

RECOMMENDATION ITU-R SM.1598

**Methods of radio direction finding and location
on time division multiple access and code
division multiple access signals**

(Question ITU-R 28/1)

(2002)

The ITU Radiocommunication Assembly,

considering

- a) that the considerable expansion of cellular radiotelephony networks increases the risk of interference within networks and to networks, especially in the boundaries of countries at the edges of station coverages operating by different operators and/or in the case of sharing frequency bands or adjacent bands;
- b) that the maintenance of a high level of quality of service is of paramount importance for the operators and the users of the service;
- c) that it is necessary to provide to the operators and to the regulators the necessary tools to investigate harmful interference;
- d) that the techniques used in these networks require acceptable methods of direction finding;
- e) that the interference complaints dealing with the modern cellular networks are often difficult to resolve;
- f) that the systems using time division multiple access (TDMA) and code division multiple access (CDMA) technologies form a significant portion of today's radiotelephony services in the world;
- g) that the equipment with the capability of performing direction finding on digital signals is now commercially available,

recommends

- 1 that capacities of direction finding of TDMA and CDMA signals using synchronization should be implemented in the fixed and mobile monitoring stations;
- 2 that the process of direction finding should use the principles similar to those presented in Annex 1 and methods explained in Annex 2 and in Annex 3.

ANNEX 1

**Processing of radio direction finding and location
on TDMA and CDMA signals**

Concerning the radio direction finding of TDMA and CDMA signals, it is recommended to try to get a preliminary identification of the signal before or during the process of direction finding, in order to be able to use the applicable methods for radio direction finding of TDMA and CDMA signals. With this intention, an association between the techniques of radio direction finding and the techniques of preliminary identification are interesting. Indeed, the cooperative techniques are more effective in terms of precision and multisource context than the non cooperative methods.

- A radio direction finder able to process the discontinuous signals such as TDMA, CDMA or time division duplex signals should thus allow the successive application of several methods intended to improve the accuracy of radio direction finding in blind context and real time in a first phase, according to the regular methods recommended in Annex 2.
- Single channel or preferably multichannel recording of the signal being the subject of radio direction finding.
- Preliminary identification of the signal by intercorrelation with test signals, to be carried out in real time or slightly differed time.

And

- If the preliminary identification process fails radio direction finding in blind context as described in Annex 2 (synchronization and eventually high resolution methods) which can be carried out in real time or in differed time (with a multichannel recorded signal), to obtain a better angular precision, while increasing capacities of discrimination of the sources in medium difficult environments (multipath, multisource).
- If the preliminary identification process is a success, radio direction finding in a cooperative context as described in Annex 3, can be carried out in real or differed time (with a multichannel recorded signal) to obtain a better angular precision, while increasing very significantly capacities of discrimination of the sources in adverse environments (multipath, high density multisource context).

ANNEX 2

Blind context for radio direction finding with TDMA signals

If the waveform is not identified or can not be identified by the preliminary identification process and if no information is available on a possible discriminating parameter within the signal (blind context environment) then it is recommended to apply the following methods of direction finding:

All these methods could be improved by directional antennas, preliminary recognition of their technical parameters (carrier, bandwidth, type of modulation, slot duration, etc.) when they are available and multiples measurement (for triangulation processing, homing processing etc.).

- Traditional or correlative interferometry (sequential or parallel with multichannels) may be coupled to a signal synchronization by detection of energy. The principle of interferometry is the calculation of phase delay between the signals obtained on several sensors, and the comparison between the result and a table of calibration to obtain the direction of the source. Synchronizing the direction finding trigger with the time of arrival of the time slots determined by a calculation of the energy of the signal present has many advantages:
 - the direction finder is triggered during the effective duration of a time slot;
 - except in the event of interference between time slots (see afterwards), the direction finder operates on a signal coming from a single source.

The advantage of a parallel rather than sequential direction finder is related to the fact that the switching of antenna is not necessary. Thus the longer integration of the signal provides an additional gain and precision of approximately 7 dB for a measurement over the duration of a time slot.

- Regular high resolution methods such as the MUSIC algorithm for performing more complex receiving situations involve interference or adverse propagation conditions, etc. The principle of such a technique is based on the calculation and the reduction of the autocorrelation matrix of the signal received at each sensor of the antenna array. These methods require more computing power and delay than correlative interferometry. The advantages of such techniques are the following:
 - Their accuracy is better than the correlative interferometry.
 - They perform direction finding even in multi-emission or interference situations (low to medium interference density may be performed. This depends on the number of antenna elements).
 - Direction finding is performed even on multipath propagation conditions.
 - In addition, as for correlative interferometry, it is possible to synchronize the direction finding trigger with the time of arrival of the time slots of TDMA signals with the numerous advantages pointed out in the previous paragraph.
- The time difference of arrival (TDOA) technique is based on intercorrelation of the digital signals received on a set of sufficiently distant and synchronous sensors to allow the hyperbolic location of the source. The basic principle of such method in a 2D geometry is the following: In a single transmitter situation, by considering a couple of synchronous antennas (A, B) at a convenient distance, the intercorrelation processing of the signal received at each antenna A and B provide a TDOA τ_{AB} , the corresponding location of the transmitter is given at an hyperbola branch H_{AB} defined by the location of the antennas A and B, and by the TDOA τ_{AB} . By considering another couple of distant synchronous antennas (A, C) and the same the intercorrelation processing of the signal received at each antenna A and C, the corresponding location of the transmitter is given at an hyperbola branch H_{AC} defined as before by the location of antennas A and C, and by the TDOA τ_{AC} . Thus, the location of the transmitter is given by the intersection of the hyperbola branch H_{AB} and H_{AC} . Note that even in a single transmitter situation, geometrical ambiguities may occur and precision depend highly on the geometrical configuration. This may be solved by using directive antennas or additional direction finding process.

In a multisource context, the TDOA technique can be improved by the use of directional aerials, making it possible to limit the angular scanned field and the risks of ambiguity caused by multiple transmitters and the risk of false association of TDOAs related to different transmitters. In addition, directional aerials can limit the number for synchronous measurements to only two antennas. The hyperbolic location can then be used to refine the precision obtained starting from angular measurements or to resolve ambiguities.