DOC-CR-TS-82-0036

DOC
DD3FS 4806582

CANTEL ENGINEERING ASSOCIATES LTD.
402 W. Pender St.
Vancouver, BC V6B 1T6

# TRAFFIC AND SPECTRUM USE STUDY OF VANCOUVER POLICE DEPARTMENT MOBILE RADIO DATA SYSTEM (MRDS)

Report: R-276-001
September, 1982

Prepared by:

**CANTEL**
ENGINEERING
ASSOCIATES LTD.

Copy No. 11

A & 2B

Government of Canada
Department of Communications

Gouvernement du Canada
Ministère des Communications

DOC CONTRACTOR REPORT DOC-CR-TS-82-0036

DEPARTMENT OF COMMUNICATIONS - OTTAWA - CANADA

INFORMATION TECHNOLOGY AND SYSTEMS
RESEARCH AND DEVELOPMENT

---

TITLE: (2) TRAFFIC AND SPECTRUM USE STUDY OF VANCOUVER POLICE DEPARTMENT MOBILE RADIO DATA SYSTEM

AUTHOR(S): N.M. (1) LOPIANOWSKI

ISSUED BY CONTRACTOR AS REPORT NO: R-276-001

CONTRACTOR: CANTEL ENGINEERING ASSOCIATES LTD.
402 W. Pender St.
Vancouver, B.C. V6B 1T6

DEPARTMENT OF SUPPLY AND SERVICES CONTRACT NO: OPB81-07403

DOC REQUISITION NO: 36001-1-3180

DOC SCIENTIFIC AUTHORITY: R.G. FUJAROS
RADIO SYSTEMS R&D

CLASSIFICATION: UNCLASSIFIED

DATE: SEPTEMBER, 1982

## TABLE OF CONTENTS

Page

1. Summary 1

2. Introduction 15

    2.1 Terms of Reference for the Study 15
    2.2 Scope 15
    2.3 Objectives 16

3. System Characteristics 18

4. Study Methodology 19

    4.1 Available Data 19
    4.2 Sampling Plan 22
    4.3 Constraints on Study 23
    4.4 Voice Data Capture 25
    4.5 Digital Data Capture 30

5. Data Reduction 31

    5.1 Voice Tapes Data Reduction 31
    5.2 Digital Data Reduction 35
    5.3 Supplementary Data 36

6. Detailed Analysis 37

    6.1 General Comments 37
    6.2 Message Characterization 40
    6.3 Channel Utilization 52
    6.4 Traffic Assessment 66

7. Conclusions and Recommendations 71

8. Acknowledgements 73

9. References 74

Appendix A Vancouver Police Department Radio System Description

Appendix B Classification of Communications Carried on Mobile Radio Channels

Appendix C Voice Data Capture Productivity

Appendix D Statistical Software Produced as Part of Study

Appendix E Summary of Peak Busy Hours Sampled as part of the Study

Appendix F Conversion of Data Message Lengths to Radio Channel Time Occupancy

Appendix G Sample Frequency Distributions

Appendix H Definitions of Symbols (fold-out)

## TABLES

Page

TABLE 6-1 'BEFORE' AND 'AFTER' Comparison of Average Message Associated Values 50

Table 6-2 'AFTER' MRDS DATA Channel Message Characteristics 51

TABLE 6-3 Average Peak Busy Hour Occupancy Measures - Voice Channels 53

TABLE 6-4 'BEFORE' AND 'AFTER' MRDS Voice Channel Occupancy - Values of Interest 55

TABLE 6-5 Comparison of MRDS System Design Values and Those Encountered During Busy Voice Hour - Data Channel (all Four Districts Combined) 70

## FIGURES

FIGURE 4-1 Composition and Content of a Typical Police Radio Message (Shown as Entered on a Recording Form, Appendix D) 27

FIGURE 6-1 'BEFORE' AND 'AFTER' MRDS. Content of the Average Busy Hour by **Message Volume** ($N_M$) - **Voice Channels Only.** 41

FIGURE 6-2 'BEFORE' AND 'AFTER' MRDS. Content of the Average Busy Hour by **Message Volume** ($N_M$) - **Voice And Data Channels Combined.** 43

FIGURE 6-3 'BEFORE' AND 'AFTER' MRDS - **Voice Channels Only.** Sample Hourly Distribution of Messages ($N_M$) Per Unit and Type of Message. 45

FIGURE 6-4 'BEFORE' AND 'AFTER' MRDS - **Voice and Data Channels.** Sample Hourly Distribution of Messages ($N_M$) Per Unit and Type of Message. 46

FIGURE 6-5 'AFTER' MRDS - **Data Channel Only.** Sample Hourly Distribution of Messages ($N_M$) and Air-Time Occupancy ($T_{OM}$) Per Unit Versus Type of Message. 47

FIGURE 6-6 'BEFORE' AND 'AFTER' MRDS. Content of the Average **Voice Channel** busy hour by **Message Air-time Occupancy** ($T_{OM}$). 48

FIGURE 6-7 'BEFORE' MRDS. Variability of **Channel Content** of the Busy Hour as a Function of Channel **Message Time Occupancy** ($T_{OM}$). 56

FIGURE 6-8 'AFTER' MRDS. Variability of **Channel Content** of the Busy Hour as a Function of Channel **Message Time Occupancy** ($T_{OM}$). 57

FIGURE 6-9 'BEFORE' MRDS. Variability of **Voice Message Content** (Type 1 and Type 2 to 6 combined) of the Busy Hour as a Function of Channel **Message Time Occupancy** ($T_{OM}$). 58

Page

FIGURE 6-10 'AFTER' MRDS. Variability of **Voice Message Content** (Type 1 and Type 2 to 6 Combined) of the Busy Hour as a Function of Channel **Message Time Occupancy** ($T_{OM}$). 59

FIGURE 6-11 'BEFORE' MRDS. Variability of **Voice Channel Query Traffic** (Type 4 and 5 only) of the Busy Hour as a Function of Channel **Message Time Occupancy** ($T_{OM}$). 61

FIGURE 6-12 'AFTER' MRDS. Variability of **Query Traffic** (Type 4 and 5 only) of the Busy Hour **Voice and Data Channel Combined**as a Function of Channel **Message Time Occupancy** ($T_{OM}$). 62

FIGURE 6-13 Long Term CPIC Query Growth for the Vancouver Police System; 1976 - 1980. 67

# 1.0 SUMMARY

## INTRODUCTION

This report presents the results of a traffic and spectrum use study of the Vancouver Police Department Mobile Data System (MRDS). The periods of study covered the time 'before' and the time 'after' the introduction of data terminals into the Police Force. These correspond to 1980 and 1982 respectively.

The terms of reference established for the study were:

1. To retrieve and to analyze the records of voice and data traffic activity on the Vancouver Police radio channels. These records are contained on magnetic tapes. Voice channel tapes are in analog format and data channel tapes are digital.
2. To carry out a comparative analysis showing how the introduction of data terminals affected the message content, radio channel utilization and traffic volume on the Vancouver Police System.
3. To attempt assessment of the impact of MRDS on radio spectrum utilization and long term growth of the Canadiam Police Information Centre (CPIC) query traffic.

The objective of the study was to provide a post-installation assessment of one aspect of the MRDS System relative to design objectives and provide detailed radio channel-use data in a comprehensive form suitable for the DOC spectrum planning and management functions. A secondary objective was to foster development of Canadian Industry expertise and methodology appropriate to this type of radio channel evaluation.

## SYSTEM CHARACTERISTICS

The periods of study cover two system situations:

- the first one, in 1980, characterized by all analog voice communications – the 'before' situation
- the second one, in 1982, represents a time period following the introduction of digital techniques to augment the voice communications – the 'after' situation

### 'Before'

In the 'before' situation the Vancouver Police Department employed four analog voice radio channels, one for each of the policing districts, to support all dispatch, status reporting, information support and other related functions.

Requests from patrol units for queries to the national and provincial (B.C.) computer data bases were accomplished in two stages. The first by voice communications carried over the radio channel from the unit to the dispatcher. The second by means of conventional landline data base access from a remote terminal placed at the dispatcher's console. Responses were communicated to the unit from the dispatcher by voice. A significant amount of radio channel time was required for this purpose.

### 'After'

Data communications was introduced into the Vancouver Police Department for the first time in 1980 as an adjunct to existing voice radio systems. This new mode of communications became known as the Mobile Radio Data System (MRDS) and provided an alternate and more efficient means of communicating with patrol units for certain types of messages. It was intended to augment rather than displace the existing voice radio communications. In the Vancouver Police operations, MRDS became particularly well suited for handling queries to the remote computer data bases directly from data terminals in the patrol units thus off-loading the dispatch personnel. In addition MRDS proved valuable as a communication channel for narrative traffic between patrol units and for bulletins and descriptions originated by the dispatcher. No dispatching is carried out by means of MRDS and for status communications it is only rarely used.

**Operational Aspects**

During the time interval between the two periods of the study - from 3rd quarter 1980 to 1st quarter 1982 - some important operational changes were introducted within the Vancouver Police Department. It is of some importance to understand these changes, since they had, jointly with the effect of MRDS, a strong bearing on the intensity and character of communications, in particular during the peak busy hours of traffic.

The changes of importance to the study are characterized by the following:

'Before' Operation - 3rd quarter 1980

- vehicular patrol units deployed in five overlapping 8-hour shifts during a 24 hour period
- manpower allocated to each of the four districts in accordance with its size and crime characteristics
- manpower alloctions relatively flat (40 to 60 units) over the course of a working day
- personnel assigned to two-men per unit on the average 60% of the time

'After Operation - 1st quarter 1982

- team policing concept in effect as introduced in a modified and expanded form in June 1981
- overlapping shift schedule made longer and arranged to permit the peak demand for service to be better satisfied
- manpower allocation and overlapping 10-hour shifts arranged to have maximum number of patrols during the hours 2000 to 0200
- variation in units employed in a typical 24 hour day became as follows:
  0700 - 1600 60 units
  1600 - 2100 build up to 120 units

2100 - 0200 120 units
0200 - 0400 reduction to 40 units
0400 - 0700 40 units

- MRDS terminals introduced into the patrol vehicles to a level of approximately fifty (50) terminals at this time

## STUDY METHODOLOGY

### Available Data

Radio voice traffic recordings were available on magnetic tapes, one for each 24-hour period starting at 0700 hrs. Twenty-nine (29) voice tapes were available for 1980, the 'before' situation and fifteen (15) for 1982, the 'after' situation.

