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Spectrum Management and Telecommunications Policy  
Guidelines

# Channel Loading Guidelines

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## 1. Intent

This document is published as a guide to assist in the determination of the number of radio channels to be assigned to a land mobile radiocommunication system, based on telephone traffic theory. This document is not intended as an Industry Standard for defining minimum Grade of Service Performance levels for private or commercial radio communications systems, but as a methodology to help equitably distribute any available radio spectrum. This document does not apply to cellular and PCS systems.

## 2. Background

- 2.1 In 1983, the Department published Radio Policy 003, *Policy Guidelines for Mobile Radio Trunked Systems* (RP-003), establishing guidelines for the assignment of channels to trunked radio systems. The guidelines were based on the loading of the traffic capacity of the channel. Initially established for conventional systems, they were extended to trunked systems. Assignment of channels was based on the evaluation of the loading of the system, by the number of mobiles per channel, and on the nature of the service provided by the systems.

In addition to evaluating the minimum number of mobiles per channel, system loading was also assessed using data gathered concerning channel occupancy. It was recognized that larger systems with more channels could accommodate a larger number of mobiles per channel. It was also recognized that for different types of users, the traffic offered per user varied widely. Assessing the number of channels to be assigned based solely on the number of users per channel treated unfairly users of smaller systems.

- 2.2 In 1993, the Ontario Regional Office developed, *Grade of Service Determination for Land Mobile Systems in the Golden Horseshoe Area*<sup>1</sup>, to assist departmental staff in making frequency assignments. This approach fairly assigns spectrum with similar system performance in terms of spectrum access, based on the traffic theory. It determines the number of radio channels that will be assigned to a radiocommunication system based on the access delay to that system. This method continues to be used and has been adopted Department wide and by other Regional Offices. The *Channel Loading Guideline* will use the same approach.
- 2.3 In RP-003 and subsequent documents, Industry Canada has separated land mobile radiocommunication systems into two main categories: Safety Services and Other Services. Industry Canada will retain these two categories and will apply a different Grade of Service (GOS) for each category. The parameter GOS expresses the probability of a call being blocked or delayed by the system.
- 2.4 The access delay initially adopted for single channel conventional systems is extended to trunked systems. For safety services conventional systems, 50% occupancy translates to 1 message length delay; for non-safety services conventional systems, 75% occupancy translates to a delay of 3 message lengths.

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<sup>1</sup> *Grade of Service Determination for Land Mobile Systems in the Golden Horseshoe Area*, P. Vanderveen, Industry Canada, 1993.

The default GOS values that were determined in terms of those access delays will continue to be used in the preliminary analysis to establish the initial number of voice channels and radio frequencies needed by the radiocommunication systems under study.

### **3. Channel Loading Guidelines**

#### **3.1 Prescribed 'GOS' for Systems Without Queuing Capability**

The channel loading analysis of a system that does not queue service requests will be dealt with on a case-by-case basis.

#### **3.2 Prescribed 'GOS' for Systems With Queuing Capability**

The channel loading analysis of a system that places blocked calls in queue will be based on a traffic theory model that uses a probability of delay and will be normally calculated using the Erlang C formula. The Department may apply other known formulas if deemed necessary. As, the parameter GOS expresses the probability of a call being delayed, it is always associated with a multiple of Holding Time (HT).

The following is established as default values for basic queued systems GOS:

GOS = 0.03 @ 1 HT	Safety services category
GOS = 0.03 @ 3 HT	Other services category

This means that for an average busy period, 97% of calls will not be delayed by more than one holding time for services of the Safety Services category and 97 % of the calls will not be delayed by more than 3 Holding Times for services of the Other Services category. The average busy period and Holding Times for both categories are defined in Annex 1 - *Parameters Definitions*.

#### **3.3 Application of the Guidelines**

- 3.3.1 Industry Canada recognizes that the spectrum requirements of a land mobile radiocommunication system are reflective of its operational characteristics, the technology deployed and the services and features offered. Therefore, other considerations may, at times, need to be taken into account when determining the number of radio channels to be assigned to a system. Consequently, further detailed analysis may be carried out in conjunction with Industry Canada staff. Industry Canada hence encourages applicants to provide as much traffic related data as possible.
- 3.3.2 These guidelines are provided as a guide concerning the Grade of Service standards to be used in engineering traffic models during the determination of the number of new and/or additional channels for land mobile radiocommunication systems. They are not necessarily reflective of the GOS that users experience. System licensees may for example offer GOS levels higher or lower than recommended in this document in the management of traffic on their network.
- 3.3.3 Additional information about the radio system provided by the applicant will be taken into consideration to arrive at the number of channels to be assigned. For example,

consideration will be given to the operational requirements of the Safety Services for the impact of peak or special event traffic periods and for the traffic of roaming users over wide-area systems. Adjustments to the number of channels initially assigned may be made after initiation of service, and based on measurements carried out over a representative busy period.

