Source: **Motorola**
Title: **Circular Angle Spread**
Document for: **Discussion**

1. SUMMARY

Two different approaches have been used to calculate angle spread in recent SCM contributions.

One method uses a fixed reference assigning zero degrees to the Line-of-Sight direction. This method is convenient for use with measured data because there is a meaningful reference direction for comparison, i.e. LOS direction. It also requires significantly fewer calculations.

The second method is described in [1] and [2] which uses a circular wrapping to find the reference direction which yields the lowest angle spread. In some cases, there is no difference in the results of the two methods, and in other cases the two methods can produce different results. Either method is meaningful and non-ambiguous. Further discussion of the circular method and examples are given in this contribution.

2. CIRCULAR ANGLE SPREAD

In some conditions, where path powers are close to + or – 180°, offsets to the reference angle may cause the components to wrap around the +/- 180° boundary, and thus appear close together. Thus by including the offset, the resulting angle spread may be somewhat smaller. This is referred to as circular angle spread. e.g. this circular method was used to evaluate UE per-path spreads in [1].
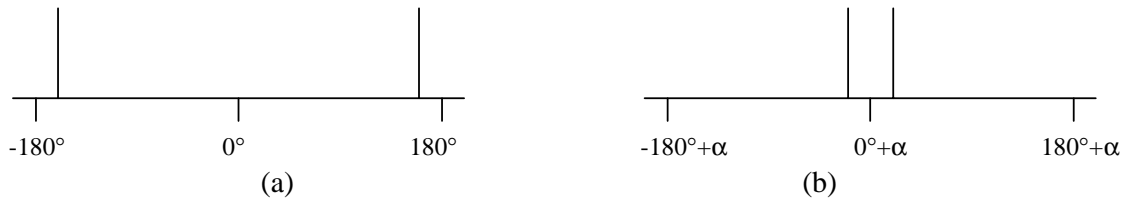

(a)   (b)
Figure 1, Illustration of a case where (a) fixed reference AS > (b) circular AS

When the angle spread is narrow with limited directions of arrival or departure, there is no wrap effect, and the two methods produce the same results. This is evident from Table 1, showing that the two techniques produce approximately the same result for the BS calculations.

SCM Model	Node B Non-circular AS	Node B Circular AS	UE Non-circular AS	UE Circular AS
Urban Macro 8°	8.03	8.03	71.63	68.30
Urban Macro 15°	15.06	15.05	71.38	68.04
Suburban Macro	5.03	5.03	72.60	69.21

FSC	19.18	19.14	89.16	64.25
Urban Canyon	8.08	8.05	38.89	38.51
Micro LOS	17.59	17.59	66.23	62.48
Micro NLOS	19.21	19.21	71.70	67.45

Table 1, SCM output showing the average result using a fixed reference AS and a circular AS

For the UE calculation, Table 1 shows that the circular AS produces a smaller result, usually by a few degrees. To evaluate the circular AS, angle offsets in 1° steps were used to search for the smallest resulting AS.

3. UE MEASUREMENTS

Previous measurements showing a distribution of AS values at the MS [3] have been re-calculated using the circular AS method.   Small values of AS were not affected by the change, but some of the larger AS values, especially those > 104° where reduced. The results of using the circular angle spread on the measured data causes the average value of AS to be reduced from 72° to 65°.
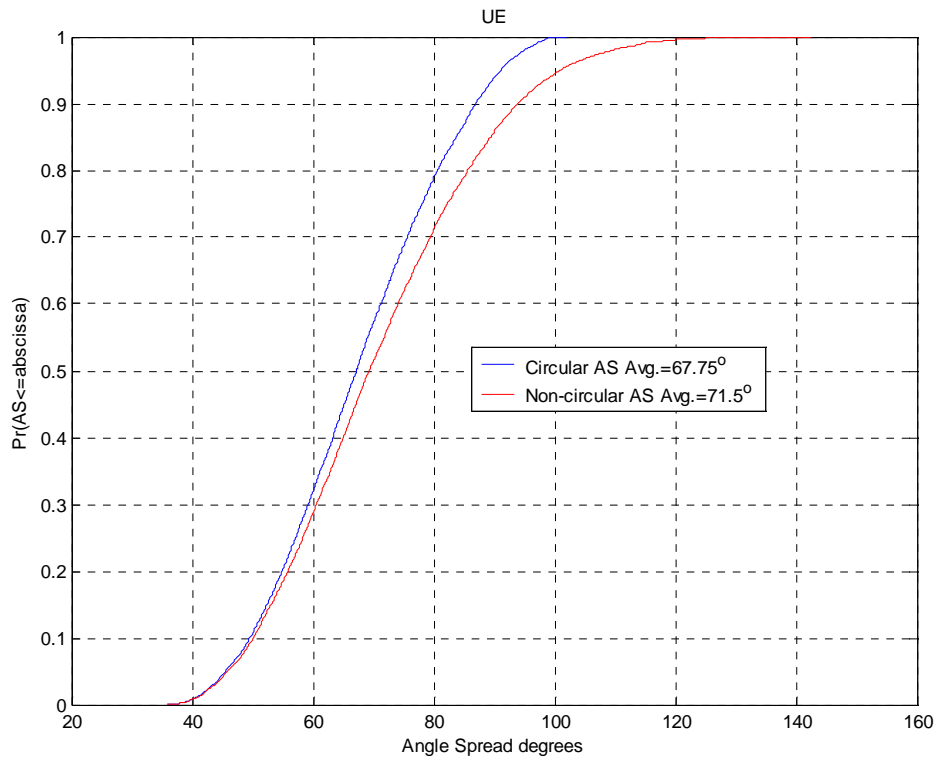