Data channel traffic is recorded on computer tapes each covering a time interval varying from three to six 24-hour periods. Tapes were saved for the periods corresponding to the voice records.

Certain supplemental information was required for analysis purposes. It included: the CPIC query statistics; Vancouver Police daily duty sheets and records of assignment of MRDS Terminals to policing districts; records of radio channel use; a number of reports and specifications relating to the MRDS overall plan and to the Vancouver Police Department System.

### Sampling Plan

The terms of reference of the study required that peak busy hours for voice channels be studied - these being defined as the hours during which radio channel use exceeded 1080 seconds during the hour. Such level of use is considered as a threshold above which queueing time for access to the channel increases, messages become shorter and dispatchers start working under considerable stress.

Radio channel use records served as the primary source of information on the basis of which peak busy hours were identified. The sample of busiest hours covering 'before' MRDS consisted of seventeen (17) hours on each of two voice radio channels: channel 1 and channel 3. 'After' MRDS twenty-one (21) hours were analyzed on each of the voice channels and the data channel.

## Voice Data Capture and Reduction

Analysis of voice tapes was carried out by listening to the conversations, identifying them as to type and timing the individual voice activity periods (transmissions), gaps of silence between them, and the duration of the overall message from start to finish including inter-activity gaps.

Data captured from voice tapes was first manually recorded on forms and then transferred to diskettes using an Apple II+ microcomputer. Approximately 120,000 data entries were gathered during this part of the study and it was therefore considered essential to have machine computation assistance during the analysis stage.

Because the accuracy of data captured from voice tapes was very much influenced by the operator's reaction, attitude and alertness, regular spot checks of records were instituted. Integrity of captured data was thus preserved by taking corrective action as deemed necessary.

Reduced data was primarily made available in the form of a computer printout which provided, on an hourly basis, information on all the important parameters required to characterize the message and channel content of a radio channel. This includes:

- **number of messages** per hour - all types combined and each type individually
- average **duration per message** of dispatcher voice activity (transmissions), patrol unit voice activity and idle time gaps
- average **overall message length**
- average **number per message** of dispatcher transmissions, unit transmissions and idle time gaps
- **frequency distributions** of message duration for the total number of hours sampled on each voice channel

Further manual reduction was undertaken with a hand calculator to produce information of interest to the study.

### Digital Data Capture and Reduction

A record of messages carried by the data channel is available in digital format on computer tapes. This information was accessed and analyzed by means of a software program prepared as part of the study. The following statistics were produced for each sampled hour:

- **frequency distribution** of message duration for each digital message type
- mean **message duration** for each type
- **number of messages**
- **number of MRDS terminals** which have **originated** messages during the sampled hour

## STUDY RESULTS

### General Comments

As discussed above a number of significant operational changes took place in the Vancouver Police system between 1980 and 1982. To make comparisons more meaningful between the two periods of time it was felt desireable to normalize some of the values characterizing the traffic on radio channels. A concept of describing the activity on a **per patrol unit** basis was adopted to assist in understanding the changes that took place.

Thus, typical peak busy hour ratios that evolved are:

- average **number of messages** handled **per patrol unit(messages** per unit)
- average **time** contributed to the **message occupancy** (transmissions plus gaps) or a radio channel **per patrol unit** (seconds per unit)
- average **time** contributed to the voice activity or **transmission occupancy** of a radio channel **per patrol unit** (seconds per unit)
- average **number of digital messages** handled by a MRDS terminal in a **patrol unit** (messages per unit)

Throughout the study the terms '**message length, duration or time**' are used in line with the international definition and include the aggregated air time of individual voice activites and idle gaps between the first and the last activity. In describing traffic on police systems the term message time frequently refers to the aggregated time of only the voice activities in a message. In this study '**transmission length, duration or time**' are used to describe this value.

Finally, the study examined in detail only channels 1 and 3 of the radio system. However since there does not appear to be anything that would cause traffic on channels 2 and 4 to have different characteristics, discussions and conclusions stemming from the work of this study are stated as applying equally to each of the four radio channels of the Vancouver Police Department.

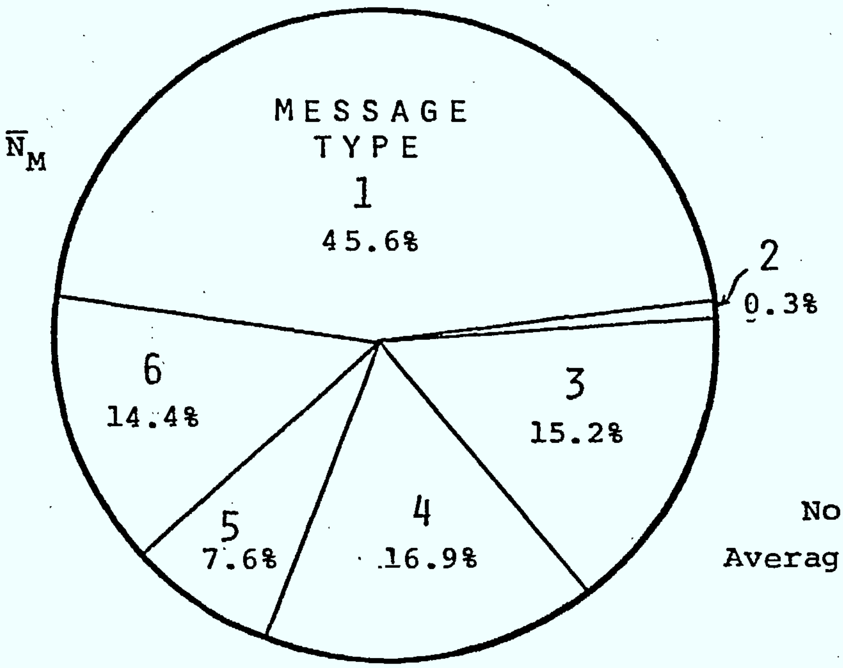
### Message Characterization

Analysis and comparison of the 'before' and 'after' radio channel data has shown that overlay of the MRDS mode of communications on the existing voice radio system has caused little change in the volume distribution of different message types during an average peak busy policing hour. This is depicted in Figure 1-1 showing the 'before' and 'after' content charts.

Status messages (type 3) have somewhat increased and narrative messages (type 6) have decreased slightly. The average number of messages per hour ($N_M$) has increased by 6.6% while the average message length ($T_M$) has remained the same indicating good channel control exercised by dispatchers under peak loads.

The number of messages per unit ($N_M/F_P$) has decreased, in part probably because of increased number of units contesting the voice radio channel access and in part because of availability of MRDS terminals in some 60% of the patrol cars. This latter aspect becomes evident when examining Figure 1-2 which is similar in presentation to Figure 1-1 except that the 'after' chart shows the combined content of traffic on voice and data channels. As expected on an overall basis there has been an increase (43%) of the combined data base query and response class of messages.

'BEFORE' MRDS



$\bar{N}_M$ = 148.3

$\bar{T}_M$ = 10.9 s

$\bar{N}_M / \bar{F}_P$ = 8.7

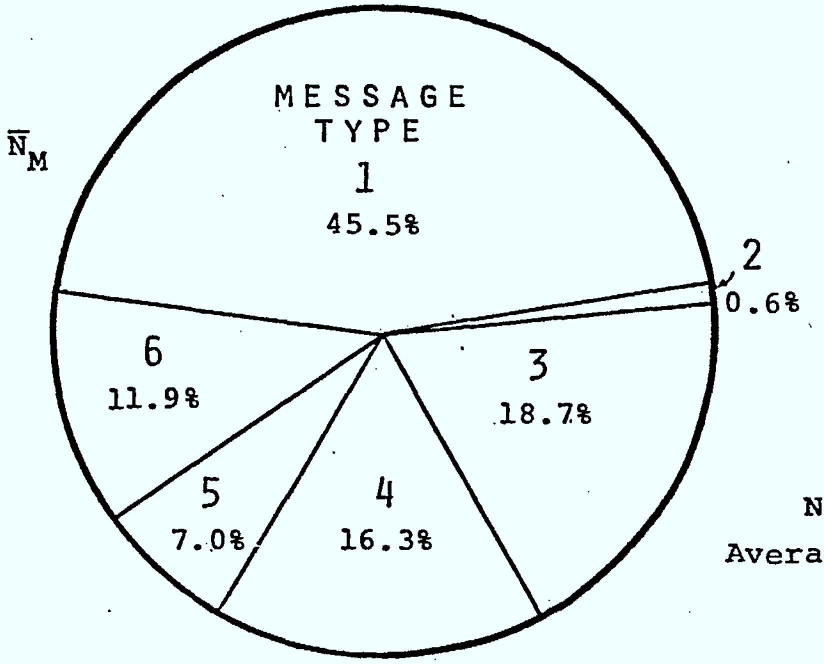
No. of hours sampled = 34

Average no. of units, $F_P$ = 17

MESSAGE TYPES:

Type 1 - Dispatch
Type 2 - Tactical
Type 3 - Status
Type 4 - Data Base Requests
Type 5 - Data Base Responses
Type 6 - Descriptive/Narrative

'AFTER' MRDS



$\bar{N}_M$ = 158.1

$\bar{T}_M$ = 10.9 s

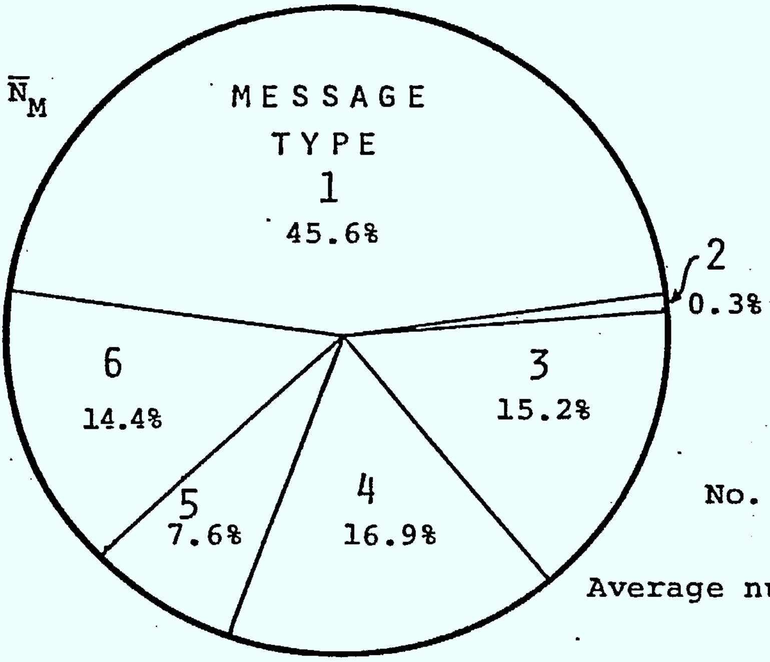
$\bar{N}_M / \bar{F}_P$ = 5.7

No. of hours sampled = 42

Average no. of units, $F_P$ = 28

FIGURE 1-1 'BEFORE' AND 'AFTER' MRDS COMPARISON
Content of the average busy hours by message volume ($\bar{N}_M$) - VOICE CHANNELS ONLY