- 3.3.4 These guidelines are also used for maintaining minimum levels for the efficient use of spectrum. As other factors play important roles in this context, the application of the guidelines will be flexible enough to take them into account in the overall assignment process of channel allocations. Such factors include the types of systems, i.e. trunking versus conventional, simulcast<sup>2</sup> versus multicast<sup>3</sup> or micro-cells, quasi-transmission trunking versus message trunking. Each of these configurations are filling particular needs but may have different value from a spectrum efficiency point of view. For example, special considerations and/or methodologies are required to evaluate highly complex and spectrally efficient ESMR networks. The evaluation of such networks requires that proper account be taken of the traffic mixes resulting from the variety of integrated services and features being offered (i.e. data, interconnect, private and group dispatch, SMS), as well as the overall network and spectral efficiencies that result from a high degree of frequency reuse and other techniques.

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<sup>2</sup> Simulcast refers to a technique that utilizes multiple transmitter sites with overlapping coverage, broadcasting simultaneously and using the same frequency pairs at every site. This technique is used to conserve frequencies and increase RF density over a geographical area.

<sup>3</sup> Multicast refers to a technique that utilizes multiple transmitter sites with overlapping coverage, broadcasting simultaneously and using different frequency pairs at each site. Frequency pairs may be re-used in the system as long as no same channel coverage areas overlap. This technique is used where frequency availability is not a problem.

## Annex 1

### Parameter Definitions

1. *Access Delay* is the amount of time it takes to get access to the first available server. This time delay is expressed as multiples of the average Holding Time (HT).
2. *Average Busy period* is a continuous period of time during which the highest usage occurs.
3. *Blocking* is the inability of the incoming call to get access to a server. Blocking occurs only in radio systems that either do not queue users requesting a radio channel or when the number of users requesting a radio channel exceed the size of the queue, whereby user requests for system access are rejected.
4. *Erlang*: Unit commonly used to measure call intensity or telephone traffic volumes, over a time period, normally 1 hour. It is generally accepted that when referring to traffic usage, one Erlang represents a single server occupied for 1 hour. One E of traffic (1E) then represents 36 UC (Unit Call) or CCS (hundred-call-seconds).
5. *Grade of Service (GOS) for non-queued systems* represents the probability of lost calls.
6. *Grade of Service (GOS) for systems with queues* is the probability of a call being delayed by busy servers and is associated to an access delay. It is expressed as a decimal or percentage.
7. *Holding Time (HT)* is the period of time a server is busy on a call. The holding time includes the channel request and seize time, the message length, and the hang and the squelch time.
8. *Message Length (ML)* is the time taken by the server to send the information portion of a transmission associated with a call. This time varies widely depending on the business type or radio service category.
9. *Safety and Other Services* are the two types of service or categories defined for land mobile radiocommunication systems. A radio system is recognized to be in the Safety category of service if it is used by an organization that provides safety of life services such as police, ambulance, and, fire-fighting<sup>4</sup>.
10. *Server* describes the resources required, or resources available, to carry traffic. For analogue traffic, a server is usually equal to one radio channel. For digital traffic, a server may be a dedicated radio channel or one slot within multiple time slots or one code within a list of codes.
11. *Total Traffic Volume or Traffic Intensity* is the volume of traffic the radio system is expected to carry during peak periods. This traffic is usually expressed in Erlangs.

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<sup>4</sup> The Safety Services Category is also discussed in Standard Radio System Policy-502, *Technical Requirements for Land Mobile and Fixed Radio Services Operating in the Bands 806-821/851-866 MHz and 821-824/866-869 MHz* (SRSP-502) under Section 5.1.1 concerning the eligibility criteria for public safety spectrum in the 821-824/866-869 MHz bands.

12. *Traffic Offered Per User* is the volume of traffic each user is expected to be offered by the system during peak periods, i.e. traffic per mobile. This traffic is usually expressed in Erlangs.
13. *Message Trunking* is a traffic management method that allows a single server to be seized for the entire duration required to send all successive transmissions associated with a call.
14. *Transmission Trunking* is a traffic management method that allows different servers to be seized only for the duration required to send one of the successive transmissions associated with a call.
15. *User Population* is the total number of users supported by the radiocommunication system.

