The current wind parameters reported to ATC are the mean wind speed and direction; and the minimum and maximum values of the wind speed and/or the wind direction when criteria to report them are fulfilled. The Annex 3 of ICAO only mentions tailwind and crosswind as having operating limits for the aircrafts, thus leading to special local reports, but the Annex 3 only requires the report of geographic wind to the ATC, not crosswind and tailwind values. But crosswind and tailwind are also operational parameters, though not explicitly required from the Met provider. Tailwind is used to select the operational threshold of a runway and the tailwind values are especially important when noise abatement procedure is in use, in order to select a specific runway threshold, as often as possible, even with a small amount of tailwind.

Therefore, crosswind and tailwind components can only be currently calculated from the reported wind parameters. It is a simple trigonometric calculation for mean values, but the operational limits for the wind components include gusts. And gusts along and across the runway can’t be directly calculated from the reported wind parameters. An experiment was done to directly calculate the crosswind and tailwind components (min and max values) from the raw measured values. These components and their variability were compared to different ways of calculation from the usual reported wind parameters (mean values, min and max speed, min and max direction).
Possible calculation methods from the reported wind parameters

Let’s call the reported wind parameters as following:

- ff2, dd2 for the mean wind speed and direction (averaged values on the last 2 minutes).
- ff10, dd10 for the mean wind speed and direction (averaged values on the last 10 minutes).
- ffn and ffx the minimum and maximum wind speed (gusts) during the past 10 minutes.
- ddn and ddx the minimum and maximum wind direction (variations from the mean wind direction during the past 10 minutes).

The calculation of the averaged values of the crosswind and tailwind components is straightforward. The easiest calculation for crosswind and tailwind gusts is to combine the reported wind speed gust with the mean wind direction. Let's call ff2nc, ff2xc, ff2nt, ff2xt the min and max crosswind and tailwind calculated by combining ffn and ffx with dd2. If combined with dd10, the parameters are named ff10nc, ff10xc, ff10nt, ff10xt.

This combination method is probably the only one currently used to derive the crosswind and tailwind gusts from the meteorological reported wind parameters. But the wind direction associated to the maximum gust is not necessarily the mean wind direction. It can be any direction between ddn and ddx.

Another possible calculation is to combine the wind speed variations (ffn, ffx) with the wind direction variations (ddn, ddx) to calculate the possible minimum and maximum crosswind and tailwind components.

Let’s call QFU, the runway direction. The calculation steps are:

- Calculate DnQFU, the direction within [ddn … ddx] the “closest” to QFU
- Calculate DxQFU, the direction within [ddn … ddx] the “more distant” from QFU. DnQFU is also the “closest” to QFU+180
- Let’s call FFnt and FFxt the possible minimum and maximum tailwind speed. FFxt is calculated from ffx and the closest direction to QFU, DnQFU. –FFnt is calculated with the direction closest to QFU+180, DxQFU
- Let’s call FFnc and FFxc the possible minimum and maximum crosswind speed. FFxc is calculated using the direction the “closest” to QFU-90, -FFnc using the closest direction to QFU+90.

Expressed in a programming language, such as Pascal:

```pascal
Function MaxComponent(ffn,ffx : double; ddn,ddx,QFU : word) : double;
Var
  Temp, DnQFU : Word;
  QFUwithinDdnDdx : Boolean;
Begin
  QFU := QFU mod 360; If QFU = 0 then QFU := 360;
  If ddn <= ddx then QFUwithinDdnDdx := (QFU >= ddn) and (QFU <= ddx)
  else QFUwithinDdnDdx := ((QFU >= ddn) and (QFU <= 360)) or (QFU <= ddx);
  If QFUwithinDdnDdx then DnQFU := 0
  else begin
    DnQFU := abs(ddn-QFU); If DnQFU > 180 then DnQFU := 360 – DnQFU;
    Temp := abs(ddx-QFU); If Temp > 180 then Temp := 360-Temp;
    If Temp < DnQFU then DnQFU := Temp;
  end;
  If DnQFU <= 0 then Result := ffx*cos(DnQFU*pi/180)
  else Result := ffn*cos(DnQFU*pi/180);
End;

FFxt := MaxComponent(fftn,fftx,ddn,ddx,QFU);
FFnt := -MaxComponent(fftn,fftx,ddn,ddx,QFU+180);
FFxc := MaxComponent(fftn,fftx,ddn,ddx,QFU+270);
FFnc := -MaxComponent(fftn,fftx,ddn,ddx,QFU+90);
```
Reference values
The true min and max crosswind and tailwind values have to be calculated from the raw instantaneous wind values. As recommended by CIMO, 4 samples per second are used. Each sample is projected along and across the runway direction. Averaged values over 3 seconds are calculated every 250 ms and min and max values during the past 10 minutes are computed. These values are the reference values and are named \text{FFtn}, \text{FFtx}, \text{FFcn}, \text{FFcx}.

