

THUNDERSTORM FORECASTING

A new approach to
flight safety and fuel efficiency

Despite its excellent overall safety balance, air traffic still must deal with thunderstorm-related hazards on a regular basis. Mechanical malfunction in airplanes, for example, has been known to result from such storms. A typical case is when accumulating ice affects the airplane's pitot tube sensors, critical for determining the aircraft's airspeed by measuring fluid flow velocity. Up until now, extreme weather conditions could not always be reliably predicted since air and ground personnel have lacked the appropriate technical systems with which to obtain precise up-to-the-minute thunderstorm information. A viable improvement to this situation has finally become available thanks to the pioneering Cb-TRAM solution developed by the German Aerospace Center (DLR).

RUDIMENTARY WEATHER INFORMATION

The extent to which this novel technology may well be opening up a new chapter in air traffic becomes clear when the present data situation—regarding extreme weather conditions and their related problems—is examined. Beyond the obvious aspect of safety, adverse weather conditions are responsible for 50% of delays in Europe and up to 90% of summer delays in the US. Every year, aviation stakeholders must face costs in the millions due to powerful forces of nature such as thunderstorms, turbulence and hail storms. This includes costs for damages to the aircraft from hail, passenger injuries, failure of electronic systems due to lightning, additional fuel costs for large-scale deviations from

original flight paths, overtime for air and ground personnel, flight cancellations and even temporary airport closures. In other words, more precise thunderstorm forecasting would enable better strategic planning, which, in turn, would result in lower risk, increased safety and hard cash for all involved stakeholders.

Today, when pilots step on board their aircraft they are equipped with conventional printouts of numerical weather forecasts which are up to 12 hours old. A thunderstorm, however, can develop spontaneously within 15 to 30 minutes and cannot always be forecast before takeoff. This, then, means that, although pilots usually know when it is a "thunderstorm day", they only have rough estimates and limited information as to the occurrence of the actual convergence



THE CURRENT SITUATION

Pilots are provided with numerical weather charts when getting themselves prepared for the flight (left).

Weather radar provides pilots with a rudimentary frontview of the weather situation once the plane is airborne (below).



UP-TO-THE MINUTE INFO FOR EN-ROUTE AIR TRAFFIC

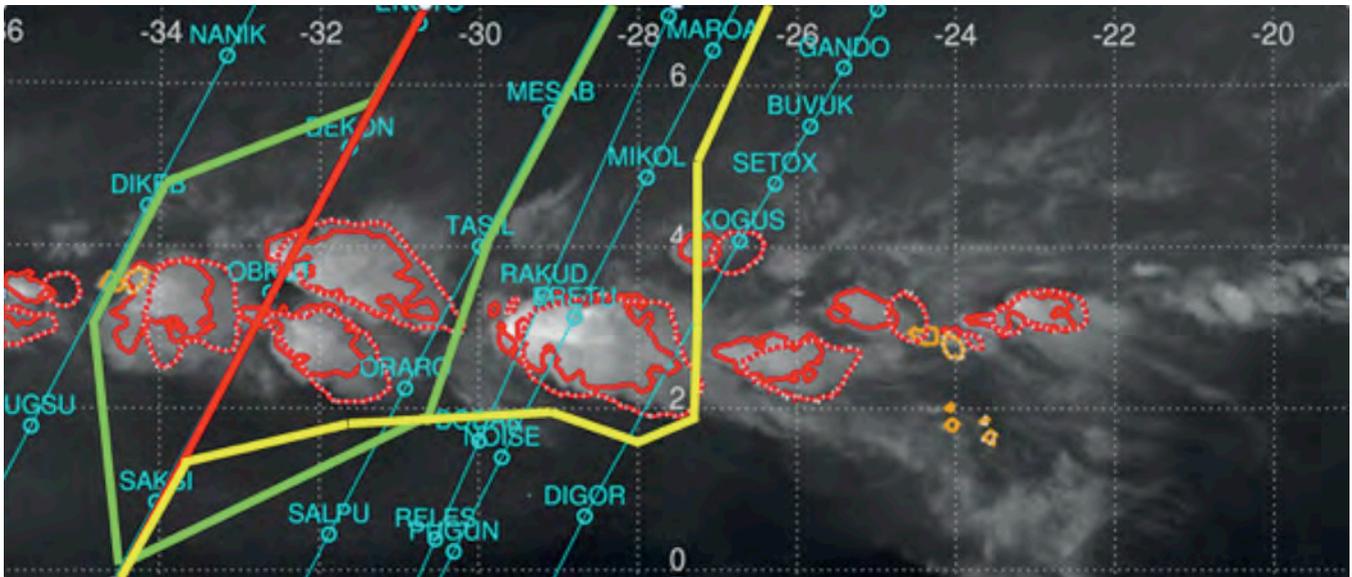
Dr. Caroline Forster and Dr. Arnold Tafferner, DLR meteorologists and the CEOs of WxFUSION, are experts in air traffic thunderstorm fore- and nowcasting. Together with their research team, they have developed an innovative technology for precise, short-term thunderstorm prediction and strategic planning. Named Cb-TRAM (Cumulonimbus Tracking and Monitoring), the technology is based on cutting-edge research in cloud physics and traffic meteorology.

