CUMULONIMBUS - MORE FRIGHTENING THAN BENGT'S MOTHER-IN-LAW?

By John Barrass

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The number one killer in aviation in the 1990s, controlled flight into terrain (CFIT), is still a major cause of fatal accidents but the advent of ground proximity warning systems has reduced the number of CFIT accidents dramatically. As the years pass by, we as an industry are certainly getting safer and, as we approach the end of the first decade of the 21st century, Loss of Control (LOC) is now the focus of concern for those involved in aviation safety. However, looking back over recent years' accident statistics, a contributory factor in many CFIT and LOC accidents is weather. Failure to ensure the adequate de-icing of an aircraft prior to departure has been a recurring cause of LOC accidents over the years, and several recent accidents have occurred when an aircraft encountered severe thunderstorms (cumulonimbus clouds) and the associated downbursts, or microbursts.

In 2007 there were a number of accidents which occurred in weather conditions which included thunderstorm activity:

- On 5 May 2007, a Kenya Airways B737 departing Douala, Cameroon crashed shortly after take-off in a thunderstorm.
- On 16 September 2007, a One-Two-GO MD82 crashed at Phuket while attempting a go-around in heavy rain and strong crosswinds associated with a severe thunderstorm over the airport.

Both of these accidents are still the subject of investigation, and the primary cause of the accidents may not be weather. Nevertheless, these accidents serve as a reminder of the powerful nature of weather associated with cumulonimbus clouds, particularly downbursts, and the threat they pose to flight safety.

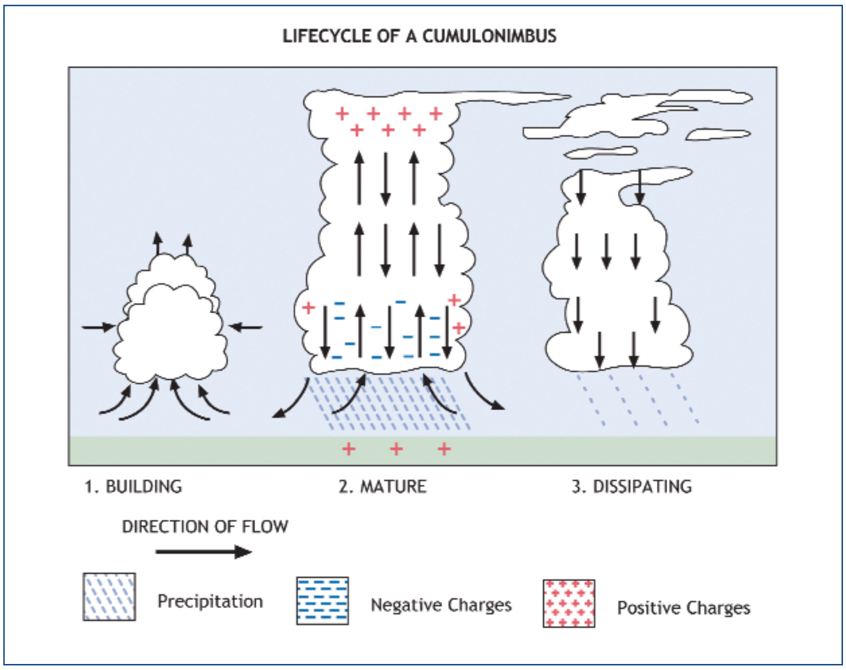
Cumulonimbus: A heavy and dense cloud of considerable vertical extent in the form of a mountain or huge tower, often associated with heavy precipitation, lightning and thunder. The mature cumulonimbus cloud has a distinctive flat, anvil-shaped top.
http://www.skybrary.aero/index.php/Cumulonimbus

Cumulonimbus clouds form when warm, moist air rises in unstable atmospheric conditions. The rising air draws more warm air up into the cloud where it continues to rise and condense into cloud and precipitation. Strong updrafts within the cloud carry rain

and ice particles (hail) aloft. The tops of the cloud may reach, and breach, the tropopause. The hail and rain falls towards the surface and may be carried back aloft by further updrafts of air. As this cycle continues, the droplets and hail become heavier and larger and static charges build up within the cloud, which discharges as lightning. In severe cases, where the vertical updrafts in the cloud become cyclonic, tornadoes can form underneath the cloud.

As the cumulonimbus cloud matures, the rain and hail eventually falls to the surface dragging cold upper air with it. At this stage in the lifecycle of the cloud, strong updrafts and downdrafts within the cloud create severe turbulence. The downdrafts can be very powerful, with vertical winds of 6,000 ft per minute. When a strong downdraft, referred to as a downburst or microburst, hits the surface, the wind diverts horizontally outwards. Downdrafts ahead of a cumulonimbus cloud push warm surface air upwards, a little like a cold frontal system, often

http://www.skybrary.aero/index.php/Cumulonimbus



creating a wall of cloud commonly referred to as a gust front.

