

**MULTI-CHANNEL LAND MOBILE SYSTEMS FOR DISPATCH TRAFFIC
(WITH OR WITHOUT PSTN* INTERCONNECTION)**

(Question 37/8)

(1978+1982-1986-1990)

Introduction

Radio spectrum allocated for dispatch traffic is becoming increasingly congested and already many users (networks) have to share a channel with several other users. This practice employs the channel more effectively but gives the participants a reduced "grade of service" in the sense that they may often have to wait for some time for a channel to become free and they suffer from reduced privacy. Not only improved channel utilization but also better grade of service and good privacy conditions are important factors to design dispatch systems.

Part A of this Report deals with the general aspects of multi-channel land mobile systems for dispatch traffic, such as system configuration, characteristics of dispatch traffic, grade of service, traffic handling capability, performance of trunked systems, signalling and so on.

Part B of this Report introduces some systems being installed or planned by some administrations.

For this purpose of this Report, "dispatch system" has the meaning: A radio system used to control the operation of a fleet of mobiles, such as air craft, taxis, police, etc., and "trunked system" has the meaning: A multi-channel system with automatic channel selection, particularly referring to dispatch systems.

However, this Report does not consider the detail of interconnection of trunked dispatch systems with public or private switched telephone networks. Such interconnection requires further study.

* Public switched telephone network.

PART A

GENERAL ASPECTS RELATING TO SPECTRUM
CONSERVATION AND SYSTEM DESIGN

1. System configuration

A typical arrangement of equipment, covering a single radio zone, is shown in Fig. 1 and consists of the following four principal items:

- a number of control posts (CP)(s) (i.e. dispatchers or control stations), consisting of a CP(s), each connected to a switching centre, either by a dedicated line or a radio path using channel equipment (CE);
- a switching centre (SC), (several switching centres may be interconnected);
- a number of base stations (BS) each containing a number n of CE(s).
- a number of groups of mobile stations, each consisting of a_m Mobile Stations (MS) and each being served by its own CP.

To enable a CP to call one of its MSs, and vice versa, each CP and each MS is considered to have access to one of the radio channels by means of an access procedure which is still to be defined.

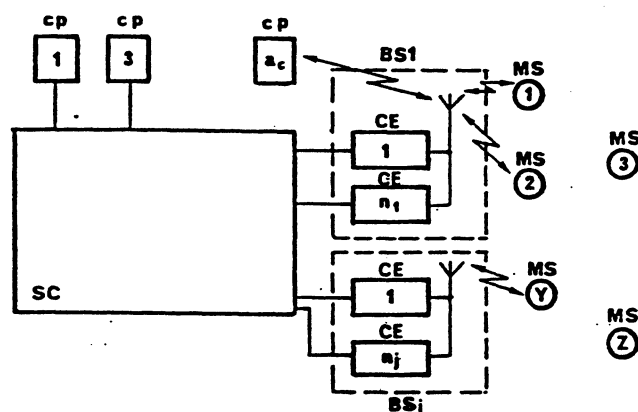


FIGURE 1

Arrangement of equipment in a trunked system

cp: control post (i.e. dispatcher or control station)

CE: channel equipment

MS: mobile station

a_c : number of control posts

SC: switching centre (several switching centres may be interconnected)

BS: base station (some administrations define the base station as one channel equipment)

$n = \sum_{k=1}^j n_k$: total number of channel equipment

2. Characteristics of dispatch traffic in private mobile radio systems

The increase in channel loading which can be achieved by trunking depends on the kind of traffic carried. Mobile radio dispatch traffic differs from public mobile telephony traffic in a number of ways:

- the mean holding time of calls is shorter (15 seconds may be typical);
- many users operate a vehicle fleet system where a single operator controls a number of mobiles;
- the size of fleets varies greatly.

2.1 Fleet operation

The number of users in the system is, in effect, equal to the number of CP operators, not the number of mobiles, because if the operator is busy nobody in the fleet can place a new call. Thus all the traffic of the fleet passes through the operator and a mobile radio system therefore is characterized by a small number of users (operators), some of which may offer large loads and some small. Such a system is termed "unbalanced" (see also § 5).

Fleet operation means that there are actually two kinds of queue. The CP operator only ever has to wait because the channel is occupied by another fleet (the "sharing" delay) but an MS may have to wait not only for other fleets but also because his own operator is busy with a call to another MS (the "fleet" delay). It can be argued that the fleet delay can be ignored because:

- it is experienced only by the MSs, each of which uses the system rather sparingly compared with the CP;
- the delay can be reduced only if the fleet owner is prepared to employ extra operators, a factor which is outside the control of the systems designer;
- the psychological effect of waiting while one's colleagues talk to the CP is not the same as that of waiting while strangers block the channel.

