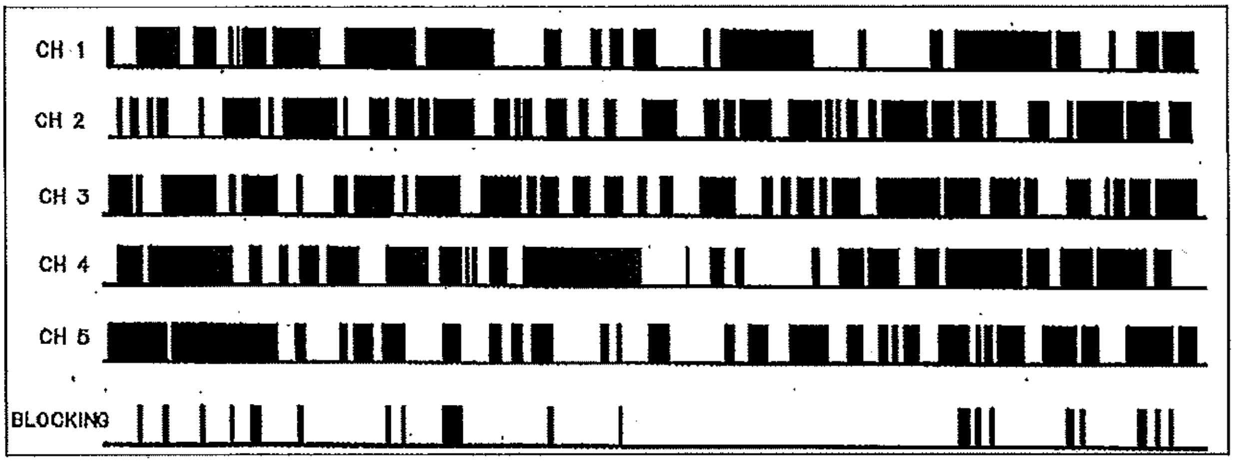

Figure 1-2 Blocking Probability Chart

1.3 INTRODUCTION TO TRUNKING

Multi-Net systems utilize a concept called trunking. Trunking, as it applies to Multi-Net systems, is the automatic sharing of channels in a multiple repeater system. Advantages of trunking include less waiting to access the system and increased channel capacity for a given quality of service. Since the probability of all channels being busy at the same instant is low (especially in larger systems), the chance of being blocked is much less than when only one channel can be accessed.

Trunking concepts can be applied to radio control because individual subscribers typically use the system only a small percentage of the time, and a large number of users do not use the system at the same time.

The effect of trunking is illustrated in Figure 1-2. This chart represents typical traffic on a five-channel repeater system. The channels shown are approximately 50% loaded which means that they are occupied by a carrier 50% of the time. The dark areas in the top five lines indicate when the repeater is in use, and the dark areas in the bottom line indicate when all five channels are busy.

It can be seen that if the channels are not trunked and only one channel is available (as represented by any of the channel lines in the chart), there is a much lower chance of obtaining a channel at any instant. However, when the user has automatic access to multiple channels as indicated by the bottom line, the probability of being blocked or denied access is greatly reduced.

Since typical traffic concepts are known, blocking probabilities can be predicted. Figure 1-3 shows that for a given percentage of air time loading, blocking probabilities are reduced as the number of trunked repeaters increases. A ten-repeater system has much better blocking performance and can provide a higher quality of service than ten independent channels utilizing manual switching (as represented by the "1 Chnl" line). Note that "Loading" as referred to here pertains to the percent of available transmission time and not the number of transceivers per channel.