The system uses satellite data from the European geostationary satellite METEOSAT to determine the size and intensity of cloud formation systems. By means of special algorithms, this data is processed to generate precise information about the development of thunderstorms up to 60 minutes in advance. The satellite data is updated every five minutes, thereby enabling almost real-time forecasting. How exactly does the software assist pilots in their strategic planning in the cockpit? The Cb-TRAM data output is transmitted from the ground to the aircraft's cockpit via satellite data link technology. The data is issued in an easy-to-read international output format (XML), which was developed as part of the EU project FLYSAFE. It is compressed into small data volumes for quick transmission to a built-in tablet-style side display in the cockpit. The display clearly shows the visual contours of thunderstorm cells as potentially hazardous objects on a

zones they may encounter en route. In terms of updates, they receive numerical data via textual messages that cannot be easily or quickly turned into a visual representation of the situation. The most important onboard instrument used by pilots to navigate their aircraft through adverse weather conditions, however, is the onboard weather radar, located in the nose of the aircraft. Scanning the airspace ahead of the plane, the radar collects data about cloud particles and precipitation for about 230 miles ahead. Depending on the cloud particle density, though, the radar's reach is limited and its sensitivity and data quality may be affected to varying degrees. Due to the "radar shadow", the radar is typically unable to provide any information about conditions beyond the closest weather front layer. Therefore, in cloudy weather, the

radar is generally only reliable for predicting weather conditions which lie 10 to 20 minutes, or around 100 miles, ahead. Furthermore, the radar has a limited horizon and does not tell pilots whether a weather front lies on either side of the aircraft. Should pilots decide to turn, then, and leave their original flight path to avoid one thunderstorm before them, they may just be heading into another storm on their new route.

Another issue that impedes smooth collaborative decision making (CDM) in difficult weather conditions is that the relevant aviation stakeholders—pilots, airport operators and flight control—presently do not share the same information regarding developing thunderstorms.



AVOIDING THUNDERSTORM DETOURS

This WxFUSION Cb-TRAM chart shows that, in fact, two gaps were missed (green lines) which would have allowed the flight to stay closer to its original flight path (red line). Thanks to Cb-TRAM, the third gap (yellow line) was taken.

One of the real benefits of Cb-TRAM is that it enables gaps to be better detected.

flight route map. The output is optimized for all types of user displays and can be integrated in electronic flight bags (EFB), information systems that are making paper printouts on board increasingly redundant. Lufthansa, for instance, uses an e-Route Manual (eRM) system in which the thunderstorm cells generated by Cb-TRAM are displayed in striking shades of red. Each object is complemented with important attributes such as speed, migration direction and cloud top height. The forecasts are updated every 5 to 15 minutes and provide additional, crucial information about the thunderstorm's potential.

FROM THEORY TO PRACTICE

Lufthansa Captain Andreas Ritter is quite impressed with the Cb-TRAM technology. As the head of the airline's eFlight-Ops project in the context of Lufthansa's e-enabling program, he was responsible for testing Cb-TRAM for Lufthansa in collaboration with WxFUSION last year. Ritter acquired first-hand experience of the

contrast between conventional onboard weather information and the Cb-TRAM data while crossing the Intertropical Convergence Zone (ITCZ), one of the most thunderstorm-intense areas in the world, in February 2013. During that flight from Rio de Janeiro to Frankfurt, the Cb-TRAM information ended up leading to rather different choices on the part of the pilots while crossing the ITCZ. Ritter and his two co-pilots had brought with them an hours-old conventional paper print-out of the weather forecast chart for midnight and 6 a.m. that day. Ritter calculated that at around 3 a.m. they would encounter the margins of the large cloud system moving into their flight path from the west, which could be easily circumnavigated with a minor deviation, and that they would only be facing a larger weather front much later over the Canary Islands. Ritter explains: "We were a bit disappointed, since we'd been hoping to experience a thunderstorm area in the ITCZ so we could try out the Cb-TRAM system, but it looked like it just wasn't going to be." So Ritter decided to take his

mandatory rest time during the first part of the flight and leave navigation to his two co-pilots until they approached the Canaries.

At this point in the flight, the crew had not yet switched on the Cb-TRAM as it had seemed unnecessary. However, by the time they approached the area which had been forecast as the outer margin of a cloud formation, the radar showed that they were heading straight into an extensive area of thunderstorms with intense thunderstorm cells. A huge cloud wall appeared before them. Therefore, the crew, still without the help of Cb-TRAM at that point, decided to deviate from their flight path to 120°, which took them completely off their original course of 90° and in the direction of South Africa.