Figure 2, MS distribution of AS (calculated from Urban SCM output)

A similar result is obtained by the SCM model, as shown in Figure 2. In this example the average value of 71.5° is reduced to 67.8° when the circular AS calculation is made. Thus the conversion to circular AS has produced somewhat lower values of angle spread, but no changes to the physical model have been required.
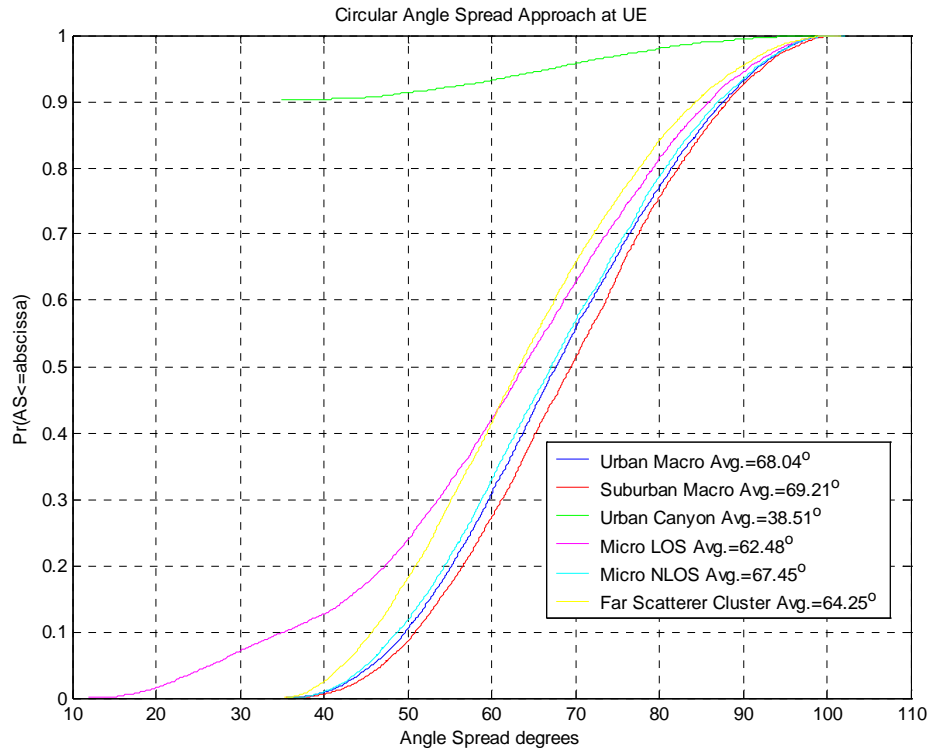

Figure 3, Circular Angle Spread calculated for the MS for several SCM cases

Figure 3 illustrates the MS angle spread using a circular calculation for several different SCM scenarios. Each of these cases produces a somewhat smaller value than the angle spread calculation which is referenced to zero degrees.

4. CONCLUSIONS

Due to the limited AS present at the BS, both circular and fixed reference methods for calculating AS produce the same results.

The concept of circular angle spread has been applied to previous measurements of the MS and found to produce a slight decrease to the average value of the composite AS, i.e. from 72° to 65°. Likewise, a similar decrease in the simulated SCM output was shown when using the circular definition. i.e. 71.5° is reduced to 67.8°

Circular AS results are somewhat lower than the case of using a fixed reference, but no changes to the physical parameters are required.

Circular AS measurements for the SCM are shown in Table 1 for reference, and additional calibration plots are included, as shown in Figure 3.

5. REFERENCES

[1] SCM-015 Motorola, "Mobile Angle Spread Measurements and Angle Distribution Model", Paris, April 14, 2002

[2] SCM-119 Nortel, "Angle Spread", Teleconference, March 14, 2003

[3] R1-01-0918, Motorola, "Spatial Channel Modeling Parameters for MIMO", Turin, Italy, August 27, 2001