

RECOMMENDATION ITU-R F.1192

**TRAFFIC CAPACITY OF AUTOMATICALLY CONTROLLED RADIO SYSTEMS
AND NETWORKS IN THE HF FIXED SERVICE**

(Question ITU-R 147/9)

(1995)

The ITU Radiocommunication Assembly,

considering

- a) the improvements available from the use of automatically controlled radio systems;
- b) the limited amount of spectrum available for the HF fixed service (FS);
- c) the demand for high reliability of HF FS;
- d) the demand for high traffic throughput;
- e) the demand for operation of networks in the HF FS;
- f) that automatic systems should be able to cope with a wide range of traffic requirements and network size,

recommends

- 1** that, for automatically controlled HF radio networks, the methods described in Annex 1 are preferred for:
- the determination of the traffic throughput capacity;
 - the estimation of the frequency requirements with respect to desired traffic throughput;
 - the general planning of such systems;
 - the comparison of the different types of system with respect to traffic throughput and frequency requirements.

ANNEX 1

**Traffic capacity of automatically controlled radio systems
and networks in the HF FS****1 Introduction**

There are three basic automatically controlled radio systems. These are identified by the following acronyms:

ACC: asynchronous common channels

SCC: synchronous common channels

SSCT: synchronous separate calling/traffic channels

The ACC system asynchronously scans a set of pre-assigned channels in order to find a usable channel. Once a suitable channel is found, the traffic is sent over that channel; i.e. the calling and traffic channels are common.

The SCC system synchronously scans a set of pre-assigned channels in order to find a usable channel. Once a suitable channel is found, the traffic is sent over that channel; i.e. the calling and traffic channels are common.

The SSCT system synchronously scans a set of pre-assigned “calling” channels in order to make the initial contact. The call offers a number of candidate “traffic” channels. Having established the call, the two stations move to the candidate traffic channels and select the best.

There are two basic types of network which may utilize the above systems: multipoint and star.

2 Multipoint networks

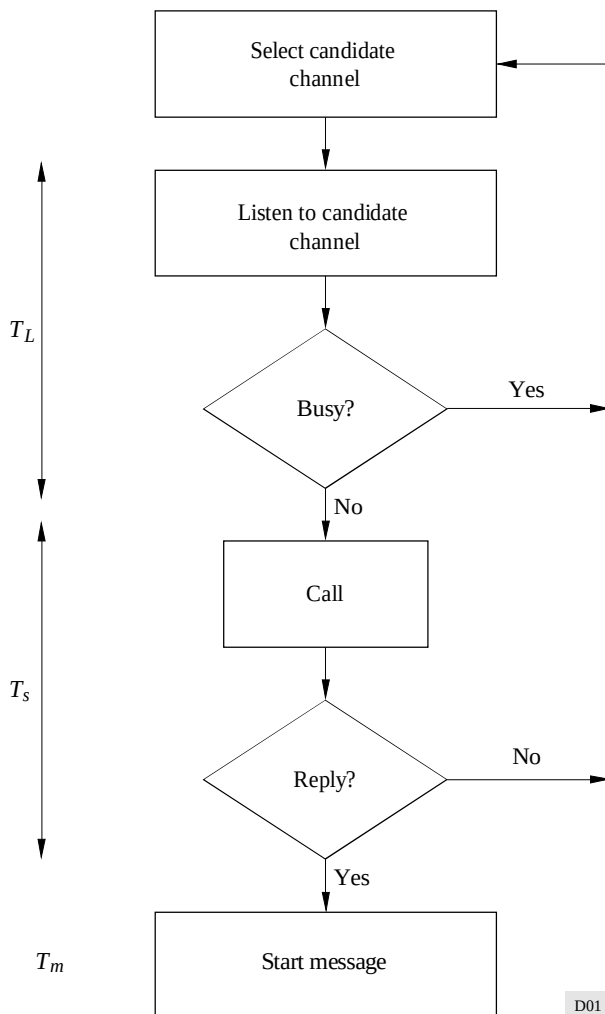
The analysis given in this section is for a multipoint network where every station is equally loaded.

2.1 ACC system

2.1.1 Calling sequence

The ACC calling sequence is shown in Fig. 1.

FIGURE 1
ACC calling sequence



In the initial listening sequence, the station selects a candidate channel and checks that it is not occupied. There is a probability, P_1 , that the channel is free. If busy, the station will select a second candidate channel and try again. The number of attempts, on average, will be $1/P_1$.

When the station transmits the call on the selected (free) channel, there are three probabilities that the call will be successful:

- the probability, P_2 , that another station is not transmitting on that same channel,
- the probability, P_3 , that the destination station is not already occupied,
- the probability, P_4 , that the propagation conditions are good enough.

Expressions for P_1 , P_2 and P_3 have been derived in Appendix 1.