Experiment
All these parameters were updated every minute and inserted in a database. Measurements and calculations were made for the aerodrome of Bordeaux (LFBD) and Marseille (LFML) for a 5 months period in 2014.

Examples of results

At LFML, this picture shows the headwind-tailwind speeds during June and July 2014, when the QFU31 threshold is in use (preferred threshold when possible, for noise abatement procedure). For this threshold, positive values are tailwind, negative values are headwind. As expected, negative values are the more frequent. But positive values (tailwind) exists (ff2t in the upper graph, ff2xt and the reference value fftx in the middle graph, dd2 in the lower graph), with the QFU31 still in use (but no or very few planes during night).
LFML. At the beginning of this period (3 June 12h → 4 June 9h), the mean wind direction gives mainly headwind, but the high direction variability (DiffDD, bottom graph, purple curve) generates some tailwind gusts, not seen from the mean wind direction dd2. The reference value (fftx, middle graph, green curve) goes up to 5 kt. The possible minimum and maximum values (ffnt, ffxt) calculated from the wind speed and direction variability (ffn, ffx, ddn, ddx) have “larger” values than the reference, but are a good indication of the possible tailwind gusts “hidden” by using only the mean wind direction.

During the second half of the period, the wind direction has turned towards 130°, giving a tailwind. With the lower wind direction variability and the wind in the axis of the runway, the two calculated tailwind gusts (ff2xt and ffxt) are very close to the reference value (fftx).
During this period (4 June 14h → 4 June 20h), the wind direction (bottom graph, blue curve) is close to 310°, giving a headwind (upper graph) with the operational threshold QFU31. But the wind direction variability (DiffDD purple curve, bottom graph) generates some tailwind gusts (middle graph, green and purple curves).

During this period, the wind direction is mainly crossing the runway. But the high direction variability generates both tailwind and headwind gusts. The operational threshold was QFU31, thus giving tailwind gusts up to 5 m/s (10 kt). But even the choice of the opposite threshold (QFU13) would have given tailwind gusts up to 8 kt.
LFBD. At the beginning of this period, the wind is crossing the runway (05-23), with a low direction variability (DiffDD = ddx – ddn < 60°). The tailwind speed is close to 0. Then, though the mean wind direction (dd2) doesn’t change, the direction variability increases (green curve, bottom graph). And the tailwind component of gusts may be either positive or negative, up to 4 m/s or 8 kt during the same 10 minutes period (middle graph, blue and green curves are the reference values fftn and fftx; the red and purple curves are ffnt and ffxt, calculated from the reported speed and direction variability, showing larger limits than the reference values). This example shows that a crosswind with a large wind direction variability may lead to simultaneous significant headwind and tailwind speed. For this period, the runway threshold in use is unknown, but it is seen that whatever is the threshold, significant tailwinds gust exist, with a mean wind direction crossing the runway.

**Conclusions**

When the wind direction is close to the axis of the runway in use, the tailwind or headwind gusts calculated from the reported gust and the mean wind direction are valid. But when the wind direction is not in the axis of the runway and some variation of wind direction exists, a tailwind or headwind gust calculated only by using the mean wind direction is not representative at all. A calculation using both the wind speed and wind direction variability allows knowing the possible presence of tailwind, though increasing the tailwind gust value by comparison to “truth”. Using an artificial tailwind gust value being the average of ffxt and ff2xt could be a solution to approach the true value. But the best method to really know the crosswind and tailwind gusts is to directly calculate them from the raw values of the anemometer.

But this is not requested by ICAO and this would lead to higher tailwind gusts values, thus reducing the airplane operations! Nevertheless, safety could be better, runway excursion being one of the frequent incident or accident during landing.