C.C.J.'s COLUMN

JETS AND TURBULENCE

WE have now had some 20 catastrophic jet accidents, and about as many serious incidents, in which that mystic trilogy—handling technique, turbulence and lift margin—joined in various proportions to form an obscure but diabolical confederacy. Of these only the first is usually associated with a name—that of the pilot; the second, turbulence, used to be regarded as an act of God but now the meteorologist seems to have been called in as a deputy; the third, lift margin, remains largely anonymous.

Meteorologists have been reviled throughout the ages, and no doubt of course they have their lapses; but is it reasonable to put upon them the burdens they are now being asked to undertake in the field of high-level and low-level turbulence measuring and forecasting?

The heat has been on for high-level turbulence forecasting since 1950 when a few large blown-up fuselages began to float about over 30,000ft; now there are quite a lot of them up there and the inexorable law of probability cuts in with something more than a noticeable severity. As one turbulence accident piles upon another, "Where's the forecaster? Why aren't these boffins doing their job and keeping the aircraft out of such conditions?" goes the cry from the design office. And so we see the pressures building up from manufacturer to operator, to the governmental met service and so on to ICAO.

Now it might not be too unreasonable to look to turbulence prediction as the saviour if there were a good chance of success, but what really are the chances of the met man drawing a high-level turbulence chart with firm lines? And if the lines are not at least as firm as those of the pressure system or of a frontal position (and they are infirm enough), how can the pilot make an intelligent flight plan to avoid all risk of severe turbulence? Some advance has of course been made in associating high-level turbulence with the jet stream, but the stream itself can shift with some rapidity in a horizontal or a vertical plane; 2,000ft upwards and the level at which turbulence was expected (and therefore circumnavigated in the flight plan) is now as smooth as a mill-pond; a shift of 30 miles to the side and the fixed-wing aircraft, having planned to go about its business with a well established angle of attack, now finds itself required to play the role of the ornithopter with an angle of attack which is entirely unpredictable. Additionally, of course, high-level turbulence can occur quite independently of the jet stream and so prove even more elusive.

ICAO is launching a world-wide campaign of turbulence analysis, and currently aims at four periods* of intensive reporting by all turbine aircraft flying over 20,000ft. Obviously the more we know about the incidence, magnitude and spectra of gusts the better and such a campaign deserves the full support of the whole industry. However, my fear is that the manufacturer, pushed as he is to mill off more aluminium and to increase the Mach number, will sit back and wait for this campaign to demonstrate how a better met service (which would permit a refined flight-planning system), plus perhaps better navigational aids (which would permit more flexible flight paths), can justify the retention of existing formulæ for structural integrity and satisfactory flying qualities.

I do not think that even a very successful attack on high-level turbulence reporting and forecasting (or on low-level for that matter) will remove the need to increase structural strength at critical points, to design more lift at the wing-tip and to eliminate all cross-coupling of controls (as in the Dutch roll). Nor do I think that the problem of irrecoverable upsets is entirely solved simply by increasing the recommended penetration speed from the minimum margin above the stall to the maximum speed associated with the design limit load —an increase of about 60kt recently recommended by Boeing.

At the design limit load the safety factor of 1.5 compares doubtfully with that of 2.5 of ICAN days or 5.0 with the bridge builder. Even with meticulous design, scatter effects remain high, an inadvertent increase in speed will eat rapidly into the margin, especially at levels below 20,000ft, and one should not have to fly at Vmo save in an emergency. Turbulence, in my opinion, is not an emergency. Further, any substantial increase in the penetration speed will, in the modern jet, tend to bring on a separate set of problems in that it takes the aircraft near or into the high speed buffet regime. Admittedly the onset of buffet with speed and altitude is likely to be gradual but nevertheless it brings with it a definite degeneration of the lift and, with the modern swept wing, lift margins in this regime are already small.†

As far as I am concerned, therefore, it is absolutely no use putting the responsibility for the wing-over type of accident on the met man and telling him to find out more about turbulence. To me the wind is always likely to blow to a large extent where it listeth; but aeroplanes should be flyable even though the wind listeth vertically at 66ft/sec. Further, if an upset does occur, the controls should respond in such a way that the average pilot can effect a quick recovery: no lag, no over-control, no cross-coupling. And (to bring up to date the old adage) aeroplanes should fly in turbulence safely and not break up.

The fault is not in our stars but in ourselves that we are underwinged.

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* March 11-15, June 10-14, September 9-13, December 9-13.

† More especially so if they are derived from a basic stall which has been undervalued in the first place—see "Minima & Manœuvrability I—IV," *Flight International*, March 7, April 4, April 18 and June 13, 1963.

IAC's Jet Programme

UP to ten Caravelles may be bought by Indian Airlines Corporation, according to the airline's general manager, Mr S. Mullick, in an interview with *Flight International*. The first of four 6Rs so far ordered was handed over to IAC's president at Paris Orly on December 12.

By 1966-67, when all ten Caravelles will be fully extended (at 3,000hr a year) meeting trunk route needs, IAC may be in the market for Trident/727 class jets. A fleet of six would be needed to supplement the ten Caravelles in the period 1967-1971, according to IAC's present best estimates. An order for the Trident or 727 would thus probably have to be placed before the end of 1964.

Mr Mullick says that IAC has no requirement for the 748 Series 1, which falls short of IAC's performance specification, but he feels that the 748 Series 2 would fulfil IAC's need to augment regional route capacity at present provided by Friendships. He estimates that up to four 748 Series 2s—Indian-built of course—would adequately supplement the fleet of ten Friendships over the period 1966-1970. IAC would for obvious reasons prefer to standardize on a one-type fleet of F.27s, but recognize the need to encourage the Indian aircraft industry. In any case, foreign exchange might not be available for importing further Friendships as well as Tridents or 727s—especially as IAC also have to replace their 12 Viscounts with jets of the One-Eleven/DC-9 class.

A fleet of 14 One-Elevens or DC-9s will, Mr Mullick estimates, been needed to replace IAC's 12 Viscounts and to meet the fast-increasing regional and trunk route traffic at present carried by these aircraft. The One-Elevens (or DC-9s) would begin to take over from Viscounts in 1966-67, by when six would have been delivered. A decision between the One-Eleven and the DC-9 would have to be taken before the end of 1964 to meet these delivery