In time, the downdrafts of cold air choke off the supply of fresh warm air entering the cloud and the cloud begins to dissipate. This whole process may last less than 1 hour but many storms contain numerous cumulonimbus cells in various stages of development.

Downburst: A downburst is created by an area of significantly rain-cooled air that, after hitting ground level, spreads out in all directions producing strong winds.

Microburst: A type of downburst affecting an area 4 km in diameter or less (term defined by severe weather expert Tetsuya Theodore Fujita) http://www.skybrary.aero/index.php/Microburst

Downbursts are a particular hazard to aircraft at low level, especially on take-off or landing. An aircraft approaching a downburst will first encounter a strong headwind, which will lead to an increase in indicated airspeed. When trying to fly a set airspeed on approach, a pilot might therefore be tempted to reduce power. This would be very dangerous because, as the aircraft passes thorough the downburst, the wind becomes a tailwind and the indicated airspeed and lift drops. The significant downward force of air in the downburst may be enough to force the aircraft into the ground or at least cause it to lose a significant amount of height. The subsequent loss of performance, as the aircraft encounters tailwinds, may cause further loss of height and be enough to cause the aircraft to stall. Once caught in a downburst, escape is only possible by flying straight ahead; whichever way an aircraft turns, it will encounter the tail winds and the associated performance impact. If the aircraft is in a turn at that point then the stalling speed will be higher, possibly making the situation worse.

Wind Shear: a sudden change of wind velocity and/or vector. Wind Shear may be vertical or horizontal, or a mixture of both. http://www.skybrary.aero/index.php/Wind_Shear

Detecting a downburst is not easy. The effects are usually localised and, if the precipitation evaporates before reaching the ground (Virga), may not necessarily be associated with heavy rain or hail. Many airports which experience regular severe thunderstorms have systems in place to detect wind shear, often comprising anemometers in a network around the airport. In the USA, this system is known as low-level wind shear alerting system (LLWAS). This type of system detects the variability of the wind in a horizontal layer which is an indication for wind shear and/or microburst. A limitation of such systems is of course that it only detects wind shear at ground level. Hong Kong airport has a sophisticated system for detecting wind shear which combines a network of anemometers with Doppler weather radar and a LIDAR (LIght Detection And Ranging) wind shear warning system which can detect the movement of much smaller particles than a conventional weather radar, like dust particles, and therefore can more effectively detect wind shear in dry air. This is particularly important at Hong Kong

http://www.skybrary.aero/index.php/Microburst
http://www.skybrary.aero/index.php/Wind_Shear

where wind shear is caused by terrain effects as well as weather.

Many modern aircraft, such as the B777, have predictive wind shear (PWS) warning systems which collect wind velocity data gathered by the weather radar to identify the existence of wind shear. These systems have a short range, and are dependent on the radar picking up velocity data from water and ice particles ahead of the aircraft and so don't work in dry conditions, but they are effective, providing the pilot with an opportunity to abort take-off or carry out a missed approach.

Thorough weather briefings, contingency planning , appropriate use of the weather radar, listening to ATIS at regular intervals, access to up-to-date actual weather conditions, warnings and forecasts, asking for reports from other pilots, as well as looking for the visual clues (cumulonimbus clouds, mammatus clouds, gust fronts, heavy precipitation, lightning, etc), and familiarity with local weather phenomena (at certain times of the year, some airports have predictable thunderstorm activity which can be avoided by careful scheduling of flights), all help to provide the flight crew with the best chance of avoiding downbursts and making the right decisions to safeguard the safety of the flight.

Mammatus Clouds: Lobes or pouches of cloud which hang down from the base of a cloud. The name comes from the Latin mamma which means breast. Mammatus clouds are normally associated with severe Cumulonimbus clouds and are indicative of Wind Shear. http://www.skybrary.aero/index.php/Mamma

Mammatus clouds are an indication of an extremely unstable air mass (and the associated shear) with the likelihood that cumulonimbus clouds could develop

http://www.skybrary.aero/index.php/Mamma

Imagine trying to read a complex terminal approach plate, maintain an instrument scan, at night, in poor visibility, and in moderate turbulence, while also trying to assimilate information from the weather radar, air traffic control and other aircraft on frequency. Even without the potential loss of control that can occur when encountering a downburst, the workload and physical stresses placed on a crew flying in bad weather should not be forgotten, especially by the crew themselves! The trick of course is not to get into that situation in the first place - and that is dependent on 2 things, the accuracy of the information and the airmanship (decision-making skills) of the crew.

In the end, it is the aircraft commander's decision whether to continue, hold, or divert. In these days when a crew have numerous means of communication available to them, information and advice are easier to come by, improving the decision-making of the captain. The decision to carry out a missed approach, or divert, clearly has a commercial implication. It is not unreasonable for a captain to confirm with his company operations what they would prefer him to do given the options he has available to him, but that preference does not ever constitute an instruction - the responsibility and authority remains with the aircraft captain.