## 'BEFORE' MRDS - VOICE CHANNEL TRAFFIC ONLY



$\overline{N}_M$ = 148.3

$\overline{T}_M$ = 10.9 s

$\overline{N}_M / \overline{F}_P$ = 8.7

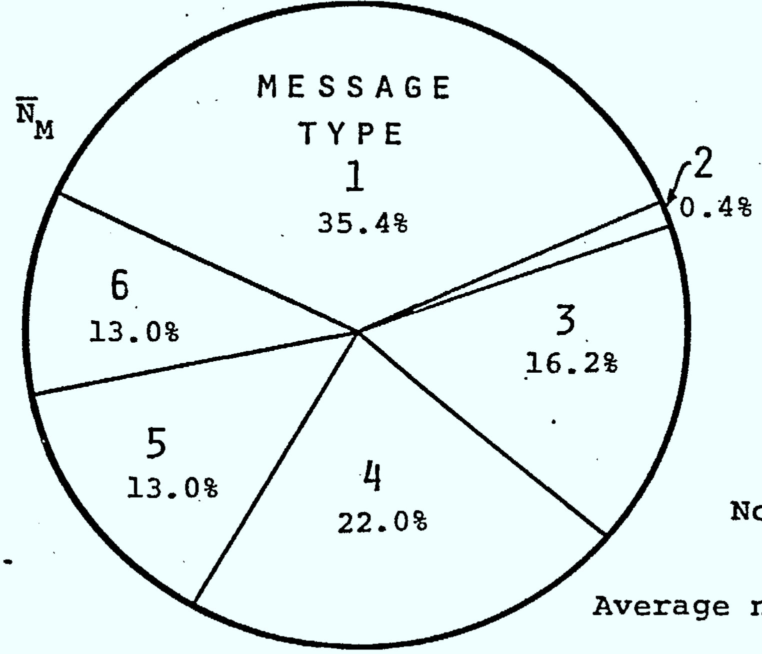
No. of hours sampled = 34

Average number of units, $F_P$ = 17

MESSAGE TYPES:

Type 1 - Dispatch
Type 2 - Tactical
Type 3 - Status
Type 4 - Data Base Requests
Type 5 - Data Base Responses
Type 6 - Descriptive/Narrative

## 'AFTER' MRDS - VOICE AND DATA CHANNEL TRAFFIC COMBINED



$\overline{N}_M$ = 203.1

$\overline{N}_M / \overline{F}_P$ (without MRDS term) = 5.7

$\overline{N}_M / \overline{F}_P$ (with MRDS term) = 11.1

No. of hours sampled = 42 (voice)
= 21 (data)

Average number of units, $F_P$ = 28
$F_M$ = 8.3

FIGURE 1-2 'BEFORE' AND 'AFTER' MRDS COMPARISON
Content of the average busy hours by <u>message volume</u> ($\overline{N}_M$) - <u>VOICE AND DATA CHANNELS COMBINED</u>

Finally a comparison of the message content by radio air-time occupancy is shown on the charts of Figure 1-3. The average message time occupancy ($T_{OM}$) and transmission time occupancy ($T_{OT}$) have both slightly increased (by about 7%) however the average per unit values, $T_{OM}/F_P$ and $T_{OT}/F_P$ have decreased as a result of the larger number of units deployed in the 'after' situation.

## Channel Utilization

The study has shown that changes in the operation and method of policing in the Vancouver Police Department have not materially affected the average message occupancy ($T_{OM}$) of the voice radio channels. The average change from Figure 1-3 is 7.3%. On the same figure the difference between $T_{OM}$ and $T_{OT}$ represents the channel idle time between transmissions in individual messages. For the two situations this idle time averages 35% of the channel message occupancy.

It may be possible to consider improvement of channel utilization by making use of this time which is made up of individual gaps within each message and averages 1.6 sec per gap. This is long enough to accomodate at least one data message which on the average is 0.3 sec long. However since we are dealing with averages, before seriously considering such an approach in practice, additional studies would be required.

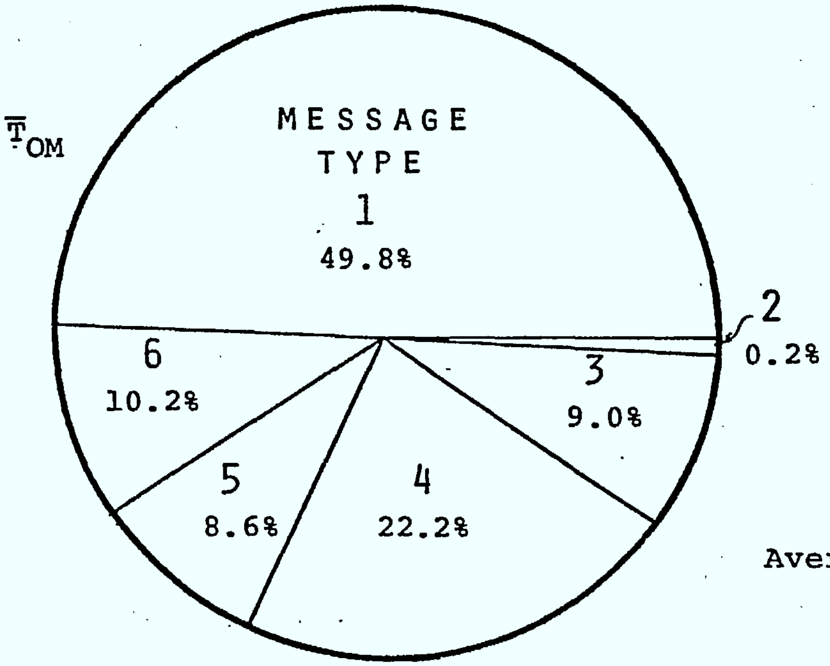
It was of interest to determine whether the voice message content during the peak busy hours was a function of total message occupancy ($T_{OM}$) i.e. whether the size of the sectors of the pie-charts in Figures 1-1 to 1-3 exhibited some relationship to the message occupancy. For this purpose a number of analyses were performed on the data gathered during the study but no particular trends could be detected.

Another value of interest was the ratio of the average dispatcher to unit transmission time ($T_D/T_U$). The study has shown that introduction of MRDS did have a small effect. The ratio changed from 0.94 'before' to 0.81 'after'.

## Spectrum Utilization

A measure of spectrum utilization of voice channels is the message occupancy averaged over a period of time. Police systems must be designed to handle the peak policing activity and it is for this reason that peak busy hours are of

'BEFORE' MRDS



$\overline{T}_{OM}$ = 1610.0 s

$\overline{T}_{OT}$ = 1048.8 s

$\overline{T}_{OM}/\overline{F}_P$ = 94.7 s

$\overline{T}_{OT}/\overline{F}_P$ = 61.7 s

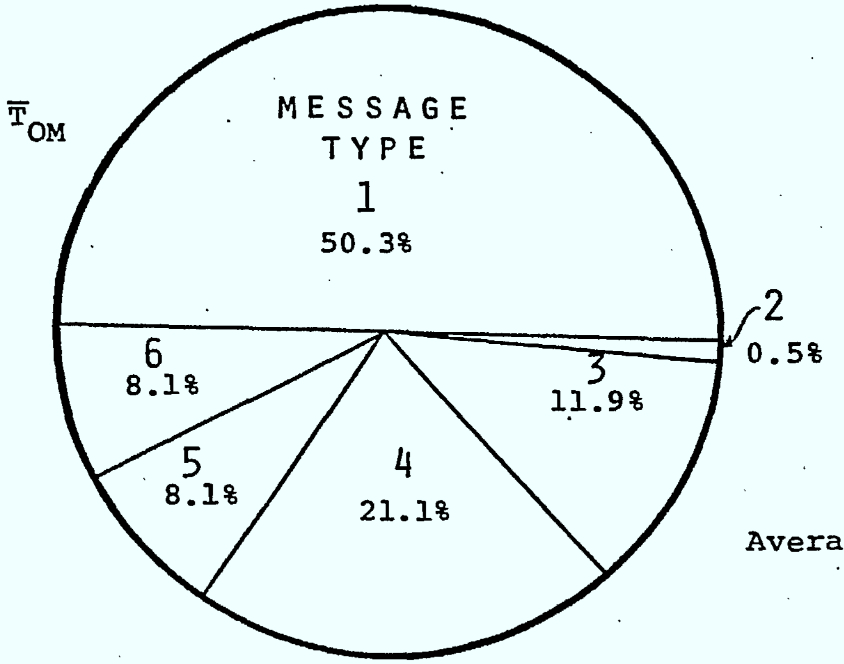
No. of hours sampled = 34

Average no. of units, $F_P$ = 17

MESSAGE TYPES:

Type 1 - Dispatch
Type 2 - Tactical
Type 3 - Status
Type 4 - Data Base Requests
Type 5 - Data Base Responses
Type 6 - Descriptive/Narrative

'AFTER' MRDS



$\overline{T}_{OM}$ = 1727.4 s

$\overline{T}_{OT}$ = 1116.2 s

$\overline{T}_{OM}/\overline{F}_P$ = 61.6 s

$\overline{T}_{OT}/\overline{F}_P$ = 39.9 s

No. of hours sampled = 42

Average no. of units, $F_P$ = 28

FIGURE 1-3 'BEFORE' AND 'AFTER' MRDS COMPARISON

Content of the average voice channel busy hour by message air-time occupancy ($T_{OM}$)

interest. The study has shown that in the Vancouver System 'after' MRDS an average peak busy hour is occupied by messages for 48% of the time, as compared to 45% in the period 'before' MRDS. However the average number of patrol units has increased by 65%, from 17 to 28 per channel.

