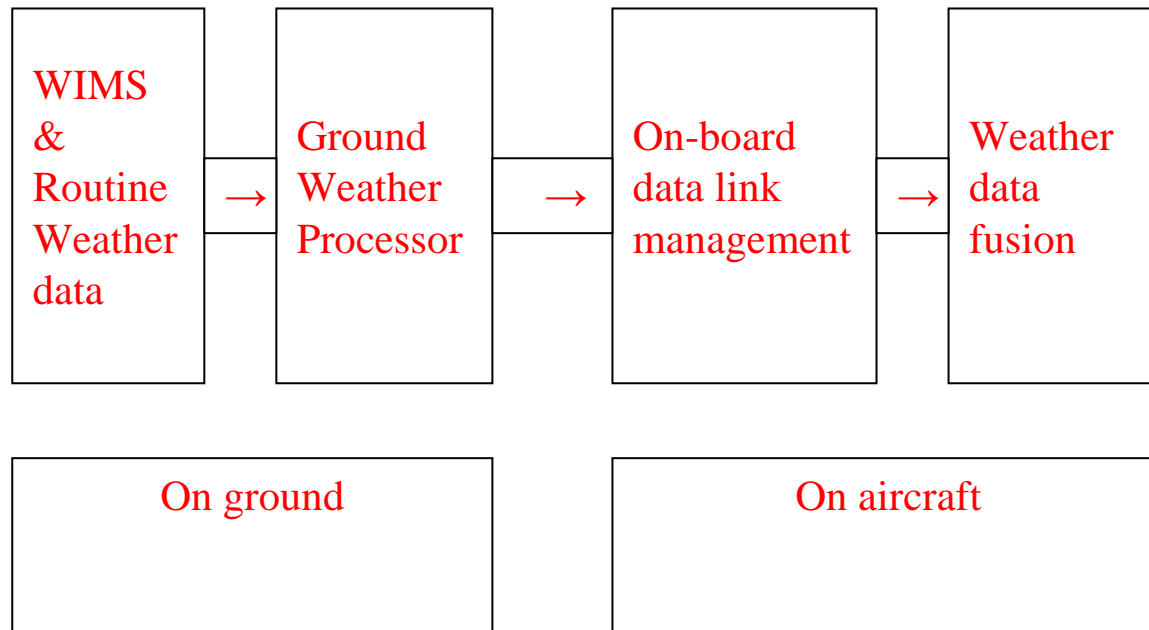
## Atmospheric state information



- **Includes wind and temperature information for whole of planned flight path**
- **Very important for accurate prediction of time of arrival**
- **Also important for enabling continuous descent approaches**
- **Major importance for SESAR**



# Architecture used in FLYSAFE



**This approach could be used to warn of birdstrikes**



## Looking forward to SESAR



- **Although focus in FLYSAFE has been on safety, safety and capacity are closely connected**
- **Uplinking complex meteorological data to the cockpit is likely to become an integral part of post-SESAR operations**
- **Accurate atmospheric state data (winds, temperatures) are essential to support 4-D trajectory prediction**
- **Accurate prediction of delays at airports also vital for SESAR**



## Conclusion



- **Questions/Hand over to Thomas Gerz**