The average weight of one

How much is the average (or typical) weight of a group of one elephant and four ants?

You can choose either one tonne (yes! – 1000kg) or 0.3 milligrams, both are correct! Both those figures are valid averages or 'typical' weights. If the elephant weights 5 tonnes and the ants weigh 0.3 milligrams each then the arithmetic average, otherwise known as mean, can be obtained by adding up all the weights and dividing by five - the number of members of this strange group. The result is a mean value of one tonne for every ant. But there is another measure of average called the "mode", which is the most frequently met weight in our group – 0.3 milligrams – the weight of each of the 4 ants. One can use a different kind of average each time because the word "average" has this loose meaning. There is also a third 'definition' of an average called "median" but let us stop here.

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All that said about the different ways of arriving at an average, what can you expect when you are told Mach 0.79 is the average cruising speed of an A320? It may help you if the aircraft flies just at this 'normal' speed without optimising it to take account of the consequences for the flight of maintenance costs, passenger delays and fuel. This speed may have meaning to an aircraft manufacturer or a certification authority. But, unless we are speaking of a great difference in the ranges – like in the case of en-route spacing between a wide body jet and a regional jet, it does not tell you a great deal about the actual speed of the aircraft you will have on your frequency today. One can go further with this argument. It is not uncommon for procedures and safety assurance calculations to assume a single performance value rather than a range within which the value can lie. The result is a rather simplistic expectation of performance, not only for aircraft, but also for ATM systems.

Working with ranges has a clear drawback – you do not know precisely where in the possible range the cruising speed will be. Or to take another example – in the case of High Intensity Runway Operations at busy airports, the time which aircraft spend on the runway needs to be minimised in order to achieve maximum capacity. This runway occupancy time for a landing aircraft can vary quite a lot and depends on a number of factors, including the touchdown speed of the aircraft, its deceleration capability, the availability of Rapid Exit Taxiways, the actual braking action, etc. This makes the expected occupancy time for a given aircraft only a guess, or expressed more for-

elephant and four ants...

mally, probabilistic. There are well-known human biases when our brain "rejects" thinking in strictly probabilistic terms. In these cases, we have a difference between what actually happens and what we thought would "probably" happen.

What can be done?

One solution is to work towards better measurement, seeking to make the world more deterministic and less probabilistic and turning away from the guess work. At an airport which relies on high-intensity runway operations, you can measure the actual duration of runway occupancy over time and find, for example, an "average" of 50 seconds for this occupancy. This average may not be enough to get the capacity you need and, on top of that, delivery of the desired occupancy will be very uncertain. It will vary within quite a wide range and you can get 40 seconds in some cases but also 1-2 minutes with crews not familiar with the airport missing the exit by just a little and rolling slowly to the next available exit. Yet saving just 5 seconds often provides an opportunity to add another movement to the hourly total achieved. A common practice in this case is to reduce the range of possible occupancy time by working with the aircraft operators and their crews with a view to raising awareness and encouraging crews to expect and plan for a given exit.

Another great example where measurement moves the probabilistic guess world of ATC towards a deterministic one is the Mode S functionality for downlinking such parameters as selected altitude, ground speed, magnetic heading, vertical rate, TCAS RA, indicated airspeed and Mach number. Having the exact Mach number, you will not need to try and figure out how much the cruising speed will "dance" in the possible range around the "average" Mach 0.79 for this A320 that you have now in your sector.

If you know the actual performance, you can run the most optimal plan and deliver the most efficient operations. If you do not have the actual performance to hand then you have to work with ranges. Working with ranges means we have to add in extra protections, additional lines of defence, one more buffer in case the actual speed is Mach 0.65 or Mach 0.80. Or, as in Bengt's case study elsewhere in this issue, the big An124 is slow to vacate the runway and becomes another factor in the chain of events endangering safety.

One cannot ask for deterministic safe and efficient performance while leaving the front line operators working in a probabilistic world.

Or, as the astonished ant would have said looking at its "average" weight – **"let's talk about the elephant in the room..."**.