This tends to suggest that there may be a saturation level for Vancouver and based on the observations collected during the study the following hypothesis has been proposed:

- the saturation level of radio channels is a message content representing approximately 50% message occupancy of the hour corresponding to the Vancouver Police Department
- this saturation level occurs when the message traffic results from a large number of unrelated crime events
- the saturation level is primarily influenced by what one dispatcher can handle on a continuous basis - dispatcher's decision time becomes shorter as the hour becomes busier
- the saturation level is exceeded, peaking-up to 75% of the hour or 2700 sec channel use, as a result of one or more multi-unit policing events occuring in series
- increasing the number of MRDS terminals will not significantly reduce the average peak message occupancy of the busy hour message occupancy but it will improve the grade of service for patrol units in the field and their ability to fulfill the policing function. Some reduction in occupancy may result from reduction of the CPIC queries currently handled by voice.

Occupancy statistics for the data channel show that it is carrying messages for 130 sec. This is a small value indicating an apparent spectrum under utilization. However if the traffic carried by this channel were to be transferred to conventional voice it would require approximately 2700 seconds of air-time or the equivalent of approximately two voice channels. From this point of view the impact of improved spectrum utilization as a result of application of MRDS mode of communications becomes apparent.

### Traffic Assessment

Message traffic carried on voice channels has only marginally increased between the two situations studied: from 148.3 messages per hour 'before' to 158.1 messages per hour 'after' or by 6.6%. The distribution of traffic by message type within the hour has also remained substantially the same.

It is the data traffic that is primarily responsible for the overall increase in message traffic. In particular the rate of generation of CPIC queries/responses has increased by almost 100%.

There appears to be a significant spare capacity left in the Vancouver Police data channel to handle the traffic not only during policing activities corresponding to the maximum peak levels currently experienced but also as the system grows to its design target with 100 terminals and an expected message generation of 1765 per hour.

## CONCLUSIONS

The study has concluded that:

- introduction of MRDS terminals has caused little change (around 6%) to the average message content of a voice channel either by volume or by air-time
- the average voice message length has not changed and remains at 10.9 seconds
- the average air-time occupancy during peak hours is approximately 50% peaking to 75% of the hour. It is hypothesized that the former value represents the average saturation level of a voice radio channel in the Vancouver System. The latter value mainly occurs as a result of multi-unit policing events of longer duration that take place simply or in sequence.
- grade of service for all types of communications has deteriorated in the 'after' situation for patrol units not equipped with MRDS terminals. For units with terminals, capability to handle queries has improved greatly

- at the traffic level the data channel is primarily responsible for most of the increase from 'before' to 'after'. The query/response traffic has on the average increased by 100%
- the average message occupancy of the data channel is 130 seconds of the hour. This traffic would require approximately 2700 seconds if transmitted by voice and would need two radio channels
- the data channel has adequate capacity to handle the existing peak busy policing hour traffic and to grow into its design target values of 1765 messages per hour generated by 100 MRDS terminals
- CPIC query statistics suggest that hours other than those studied may contain the peak busy hour data traffic

## RECOMMENDATIONS

The study recommends:

- that Vancouver Police sample the traffic on data channel at various hours throughout the week on a regular basis. This will give an insight into how peaky is the hourly traffic.
- that an attempt be made to determine the ratio of queries originated by patrol cars equipped with terminals versus those without them. This along with the background information from this study will help to determine whether the grade of service for the two cases are the same.
- that an attempt be made to find out whether the terminals are used to their full extent or are there impediments to this during situations of high stress caused by peak busy policing periods. This would be done through a behavioural type study.
- that it would be useful to develop an improved tool for sampling the message characteristics from voice tapes. The present manual techniques are too time consuming and not well adapted for use within operational environments.

# 2.0 INTRODUCTION

## 2.1 Terms of Reference for the Study

This report presents the results of a Traffic and Spectrum use study of the Vancouver Police Department mobile radio system. Emphasis of the study was on vehicular patrol communications, both the conventional two-way mobile radio system and the overlay of a radio data system. The terms of reference established for the study were:

1) to analyze the records of voice traffic activity on Vancouver Police dispatch radio channels. These records, contained on magnetic tapes, represented several twenty-four hour periods of traffic activity existing 'before' as well as 'after' the introduction of MRDS terminals into the system.

2) to retrieve and analyze the records of activity on the Vancouver Police data channel. It carries all the transactions between the MRDS terminals located in field units and the centralized computer facility. The information is stored on digital magnetic tapes each one containing three to six days of records.

3) to carry out a comparative analysis showing how the introduction of data terminals affected the message content, radio channel utilization and traffic volume on the Vancouver Police System.

4) to attempt assessment of the impact of MRDS on radio spectrum utilization and the long term CPIC traffic growth.

## 2.2 Scope of the Study

The main scope of the study was to sample the peak busy hour records contained on magnetic tapes relating to the voice and data traffic on the Vancouver Police radio channels, to capture the data and to carry out an analysis of the situation 'before' and 'after' MRDS.

The peak busy hour information content of the voice tapes was examined in detail as to the message duration and its type. Duration of each radio channel activity was timed and identified whether initiated by a patrol unit in the field or the dispatcher. Gaps of silence between activity periods within each message were also timed as well as the duration of complete messages from beginning to end. The messages were classified into different types as defined by the Vancouver Police. Software was prepared for data end and statistical analysis of the raw data derived from this manual transcription of information from the voice tape recordings.

Data radio channel records stored on digital tapes by the MRD System required the preparation of a statistical software program prior to being able to capture the data. The program was used to analyze the stored information and to classify the messages according to their duration and type.

A comparative analysis was carried out of the voice and data channel statistics and the effect of introduction of MRDS terminals was assessed on the message characteristics, radio channel utilization and the radio channel traffic.

## 2.3 Objective

The primary objective of the study was to obtain a comparative analysis of the traffic on radio dispatch channels before and after the introduction of digital data terminals into police patrol cars. This analysis would provide a post-installation assessment of one aspect of the MRD System relative to design objectives, and provide detailed radio channel-use data in a comprehensive form, suitable for the DOC spectrum planning and management functions. A secondary objective was to foster development of Canadian industry expertise and methodology appropriate to this type of radio channel evaluation.

Specifically the study was directed to address the following questions:

1) Is there a noticeable change in the message characteristics of the voice radio channels as a result of MRDS?
2) Has there been a significant increase in the CPIC enquiries during peak periods as a result of making MRDS terminals available in the field?
3) Has the average message length changed?
4) Has conversion to MRDS affected the grade of service?
5) Has increased efficiency in the overall utilization of radio spectrum resulted from the use of MRDS terminals?

## 3.0 SYSTEM CHARACTERISTICS

A comprehensive description of the Vancouver Police Department Mobile Radio Data System and the associated analog voice communications system is contained in Appendix A. This description is intended to put into clear context the nature of the overall system under study. The specific focus is on radio communications between the patrol personnel (both in vehicles and on foot) and communications centre staff (eg. dispatchers) as well as information support services. The particular system situations studied are the 'before' case which is characterized by all analog voice communications between dispatchers and patrol units, and the 'after' case which is characterized by the existing voice communications system augmented by the new mode of data communications.

Factors which are relevant to the analysis and comparison of the 'before' and 'after' cases include some which are in addition to system implementation characteristics. For example, the degree of adaptation of the patrol officers to the new data mode of communications relative to design objectives is potentially very significant, though this aspect is not addressed directly in this study. The changes to police operational practices, either by design as part of the introduction of the data communications capability or for other reasons such as resource reallocation, affect the comparisons to be made regarding radio spectrum use for the 'before' and 'after' cases. Such factors are specifically accounted for in this study to the greatest extent feasible.

Thus, the impact on radio spectrum use due to augmented communications capability must be interpreted in the context of both technical and non-technical features of the overall system.

# 4.0 STUDY METHODOLOGY

## 4.1 Available Data

The main source of information around which the study was centered are magnetic tape recordings of traffic on voice and data radio channels described as follows:

**Voice Tapes**

- All transactions on voice radio channels are continuously recorded over a 24-hour period on twelve-inch multichannel reels starting at 0700 hrs one day and finishing at 0700 hrs the following day.

- The tapes are coded with the date at the time of removal. Thus tape 82.03.07 represents a tape covering the period 0700 of 82.03.06 to 0700 of 82.03.07.

- Twenty-nine (29) voice tape reels are available for the year 1980, the time 'before' introduction of MRDS terminals. They cover the following days:
    - Sept. 08, 13, 16, 18, 23
    - Oct. 18 to 31
    - Nov. 01 to 10

- Fifteen (15) voice tape reels, for the year 1982, the time 'after' introduction of MRDS terminals, are available as follows:
    - 82.02.19, 20, 21
    - 82.03.05, 06, 07, 14, 20, 21, 26, 27
    - 82.04.05, 10, 12, 17

- 1982 tapes primarily cover the week-end periods (Thursday night through Sunday morning - three tapes). Tapes for week-end Mar 26-28 are not available for two reasons:
  - tape 82.02.26 was inadvertently overwritten very shortly after data capture was complete.
  - tapes 82.02.27 and .28 had a recording defect and were not kept.

- The recording voice quality of 1980 tapes is better than 1982. In particular the voice levels on the latter are quite low and it is sometimes difficult to understand the conversations.

## Digital Data Tapes

- Data channel recordings are made on 8-inch computer tapes produced by the Vancouver Police DEC PDP11/34 system.

- Each data tape covers a time interval varying from three to six 24-hour periods which is a function of the radio channel traffic.

- Digital tapes set aside for 1982 were those to correspond with the time intervals of the voice tapes. However, after writing the data capture software for the purpose of analyzing those tapes, it became evident that some of them were either totally or partially unusable. Useful tapes that have been saved cover the periods:
  - Feb. 19 to 21
  - Feb. 25 to 27
  - Mar. 04 to 07
  - Mar. 10 to 15
  - Mar. 17 to 20
  - Mar. 30

## Supplemental Information

Certain additional information was required for analysis purposes. This was obtained from various sources and is described below:

- MRDS CPIC statistics covering the period 80.12.08 to 81.04.30 (Ref.1) - source: Cpl. D. Lea, Vancouver Police

- MRDS CPIC statistics 78.01 to 79.02; 75.08 to 76.08; 77.02 to 78.01 (Ref. 2) - source: Mr. P. Vanderwood, City of Vancouver

- MRDS Radio Coverage Tests - October 1979, Research Branch, Engineering Department (Ref. 3) - source: Mr. P.Vanderwood. This information was needed in assessing the radio air-time occupancy of the digital data channel.