When Captain Ritter was woken up by his co-pilots a little later in this phase, he quickly uplinked the latest Cb-TRAM data to the Lufthansa eRM system and was provided with a much more precise picture. He immediately saw that, earlier on, they had missed a safe gap between thunderstorm cells which would have allowed them to stay much closer to their original course. Unfortunately, the radar system had not detected this gap. Says Captain Ritter: "Had we uplinked the Cb-TRAM just a few minutes earlier, we would have seen it and could have avoided the 300-mile deviation."



ELECTRONIC SUPPORT THROUGHOUT THE FLIGHT
Cb-TRAM on a Lufthansa EFB in the cockpit.

Ritter explains, “Overlooking a gap between cells—what happened to us—probably happens somewhere each and every day. One of the real benefits of Cb-TRAM is that it enables us to better detect such gaps. It can even prevent us from flying into thunderstorm ‘cul-de-sacs’ from which there’s no way out. The benefits of this technology are clear: With the full cloud top view—information that the radar doesn’t provide—and short-term thunderstorm information, the system enables us to avoid lightning and icing and gives us increased safety. And at Lufthansa, safety is by far what’s most important to us. The system also allows for a more comfortable flight since it helps us to circumnavigate turbulent areas. And it saves fuel, too, by showing us more effective routes.” Captain Ritter’s conclusion? While on the whole, there may not be a huge number of flights where the benefits of the system fully come to bear, for those flights where it can make a real difference, “it’s a great addition to the radar and an impressive product—I’m excited about it.”

INTO THE FUTURE

After his successful tests, Captain Andreas Ritter presented the WxFUSION product at the EFB Users Forum of the Airlines Electronic Engineering Committee (AEEC) in Stockholm last May. “The response was overwhelming,” Ritter re-

ports. “No other presentation at the event attracted so much interest, both from aviation stakeholders and the media.” Lufthansa is presently working toward completing and certifying the necessary airside and landside data transmission infrastructure required for fully establishing the system, which is expected for 2015. While Lufthansa is a global front-runner in terms of onboard data transmission electronics, such as its in-flight WiFi service FlyNet, establishing Cb-TRAM may prove a realistic, yet somewhat longer-term objective for airlines whose data transmission infrastructure is not quite as advanced.

At the same time, WxFUSION is further developing its system on other fronts. In addition to Cb-TRAM, the company offers two other fully operational products: Rad-TRAM, the airport-side equivalent to Cb-TRAM based on ground radar weather information and geared toward airport decision-makers, and AutoAlert, a thunderstorm e-mail alert system for airports. By providing consistent thunderstorm information on the ground and in the air, the technology aims to improve common decision making. The Cb-TRAM system itself is undergoing worldwide expansion to become Cb-Global and will soon be tying in satellite data from the Japanese satellite MTSAT and the Indian satellite INSAT for long-term global coverage.

■ FRANZISKA MOSTHAF

WxFUSION

WxFUSION stands for Weather Fusion of User Specific Information for Operational Nowcasting. WxFUSION GmbH was founded as a spin-off of DLR’s Institute of Atmospheric Physics. Its CEOs are DLR meteorologists Dr. Caroline Forster and Dr. Arnold Tafferner, experts in numerical weather forecasting, integrated systems design, aircraft icing, winter weather and thunderstorm nowcasting. WxFUSION’s central mission is to make innovative thunderstorm information accessible to the market and to turn the results of scientific research into market-ready applications. The focus of WxFUSION’s most recent research has been on operational installations that have been tested and flexibly adjusted to the users’ or clients’ specific requirements. The company considers itself a bridge between operational needs for real-life applications and scientific research. In addition to ensuring a strong direct link both to the world of research and the market, the company looks after operational delivery and software support for its clients.

WxFUSION is presently bringing three fully operational and successfully tested systems to the market. While the satellite-based Cb-TRAM is a technology primarily aimed at long-haul flight applications in upper airspace, its counterpart for ground and airport applications, such as air traffic control, is the radar-based Rad-TRAM software, now fully operational within the German Weather Service (DWD). The system’s data output is then transmitted to the German Air Navigation Service (DFS) and updated every five minutes. WxFUSION’s third market-ready technology is AutoAlert, a visual e-mail thunderstorm warning system for airports which is already in operation at Munich airport. AutoAlert emails are generated automatically and sent to aviation stakeholders whenever thunderstorms approach or enter the terminal maneuvering area of the airport.

Beyond this, WxFUSION has various other tools in the developmental phase and is working toward making them operational. The company also aims to develop new methods that will expand the applications of its products to society at large. By opening up its technology to additional target groups—civil defense, agriculture, and large-scale event planners—WxFUSION hopes to make our lives just that much safer.

More information can be found at:
www.WxFUSION.com