The number of call attempts, i.e. transmissions, on average, is:

$$\frac{1}{(P_2 P_3 P_4)}$$

2.1.2 Traffic capacity

Let C : number of scanned channels

N : number of propagating channels

S : number of stations

E : traffic capacity (E) relating to a network of N channels and S stations

T_m : length of message (s)

T_s : scanning (or calling) time (s).

The number of messages/hour/station, M , is:

$$M = \frac{3\,600 \times E}{S (T_s / (P_2 P_3 P_4) + 2 T_m)} \quad (1)$$

Each station will transmit M messages and receive M messages in 1 h.

There is a limit to how many messages an individual station can handle. Taking into account the amount of time that a station spends “listening” to check that the selected channel is free, and assuming that the maximum capacity of an individual station is E_{max} (E), the maximum number of messages/hour/station is:

$$M_{max} = \frac{3\,600 \times E_{max}}{(T_L / (P_1 P_2 P_3 P_4) + T_s / (P_2 P_3 P_4) + 2 T_m)} \quad (2)$$

where T_L is the listening time (s)

NOTE 1 – $2T_m$ is to take account of both received and transmitted messages.

NOTE 2 – The appropriate value for E_{max} is the subject of further studies.

2.2 SCC system

2.2.1 Calling sequence

The SCC calling sequence is shown in Fig. 2.

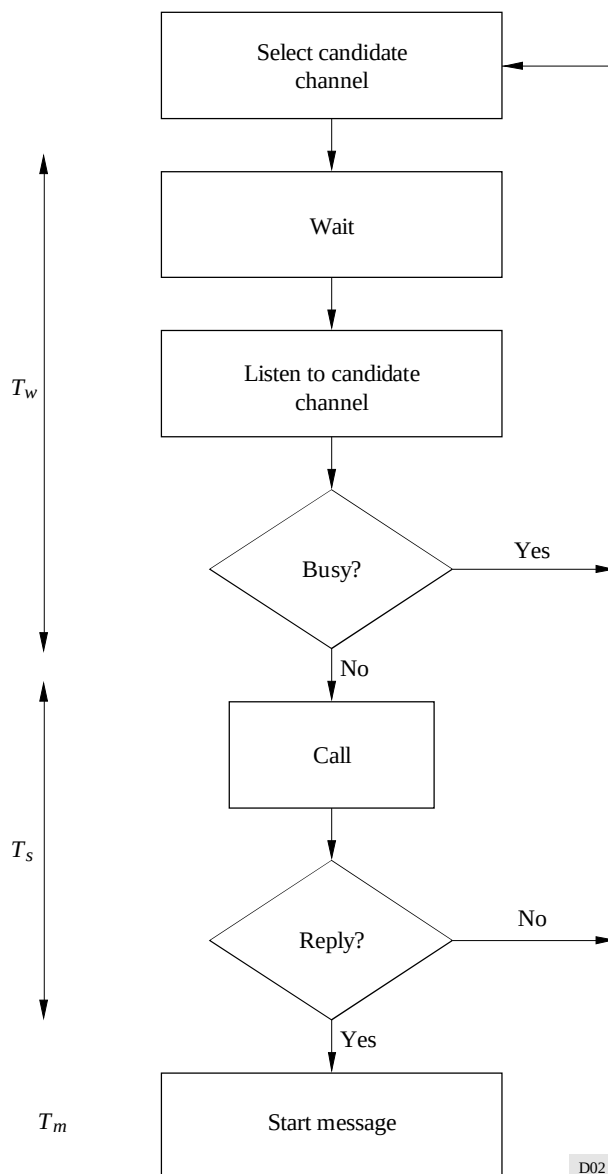
The SCC system has been assumed to be one which arranges a different order of listening out frequencies for each station (using an algorithm based on the station address).

The station selects the candidate channel and then needs to wait (T_w) until the destination station selects that channel. Just before this occurs, the calling station must listen to ensure that the channel is free. Thus the station needs, on average, to wait: T_w/P_1 (s).

The calling sequence is similar to that of the ACC station except that T_s , the scanning time, is now much shorter as only one channel is “scanned”.

If the system as described for the ACC is simply synchronized, the synchronized scanned channels effectively become a single channel and stations compete for it at the same time. This causes the system to lock-up at a certain point and therefore the system described above for SCC is preferred.

FIGURE 2
SCC calling sequence



2.2.2 Traffic capacity

The number of messages/hour/station, M , is the same as that for an ACC system (equation (1)).

For an SCC system:

$$M_{max} = \frac{3\,600 \times E_{max}}{(T_w / (P_1 P_2 P_3 P_4) + T_s / (P_2 P_3 P_4) + 2 T_m)} \quad (3)$$

2.3 SSCT system

2.3.1 Calling sequence

The SSCT calling sequence is shown in Fig. 3. The synchronously scanned set of calling channels are equivalent to a “slotted Aloha” channel which has a capacity of 0.37 E. The probabilities P_1 and P_2 are taken into account in this way. However the probability P_3 must be considered.