- Vancouver Police Daily Duty sheets and Records of Assignment of MRDS Terminals to policing districts (Ref. 6) - source: Cpl. D.Lea. These records provided information on the number of patrol units and MRDS terminals operating in districts 1 to 4 during the hours for which analysis was performed.

- Records of Radio Channel Use (Ref. 4) - source: Cpl. D.Lea. These records provide a measure of the radio channel occupancy. They show on an hourly basis the total amount of time that a radio transmitter and receiver is keyed on each channel separately.

- Description of MRDS System and its Error Control Strategy (Ref. 5) -source: Mr. R. Fujaros, DOC/CRC, Ottawa. On the basis of this document with some assisstance from Mr. Strecko of International Mobile Data Inc. it was possible to convert the digital channel records available as characters per message to radio air-time.

- Classification of Communications carried on Mobile Radio Channels -Vancouver Police Department - source: developed through discussions with Cpl. D. Lea. This is the key reference document used to develop message characteristics of the radio channels. It is included in Appendix B.

## 4.2 Sampling Plan

Vancouver Police Department has four operational voice channels 1 to 4 (one for each of the policing districts), one tactical voice channel (#5) and one data channel. A review of the historical records at the beginning of the study indicated that voice radio channels 1 and 3 (corresponding to the same numbered districts) were generally more active than the others and that districts 1 and 3 were the first ones to use the MRDS terminals. This consideration led to the choice of channels 1 and 3 as those to be studied.

Since the terms of reference required that peak busy hours be studied, the following sampling plan was adopted:

**'Before' MRDS – 1980**

- Channel Use Records (Ref. 4) were examined to identify those hours which showed channel use in excess of 1080 seconds during the hour. This is considered by the Vancouver Police as a threshold above which queueing time for access to the channel increases, messages become shorter and dispatchers start working under considerable stress. These hours are referred to throughout the report as **peak busy hours.**

- The selected hours were then grouped as to channel use in descending order and data capture proceeded starting with the largest one, examining as many hours on each channel as the project budget permitted. A list of the actual hours sampled is included in Appendix E.

**'After' MRDS – 1982**

- A somewhat modified sampling plan was applied to the records 'after' MRDS. Since the digital data channel is shared by the MRDS terminal users in all districts it was considered necessary to locate, as candidates for sampling only those hours that had channel use in excess of 1080 seconds on each of the channels 1 and 3 simultaneously.

- The peak busy hours were sampled as above from the records (Ref. 4) obtained during six successive weekends (Thursday evening to Sunday morning) in February and March 1982. The project budget did not permit any analysis of the April 1982 records. Refer to Appendix E for the list of actual hours sampled.

## 4.3 Constraints on Study

There were a number of constraints under which the study was carried out and it is important for the reader to have a clear understanding of them while reviewing the results of analysis.

### 4.3.1 Size and Type of Sample

Data capture process from voice tapes is quite time intensive and, in view of the project budget limitations, the total number of hours sampled had to be constrained to a relatively small number:

| | |
|---|---|
| - for 1980: | 17 hours on channel 1 |
| | 17 hours on channel 3 |
| - for 1982: | 21 hours on channel 1 |
| | 21 hours on channel 3 |
| | 21 hours on data channel |

The main criterion for selection of an hour for analysis was its activity as determined from channel use records. No other information was available as to the causes contributing to the hour being busy e.g. planned events, tactical situations, armed hold-ups, etc.

### 4.3.2 Voice Traffic Analysis

Prior to commencing the data capture from voice recordings it was necessary to adopt a uniform method of classification of communications carried on mobile radio channels. Initially it was felt that the classifications developed by CPIC in 1976 would be satisfactory. However because problems arose with their practical application a modified list (Appendix B) was developed through discussions with Vancouver Police and was used throughout the study.

### 4.3.3 Voice Data Entry

As data was captured from the voice tapes, it was entered onto floppy diskettes using an Apple II+ microcomputer. Statistical analysis on this machine presented some difficulties because of its limited core capacity. A significant amount of data had to be processed manually to complete the analysis.

### 4.3.4 Digital Data Analysis

Information stored on digital magnetic tapes contains the following records:

- All completed messages originated by the patrol units equipped with MRDS terminals in districts 1 to 4.
- All CPIC and other data base responses regardless of whether or not they were transmitted to the unit in the field.
- Error messages transmitted over the radio channel.
- Messages, local to the Police Communications centre and not carried on the radio channel.

The tapes do not contain any information on messages that were subject to retransmission due to radio channel propagation errors, nor could the information be readily obtained as to the district of origin (i.e. district 1,2,3, or 4) of the messages.

To convert the statistics obtained from digital tapes it was necessary to exercise some judgement regarding:

- percentage of any data base response (text) message which is transmitted over the radio channel. These messages are blocked into pages up to 315 characters in length. The pages (up to 30 in number) are stored in the host computer ready to be sent out when requested by the patrol unit personnel via the terminal. The number transmitted depend on the nature of information contained in them. Vancouver Police were helpful in making this assessment. For more details refer to Appendix F.

- retransmissions due to propagation errors. A radio propagation test report for the City of Vancouver (Ref. 3) was helpful in assessing this aspect. Some comments on this are included in Appendix F.

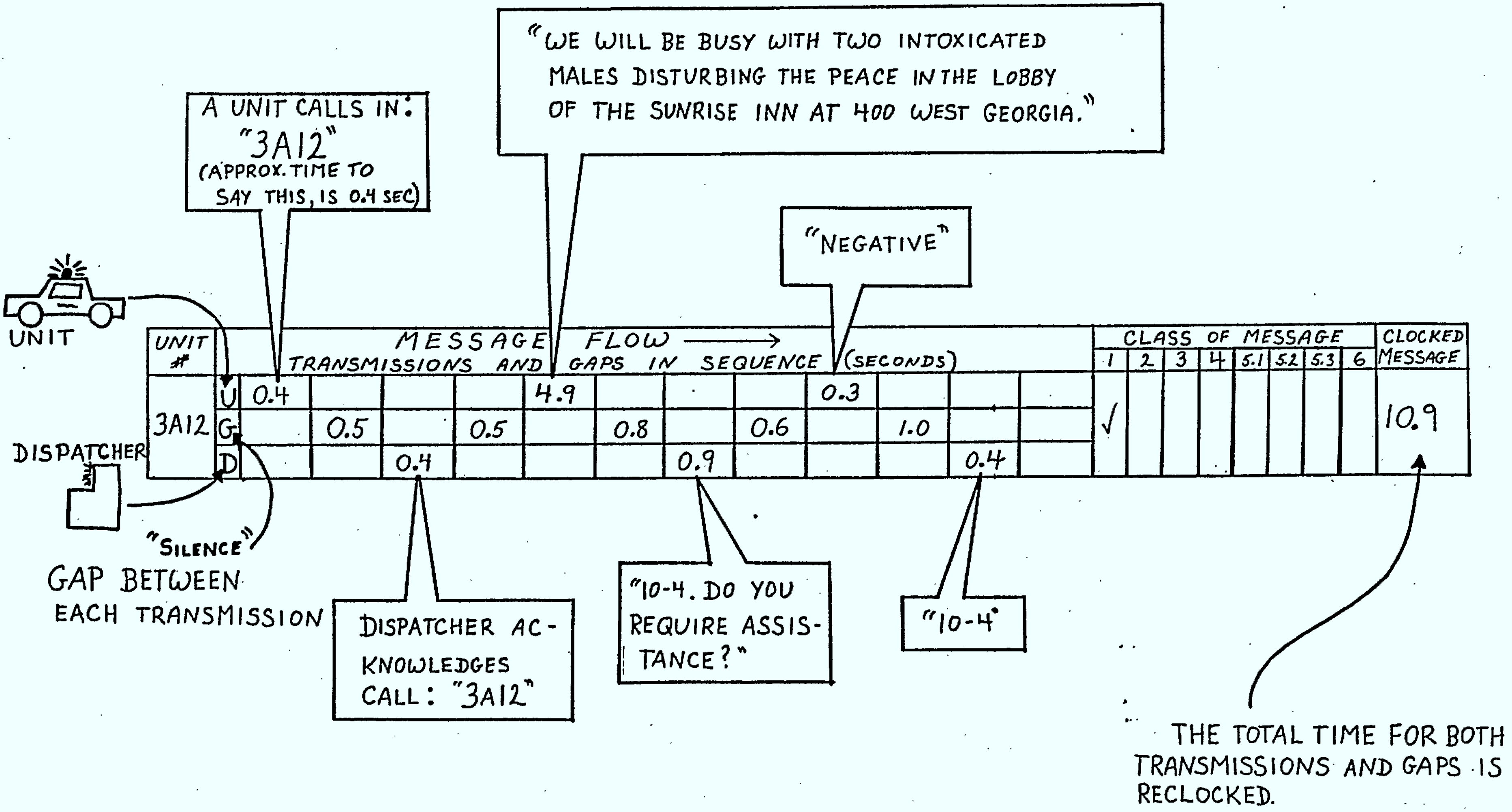
## 4.4 Voice Data Capture

### 4.4.1 Voice Tape Analysis

Prior to commencement of a full scale program for data capture a pilot run was initiated to establish an acceptable approach of analyzing the voice tapes. A number of techniques were tried including simultaneous use of two operators - one for classification of messages and the other for timing.