2.2 Random fluctuations

The random nature of mobile radio dispatch traffic means that the busy hour traffic level will fluctuate. The fluctuations can be surprisingly large and last for significant periods. Upward fluctuations in the traffic level will result in a reduced grade of service which will be unacceptable to the users if they occur too often or last too long. It may be desirable to protect against this with an 'overload' criterion of the form:

- the ordinary busy hour grade of service should not degrade by more than, e.g., a factor of 2 for periods longer than half an hour occurring no more than once every 20 days.

2.3 Day to day traffic variations

Telephony experience [Hayward and Wilkinson, 1970] shows that there will be variations in the mean busy hour traffic from day to day in addition to the random fluctuations. With small numbers of users the variations can be expected to be large: the traffic will vary not only because of changes in the activity of the whole community, but also because of sudden changes in the demand of just a few of the users. The day to day variations add to the random fluctuations and so, in practice, the safety margin required for protection against overload is likely to be significantly larger than consideration of the random fluctuations alone would indicate. At present the extent of these variations has not been studied.

2.4 Operating procedures

Operating procedures which may cause excessive simultaneous call requests from many mobile stations can overload the access protocol or the switching centre of a trunked system. For example, transactions in which a control post seeks to allocate work to mobile stations by means of a fleet call requesting offers or "bids" for the work. System design may make special provision for such procedures (see also Annex I to Part A, section 3.3).

3. Grade of service and traffic handling capability

The increase in channel loading that can be achieved with a trunked system also depends on the grade of service required.

3.1 Reference system

The merits of the trunked system with respect to traffic handling capacity and radio channel efficiency can be compared with those of a single channel reference system employing automatic sharing, having the same amount of traffic per MS and the same number of MSs per CP and offering the same grade of service.

It is assumed that a CP is connected to a SC by a dedicated line, and n is less than a_c .

3.2 Traffic assumptions

In addition to the usual assumptions for estimating the volume of the traffic in ordinary telephone networks, the following assumptions may be made:

- communication is possible, in two directions in a simplex mode, between a CP and each of its MSs, but not more than one at a time;
- any other communication, for example between MSs of the same or different networks or between CPs of different networks, is excluded;
- all calls are queued and processed in the order of arrival;
- any degradation due to multipath fading, interference and other deficiencies inherent in radio transmission is disregarded.

3.3 Delay criteria

Because of the relatively short mean holding times encountered in mobile radio networks for private use, the character of the messages and the general pattern of conduct of the user of such networks, a waiting system, also known as delay or queueing system, is desirable.

For the purpose of traffic calculations a delay criterion, both under normal traffic and overload conditions, may then be used as a measure of the grade of service in accordance with current telephone practices.

The following criteria are appropriate:

- under *normal traffic conditions* the probability of excess delay (P), that is, the probability that a given waiting time is exceeded, shall be limited. If, for example, this waiting time is one mean holding time, then $P = P_r$. It may also be desirable to guard against occasional very long delays;
- under *overload conditions* the probability of excess delay shall not be more than, for example, twice the probability under normal traffic conditions (e.g. P_r), in the case that the traffic per MS increases by a given percentage, for example 10%. An alternative way of specifying the overload criteria is given in § 2.2.

3.4 Probability of excess delay in the single-channel reference system

The distribution of waiting time in the theoretical model of one telephone line serving a finite number of traffic offering sources is known and has been published. It can be shown that the model of a single mobile radio network consisting of one CP and a finite number of MSs is equivalent to the telephone model mentioned above, with the CP corresponding to the line and the MSs corresponding to the traffic sources.

However, the single-channel reference system consists of several such networks, each comprising one CP and several MSs. As the CPs are linked by the fact that they have access to only one radio channel, it was necessary to also consider the CPs as traffic sources. Consequently, a single radio channel serving simultaneously several CPs and their MSs will give rise to two rows of queueing calls which are linked to each other.

An exact solution of the distribution of waiting times has not been obtained but an approximate solution by means of computer calculations shows that for a single-channel reference system consisting of 10 CPs, each serving 10 MSs with a traffic load of 0.005 erlang per MS, the probability, P_r , of the waiting time exceeding the mean holding time (e.g. 15s) is equal to about 0.3.