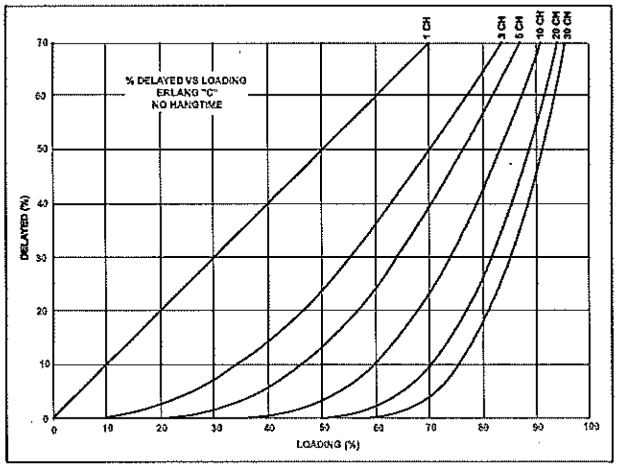

Figure 1-3 Percentage of Calls Delayed

Trunked systems are also often characterized in terms of the delay in gaining channel access. Delay probabilities can be calculated if assumptions are made for average transmission length and statistical distribution of transmission lengths. Statistics gathered by the Stanford Research Institute under FCC contract RC 10056 support 5 seconds as a reasonable estimate of transmission length. Using a 5-second transmission length and exponential distribution, access delays can be calculated and plotted as shown in Figure 1-4. The FCC permits trunked systems to have up to 30 channels (repeaters) which is the number that Multi-Net systems can accommodate.

1.4 TRUNKING METHODS

1.4.1 INTRODUCTION

There are two different methods currently being used to control trunked systems. One is distributed control used by E.F. Johnson Multi-Net, LTR-Net, and LTR systems, and the other is a dedicated control channel used by some other systems.

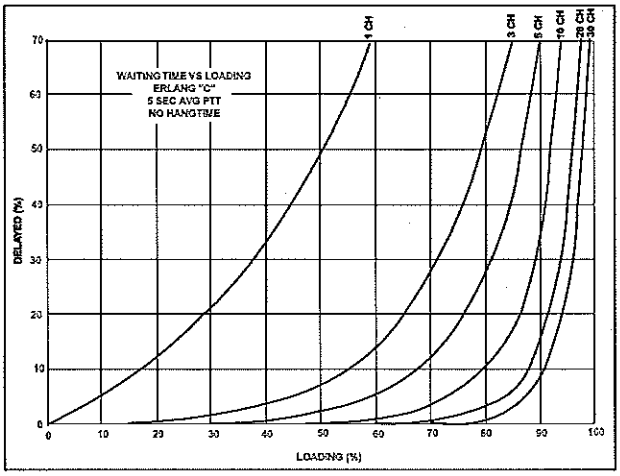

Figure 1-4 Access Delay Times

The distributed method utilizes a small logic unit in each repeater to provide all the control functions on that channel. A dedicated control channel is not required with this method because all necessary control is provided by the repeaters.

The control channel method utilizes a dedicated control channel and a system controller to provide system control functions. This method is used by most other trunked radio systems. The following information compares these two control methods.

1.4.2 DISTRIBUTED CONTROL

With the distributed method used by Multi-Net systems, access can be made on any channel that is idle. Each repeater is responsible for all data signaling on its channel. The repeater determines which channels are idle and then transmits that information to the transceivers in a data stream that coexists with voice information. This provides full parallel processing of calls. Collision avoidance is handled by the transceivers because the transceiver that is first to access the repeater is the one that acquires the channel.

1.4.3 DEDICATED CONTROL CHANNEL

With the dedicated control channel method, all accesses must be made using a single control channel which may result in a throughput constraint. This type of system requires some method of avoiding collisions, and most use a modified version of slotted (Aloha) access control. The characteristics of this access control method have been well documented in other literature. The maximum throughput has been shown to be approximately 37% which results in a throughput constraint even though the packets of data are typically short in duration.

Another disadvantage of the control channel system is that all calls must be processed in sequential order. Therefore, as loading increases and fewer channels are available, accesses rise exponentially and transceivers are forced to compete with each other on a single channel.

1.4.4 VOICE CHANNELS

With the distributed method, all channels are available for voice communication for maximum system efficiency. With a control channel system, one of the system channels typically must be used for control purposes and is not available for voice communication.