The technique finally adopted is to use a single operator throughout the whole process which is as follows:

- while the tape reproducer is running the operator listens for start of a message
- as soon as voice transmission starts a stopwatch is started and left on to completion of the transmission
- the lapsed time for the first transmission is recorded on a form and identified whether by a unit (U) or dispatcher (D) (Figure 4-1)
- the tape reproducer is then slightly backed-up and the time for the idle time gap (G) between the first and the following transmission is measured with a stop watch
- the gap time is recorded on a form and identified as G
- the tape reproducer is again backed-up slightly and the second transmission is timed, recorded and identified whether U or D
- the timing continues until the end of the complete message is reached recording and identifying transmissions and gaps in sequence
- the tape reproducer is then backed-up to the beginning of the message and the lapsed time is clocked from beginning of the first to the end of final transmission including idle gaps in between. This value is recorded as the clocked message time.



| UNIT # | | MESSAGE FLOW → TRANSMISSIONS AND GAPS IN SEQUENCE (SECONDS) | | | | | | | | | | | | CLASS OF MESSAGE | | | | | | | | CLOCKED MESSAGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | | | 1 | 2 | 3 | 4 | 5.1 | 5.2 | 5.3 | 6 | |
| 3A12 | U | 0.4 | | | | 4.9 | | | | 0.3 | | | | ✓ | | | | | | | | 10.9 |
| | G | | 0.5 | | 0.5 | | 0.8 | | 0.6 | | 1.0 | | | | | | | | | | | |
| | D | | | 0.4 | | | | 0.9 | | | | 0.4 | | | | | | | | | | |

FIG. 4-1 COMPOSITION AND CONTENT OF A TYPICAL POLICE RADIO MESSAGE (SHOWN AS ENTERED ON A RECORDING FORM, APPENDIX D)

- while clocking the complete message the content of the message is listened to, and the message type classified and recorded
- the process continues from message to message until data for the sampled hour is completely captured. Idle gaps between the end of one message and the start of another are not timed
- after every lapsed operator hour of capturing the data a short period of rest is taken

Definitions of various terms used in capturing the data are included in Appendix H.

### 4.4.2 Computer Data Entry

Captured voice channel data, recorded on forms as above was entered on diskettes using an Apple II+ microcomputer. Because of the large amount of data being gathered (approximately 120,000 data entries) it was considered essential to have machine computation assistance during the analysis stage. In total twenty six-inch (26) single density diskettes were required to enter all the data. Details on data entry software developed for this study and labeled VOICEDAT is included in Appendix D.

### 4.4.3 Quality of Captured Data

Because the accuracy of data captured from voice tapes was very much influenced by the operator's reaction, conscientiousness, attitude and alertness, regular checks of records were instituted on a weekly basis. These checks were set up as follows:

- Several tape minutes of the data were selected at random from each of the two operators records.

- Each operator was asked to repeat the analysis on his own and the other operator's segment.

- The data from re-analyzed segments was then compared with that originally captured and comparison made of the measured message time and classification to assess the data reliability.

An additional check was built-in to the measurement process itself. As described in section 4.4.1 the records contain information not only on the individual components of the message i.e. transmissions and gaps but also on the overall clocked message length. By aggregating the time for individual components and comparing it to the clocked time an indication could be obtained of the accuracy of the data. This feature proved useful in the analysis since the computer was made to flag any entries which had more that 20% difference between the aggregated and clocked message time. It permitted identification and correction of major data entry errors and gave a measure of the overall data reliability.

### 4.4.4 Productivity

The overall process of capturing data from recordings of voice traffic on the radio channels proved quite time consuming. On the average, to capure the data from an hour's activity on one radio channel, it took 9.7 operator hours (Appendix C provides a detailed breakdown of this budget). A total of 76 channel hours were analyzed in this manner.

## 4.5 Digital Data Capture

As described earlier in this section, traffic associated with the MRDS radio channel is recorded on computer tapes by the Vancouver Police PDP11/34 system. A computer program, labeled MAGREAD, was made available to the study by means of which data recorded on the tapes could be accessed. Supplementary software labeled MAGSTAT was written which in conjunction with MAGREAD produced the desired statistics (see Appendix D).

# 5.0 DATA REDUCTION

## 5.1 Voice Tape Data Reduction

### 5.1.1 Microcomputer Output

The statistical data reduction program (VOICEDAT), working on the information captured from voice tapes was designed to produce the following values for each analyzed channel hour:

- Total number of messages per hour ($N_M$)
- Average aggregated duration per message of:
  - Dispatcher transmissions ($T_D$)
  - Patrol unit transmissions ($T_U$)
  - Idle time gaps ($T_G$)
- Average clocked message time ($T_{CM}$)
- Average of the absolute value difference ($\Delta T_M$) between ($T_D + T_U + T_G$) and $T_{CM}$
- A tabular presentation for each class of message of the following:
  - number of messages in the class ($N_M$)
  - average clocked message duration ($T_M$)
  - average aggregated gap duration ($T_G$)
  - average aggregated duration of transmissions ($T_U + T_G$)
- Average number per message of:
  - dispatcher transmissions ($N_D$)
  - unit transmissions ($N_U$)
  - idle time gaps ($N_G$)

- The types of messages for which printout is provided are:

| | |
|---|---|
| Type 1.1 | Initial Dispatch of Call |
| Type 1.2 | Supplementary Call Information |
| Type 1.3 | Unit Clearing |
| Type 1.4 | Information Request |
| Type 1.5 | Repeat Broadcasts |
| Type 2 | Tactical Communications |
| Type 3 | Status Communications |
| Type 4 | Information/Assistance Request |
| Type 5.1 | Information Dissemination - vehicles not on file |
| Type 5.2 | Information Dissemination - vehicles hit |
| Type 5.3 | Information Dissemination - persons and others |
| Type 6 | Descriptive/Conversational Exchanges |

A description of these types is provided in Appendix B.

In addition, summary statistics of the analyzed hours (17 hrs for each of the channels 1 & 3 'before' MRDS and 21 hrs 'after' MRDS) are printed out on a per channel basis at the end of the hourly printout. These statistics provide time-frequency distributions of:

- Aggregate **time** of the duration of **transmissions** for the sample
- Aggregate **time** of the duration of **idle gaps** for the sample
- Aggregate **time of clocked message** duration for the sample
- Total **number of messages** in the sample

The time intervals within which the distributions are presented are one second apart from 0 to 15 seconds and five seconds apart from 0 to 60 seconds.

### 5.1.2 Further Statistics

Additional data reduction to produce further information of interest to this study was undertaken manually with the aid of a HP 41C calculator and included the following:

: aggregation of the sub-type message classifications to produce statistics for only six major types 1 through 6 as defined in Appendix A

: Hourly values for the 'before' and 'after' sample of combined channel 1 & 3 hours for:

- number of messages ($N_M$)
- message length ($T_M$)
- transmission time per message ($T_T$)
- total channel occupancy time by messages ($T_{OM}$)
- total channel occupancy time by transmissions ($T_{OT}$)
- average number of messages by a patrol unit ($N_M/F_P$)
- average channel occupancy time by a patrol unit ($T_{OM}/F_P$)
- average ratio of dispatcher (base) to unit (mobile) transmission time ($T_D/T_U$)
- average ratio of idle time gaps in the message to the message duration ($T_G/T_M$)
- average of the absolute difference between the sum of individual measured transmission and gap durations and the clocked message time ($\Delta T_M = T_M - T_{CM}$)

Note that values described in section 5.1.1 and 5.1.2 which have been computed as part of the study are not necessarily presented in the report on an hour-by-hour basis but typically on an aggregate basis. Hour-by-hour values are available in the working information for the study and may be reproduced from the raw data entered onto diskettes.

### 5.1.3 Estimation of Errors

The process of data capture from voice tapes was subject to two types of errors:

- time measurement errors
- message classification errors

**Timing Errors**

The timing errors could result from a number of causes such as:

- inconsistent reaction time
- variation of reaction time between operators
- operator fatigue
- variation in work attitude
- physical state of well being of the operator

As described in section 4.4.3 checks were carried out on a regular basis by re-analyzing small time segments of the voice tapes randomly selected. The number of message rechecked for timing and classification are 257 out of a total of approximately 11,600 or 2.2%. The following results were obtained for differences between operators:

- measured message time:
  for 79% or messages -within 5%
  for 87% of messages - within 10%
  for 98% of messages - within 20%

No dominant sign of differences were evident.

A cross-check of operator accuracy in measuring the individual components of a message was provided by the $\Delta T_M$ factor described earlier (section 5.1.1). The absolute value of this factor averaged over each hour was available as part of the VOICEDAT program developed for the study (Appendix D). An analysis of $\Delta T_M$ over the total sample of 76 hours shows:

- Average message length, $\overline{T}_M = 10.9$ sec
- Average $\left|\overline{\Delta T}_M\right| = 0.48$ sec
- Std. deviation = 0.17 sec

**Classification Errors**

The problems with obtaining consistency of message classifications were more pronounced than with timing. Operators had problems with deciding when to consider messages containing more than one class of information as a single longer message or a number of shorter messages each of a different type. Even with the assistance of Vancouver Police it became evident that the process was not clear-cut and that some judgement was required on behalf of the operators in deciding on the classification. As a result of these classification difficulties, the measured difference in message count between operators was 7%.

The effect of this problem does not appear too serious on the shape of a distribution when 5-second time intervals are used. Differences of up to 15% in the ordinate of the distribution have been observed. Using 1-second time intervals differences between the operators of up to 40% can occur.

## 5.2 Digital Data Reduction

A statistical program (MAGSTAT) prepared as a subroutine to MAGREAD (see section 4.5) produced the following hourly statistics for each sampled hour.

- time-duration frequency distribution for each digital message type
- mean message duration for each type ($T_M$)
- number of messages ($N_M$)
- number of MRDS terminals ($F_O$) which have originated messages during the sampled hour.

Provided for convenience on the printout, following each hour, is a summary of statistics for all the previous hours.

The number of different types of digital messages is quite large (eighty four (84) in number as shown in Table 4-1 of Appendix F). Only about 30% of these are in frequent use, but not all are transmitted over the radio channel. In addition some are error messages which cannot be easily classified.

For the purpose of this study, to facilitate comparisons with traffic over voice channels, digital data functions were grouped into seven types, (as shown below), the numbered ones corresponding to voice classifications of Appendix B:

Type 3 - Status Communication
Type 4 - Information/Assistance Requests
Type 5 - Responses
Type 6 - Descriptive/Consversational Exchanges
Type E - Error Messages
Type L - Message not transmitted over radio

Details of the MAGSTAT program are included in Appendix D.

## 5.3 Supplementary Data

Analysis of references 1, 2, and 9 has produced the following additional information for the Vancouver Police Department (VPD):

- long term growth trend of CPIC queries over a period from 1976 to 1981

- number of patrol units in policing districts 1 & 3 operating during the hours of interest to this study

- number of patrol units in districts 1 & 3 equipped with MRDS terminals during the hours of interest

- ratio of MRDS terminals in districts 1 & 3 to the total number of terminals in the field during the hours of interest place. The following per unit ratios were developed for each hour sampled and were extensively used in the analysis:

- average **number of messages** ($N_M$) per hour either originated by or directed to a patrol car ($F_P$) in the field - $N_M/F_P$ (messages/unit)
- average **time** in seconds contributed to the **occupancy** ($T_{OM}$) or air-time of the radio channel during the busy hours by messages, either originated by or directed to a patrol unit ($F_P$) in the field - $T_{OM}/F_P$ (seconds/unit)
- average **time** in seconds contributed to the voice activity or **transmission time** ($T_{OT}$) of a radio channel by messages either originated by or directed to a patrol unit ($F_P$) in the field - $T_{OT}/F_P$ (seconds/unit)
- average **number of data messages** ($N_M$) resulting from activity of a single MRDS terminal in a patrol unit ($F_M$) - $N_M/F_M$ (messages/unit).

The number of MRDS terminals is at present always less than the number of patrol units hence in a mixed situation 'after' MRDS usually two values are used to describe the activity:

1) $N_M/F_P$ (**without** MRDS terminal) - this is the number of voice messages per patrol unit averaged over the total number of field operating units. i.e. it includes all units; those with and without an MRDS terminal. It is assumed that the average rate of voice message origination from units not equipped with a MRDS terminal, is the same as those with a terminal. There is no data available to test the validity of this assumption, however discussions with the Vancouver Police indicate that this may be true but only for the peak busy hours.

2) $N_{M/F_P}$ (**with** MRDS terminal) - this is a value which applies only to those units equipped with a MRDS terminal. It is the arithmetic sum of $N_{M/F_P}$ (without MRDS terminal) defined as above and the average number of data messages per MRDS terminal $N_{M/F_M}$. i.e.

$$N_{M/F_P} \text{ (with MRDS terminal)} = N_{M/F_P} \text{(without MRDS terminal)} + N_{M/F_M}.$$

Some comments are necessary relative to the term "**Message Length**" as applied to voice channel activity. During earlier project work associated with the MRDS program this term was used to designate the aggregated air-time during which a transmitter and a receiver of a simplex or half-duplex radio channel was busy handling voice activity (or voice transmission). The time of idle channel gaps between periods of voice transmissions was excluded from the definition of message length (Ref. 6).

Since this study is not only concerned with the traffic on police radio channels but also with spectrum utilization it was decided to use the international definition for the message length which includes not only the voice activity but idle channel gaps in the total. For comparison purposes with previous MRDS work the terms "**Transmission Length, Duration,** or **Time**" are used to replace the earlier message definition and designate the aggregated air-time of voice activity periods in a message.

Finally it should be remembered that only channels 1 and 3 were analyzed as part of the study. However there does not appear to be anything different relative to policing methods of districts 2 and 4 that would cause the traffic on radio channels for these districts to behave in a manner different from channels 1 and 3 during equivalent peak busy periods. Discussions and conclusions stemming from this analysis are therefore stated as applying equally to each of the four radio channels of the Vancouver Police Department.

## 6.2 Message Characterization

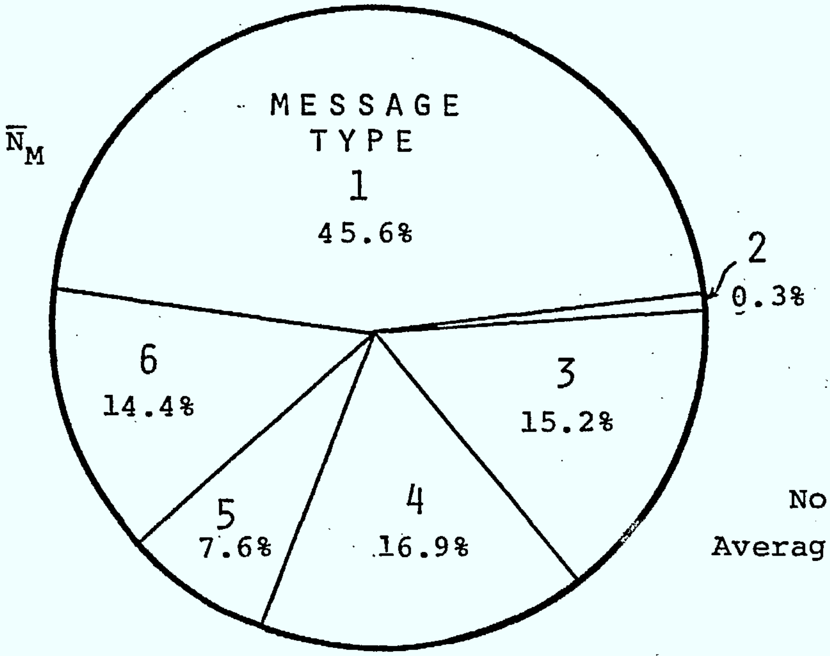
### 6.2.1 'Before' and 'After' Comparison

This section discusses the results of analysis relating to the message itself i.e.:

- average **message time** statistics for different types of message classifications given in Appendix B
- frequency distributions of **number of messages** and **message air-time occupancy** for different types of messages
- statistics for average **transmission time** associated with different types of messages
- frequency distributions of **transmission air-time occupancy** for different types of messages. This as well as all the above are present for both voice and data channels.
- voice message statistics dealing with transmission and idle gaps in the message including ratios showing the relationship between dispatcher and unit voice activity ($T_D/T_U$), gap to message ratio ($T_G/T_M$)

Examination of Figure 6-1 shows that introduction of MRDS has caused little change in the volume distribution of different message types during an average peak busy hour. The dispatch (type 1), query (type 4), and response (type 5) message proportion is virtually identical. Status messages (type 3) have increased by 3.5% to 18.7% of the total and narrative, bulletins and miscellaneous messages (type 6) have decreased by 2.5% to 11.9% of the total.

'BEFORE' MRDS



$\overline{N}_M = 148.3$

$\overline{T}_M = 10.9$ s

$\overline{N}_M / \vec{\overline{F}}_P = 8.7$

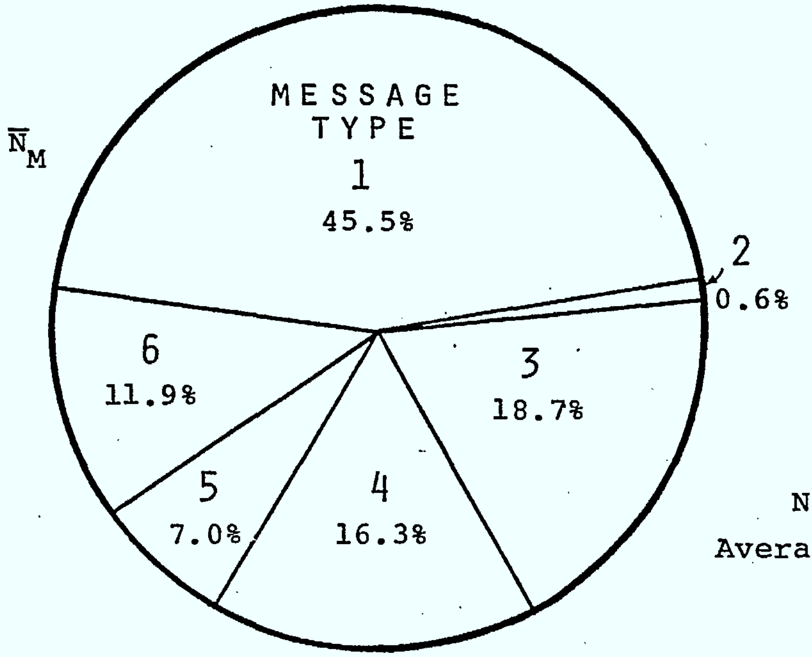
No. of hours sampled = 34

Average no. of units, $F_P$ = 17

MESSAGE TYPES:

Type 1 - Dispatch
Type 2 - Tactical
Type 3 - Status
Type 4 - Data Base Requests
Type 5 - Data Base Responses
Type 6 - Descriptive/Narrative

'AFTER' MRDS



$\overline{N}_M = 158.1$

$\overline{T}_M = 10.9$ s

$\overline{N}_M / \overline{F}_P = 5.7$

No. of hours sampled = 42

Average no. of units, $F_P$ = 28

FIGURE 6-1 'BEFORE' AND 'AFTER' MRDS COMPARISON
Content of the average busy hours by message volume ($\overline{N}_M$) – VOICE CHANNELS ONLY

The average number of messages per hour ($N_M$) has increased by 6.6% but the average message length ($T_M$) has remained the same. This is somewhat surprising as instinctively it was felt that since many more patrol units (65% more) had access to a radio channel in 1982, the pressure would contribute to communications being shorter in length. It indicates good channel control exercised by dispatchers and units under peak loads.

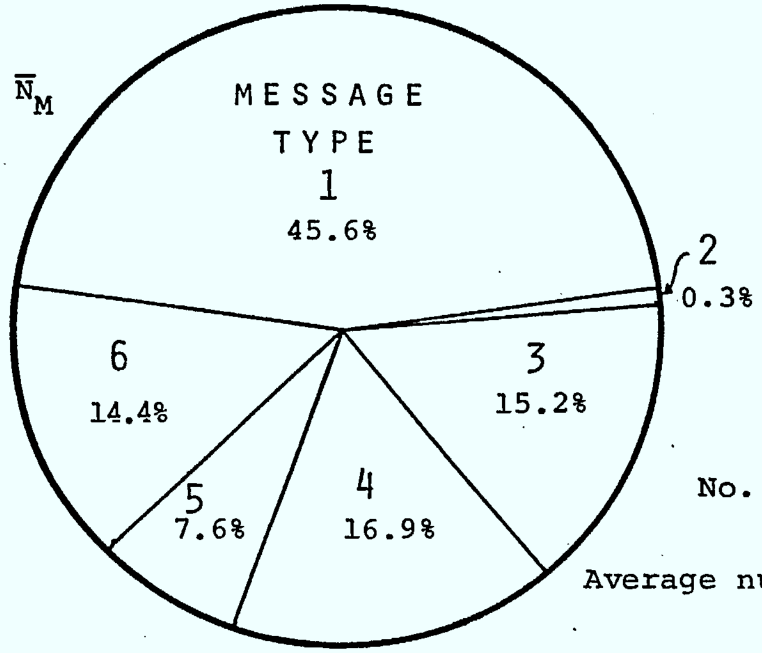
The number of messages per unit has decreased on voice channels probably partly because of the increased number of units contesting for access to the radio channels and partly because of availability of MRDS terminals in some 60% of the patrol cars. The latter aspect becomes more evident from Figure 6-2, which shows the volume content 'after' MRDS with the voice and data messages combined.