In Figure 1-5, the blocking rates of a five-channel system are compared to those of a four-channel system (one channel used for control). It can be seen that there is significantly less blocking on the five-channel

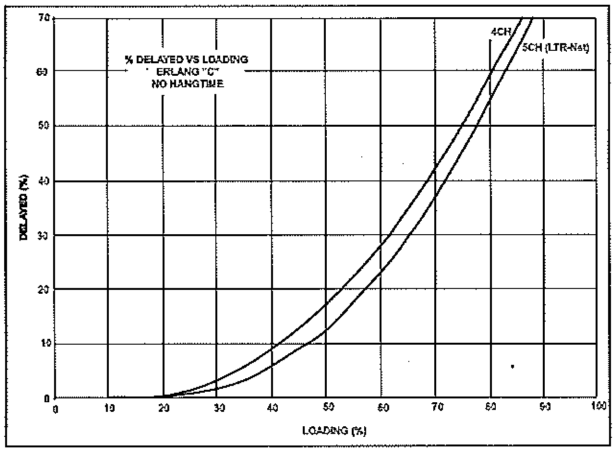

Figure 1-5 Blocking Percentage Comparison

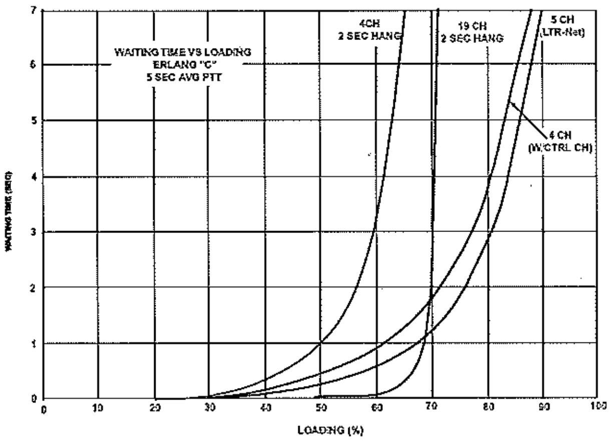

Figure 1-6 Delay Comparison

system. For example, at 57% loading, the five-channel system is delayed (blocked) 20% of the time compared to 25% for the four-channel system.

The waiting time when a call is blocked is directly related to the blocking rate and the traffic loading. Therefore, the distributed method also has less waiting time. As shown in Figure 1-6, the waiting times for a five-channel system with a traffic load of 57% is 0.45 second compared to 0.71 second for a four-channel system using a control channel.

1.4.5 HANG TIME

Hang time holds a repeater to allow a called party to respond without having to worry about being blocked. However, hang time may have a detrimental affect on blocking and waiting time as described in the following information.

Hang time can either be enabled or disabled at the repeater and for various Multi-Net calls using the SSM. For example, if it is not used for a standard dispatch call, the channel is held for only the length of the transmission. This means that an entire conversation consisting of several transmissions may occur on several channels. This is called transmission trunking and it provides maximum system efficiency because the time between transmissions can be used by other callers.

Some other types of trunked radio systems do use hang time with dispatch calls during heavy loading periods. This allows a called party to almost always respond to a call without being blocked. However, it comes at the expense of increased blocking and waiting time for all other users.

As indicated in Figure 1-6, the waiting time with a traffic load of 57% for Multi-Net trunking ("5 Chnl" line) is 0.45 second compared to 2.1 seconds for the control channel method using 2 seconds of hang time ("4 Chnl, 2 Sec Hang" line). Notice that the waiting time of the 20 channel system using a dedicated control channel and 2 seconds of hang time approaches infinity at 70% effective loading. However, Figure 1-4 shows that an Multi-Net (distributed) system has only about 0.1 second waiting time under the same conditions.

1.4.6 ACCESS PRIORITY

Access priority determines who gains access to a busy system. The method used by most systems with a dedicated control channel is to allow all transceivers to attempt access to the system but deny access to lower priority transceivers by not providing a channel to use. This means that lower priority transceivers still busy up the system with their access attempts even though they are not given a channel for voice communication.

With distributed (Multi-Net) systems, no transceivers can even attempt to access the system until a channel is available. The transceiver that then acquires the channel is the one that makes the first access attempt. This is a first-come-first-served method of access. Multi-Net transceivers have five levels of access priority.