The average number of messages generated by the car units equipped with MRDS terminals is 11.1 per unit as compared to 8.7 per unit 'before' MRDS. However, the former figure should be viewed with caution as it is derived from the sum of averages obtained from voice and data channel statistics respectively (i.e. Total of 11.4 = 5.7 per unit from voice channel activity and 5.4 per unit from data channel activity, refer to tables 6-1 and 6-2).

Insufficient information was available to determine separately the per unit values from the patrol unit group having voice only capability and the group equipped with MRDS terminals. Perhaps if this had been possible it might have shown that units with MRDS terminals in fact generate less than 5.4 messages per unit through the voice channel and those without, more than 5.4 per unit. This could be a likely scenario.

The pie-charts of Figure 6-2 show that on an overall basis there has been a 4 3% increase of the combined data base query and response class of messages.

'BEFORE' MRDS - VOICE CHANNEL TRAFFIC ONLY



$\overline{N}_M = 148.3$
$\overline{T}_M = 10.9$ s
$\overline{N}_M / \overline{F}_P = 8.7$

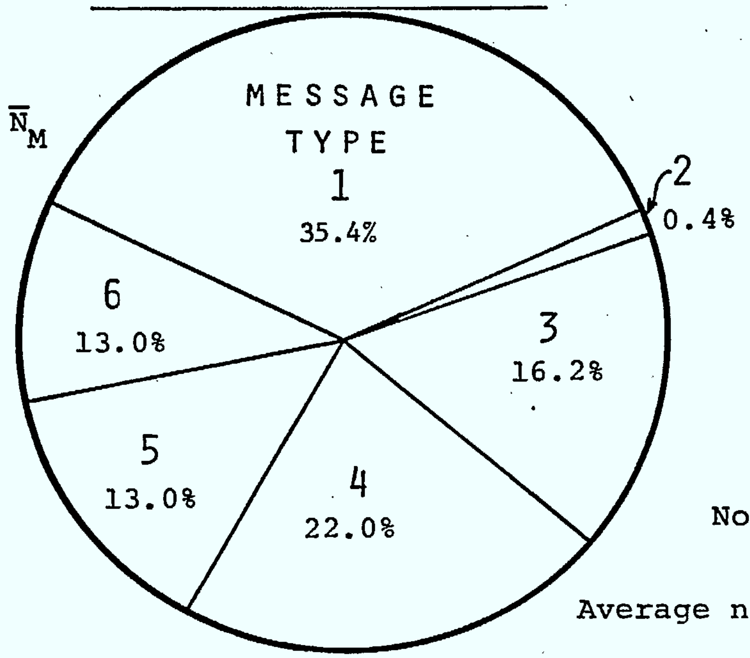
No. of hours sampled = 34

Average number of units, $F_P$ = 17

MESSAGE TYPES:

Type 1 - Dispatch
Type 2 - Tactical
Type 3 - Status
Type 4 - Data Base Requests
Type 5 - Data Base Responses
Type 6 - Descriptive/Narrative

'AFTER' MRDS - VOICE AND DATA CHANNEL TRAFFIC COMBINED



$\overline{N}_M = 203.1$

$\overline{N}_M / \overline{F}_P$ (without MRDS term) = 5.7

$\overline{N}_M / \overline{F}_P$ (with MRDS term) = 11.1

No. of hours sampled = 42 (voice)
= 21 (data)

Average number of units, $F_P$ = 28
$F_M$ = 8.3

FIGURE 6-2 'BEFORE' AND 'AFTER' MRDS COMPARISON
Content of the average busy hours by message volume ($\overline{N}_M$) - VOICE AND DATA CHANNELS COMBINED

Figures 6-3 and 6-4 show in a histogram form the message volume content of the traffic per unit on radio channels 'before' and 'after' MRDS while Figure 6-5 shows the time distribution for the data channel only. A few aspects of this latter figure are noteworthy, namely:

- Channel use time for type 4 and 5 messages on the data channel clearly dominates and confirms the use of the MRD System for its design purpose.
- Absence of type 1 and 2 messages. By decision, Vancouver Police do not use MRD System for dispatching or tactical communications. The MRD System was not implemented with full computer aided dispatch (CAD) capabilities.
- Very small percentage of type 3 status messages. Again because only part of the units are equipped with MRDS terminals it is not a regular practice to use them for indicating status.
- An additional category of data mesages has been included in the data histogram designated as '**error**'. This represents a class of messages which for various reasons were invalid but were recorded on tape. Since they occupied air time they are included here for completeness. Radio retransmission attempts for unrecognizable transmissions are, of course, not logged to tape.

Charts on Figure 6-6 show the breakdown of message air-time occupancy $T_{OM}$ for voice channels only 'before' and 'after' MRDS. Again for the 'after' situation, one observes that there is some adaptation to increased number of units on the channels, and average time occupancy per unit is smaller than for the 'before' case.

## 'BEFORE' AND 'AFTER' MRDS COMPARISON

RADIO CHANNELS ___ 1 & 3 COMBINED ____

| | 'BEFORE' | 'AFTER' |
|---|---|---|
| $\overline{N}_M$ | 148.3 | 158.1 |
| $\overline{N}_M/\overline{F}_P$ | 8.7 | 5.7 |

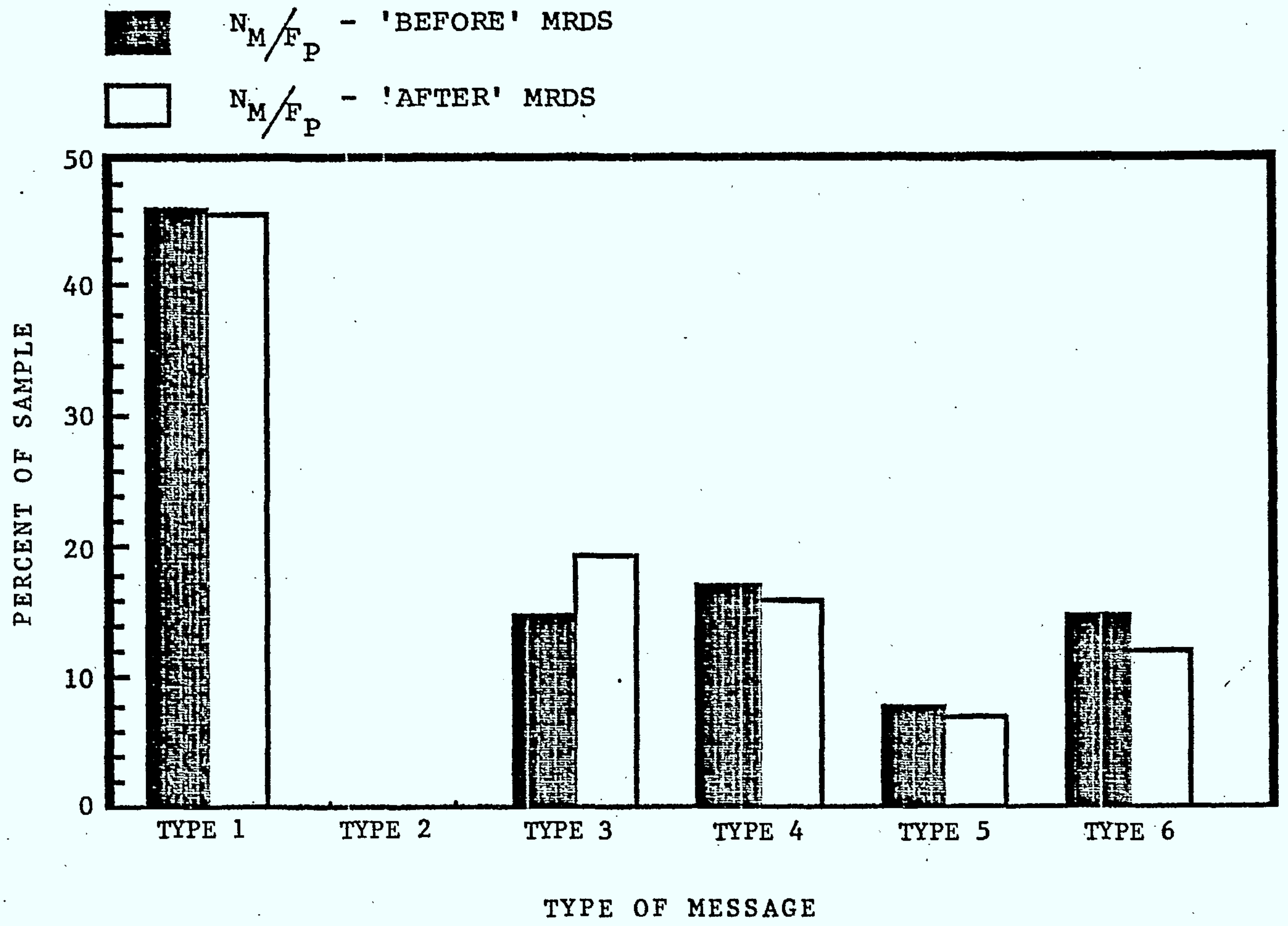


FIGURE 6-3 'BEFORE' AND 'AFTER' MRDS - Voice Channels Only. Sample Hourly Distribution of Messages ($\overline{N}_M$) Per Unit and Type of Message.

## 'BEFORE' AND 'AFTER' MRDS COMPARISON

RADIO CHANNELS 1 & 3 PLUS DATA COMBINED

| | 'BEFORE' | 'AFTER' |
|---|---|---|
| $\overline{N}_M$ | 148.3 | 203.1 |
| $\overline{N}_M/\overline{F}_P$ (without MRDS terminal) | 8.7 | 5.7 |
| $\overline{N}_M/\overline{F}_P$ (with MRDS terminal) | N/A | 11.1 |

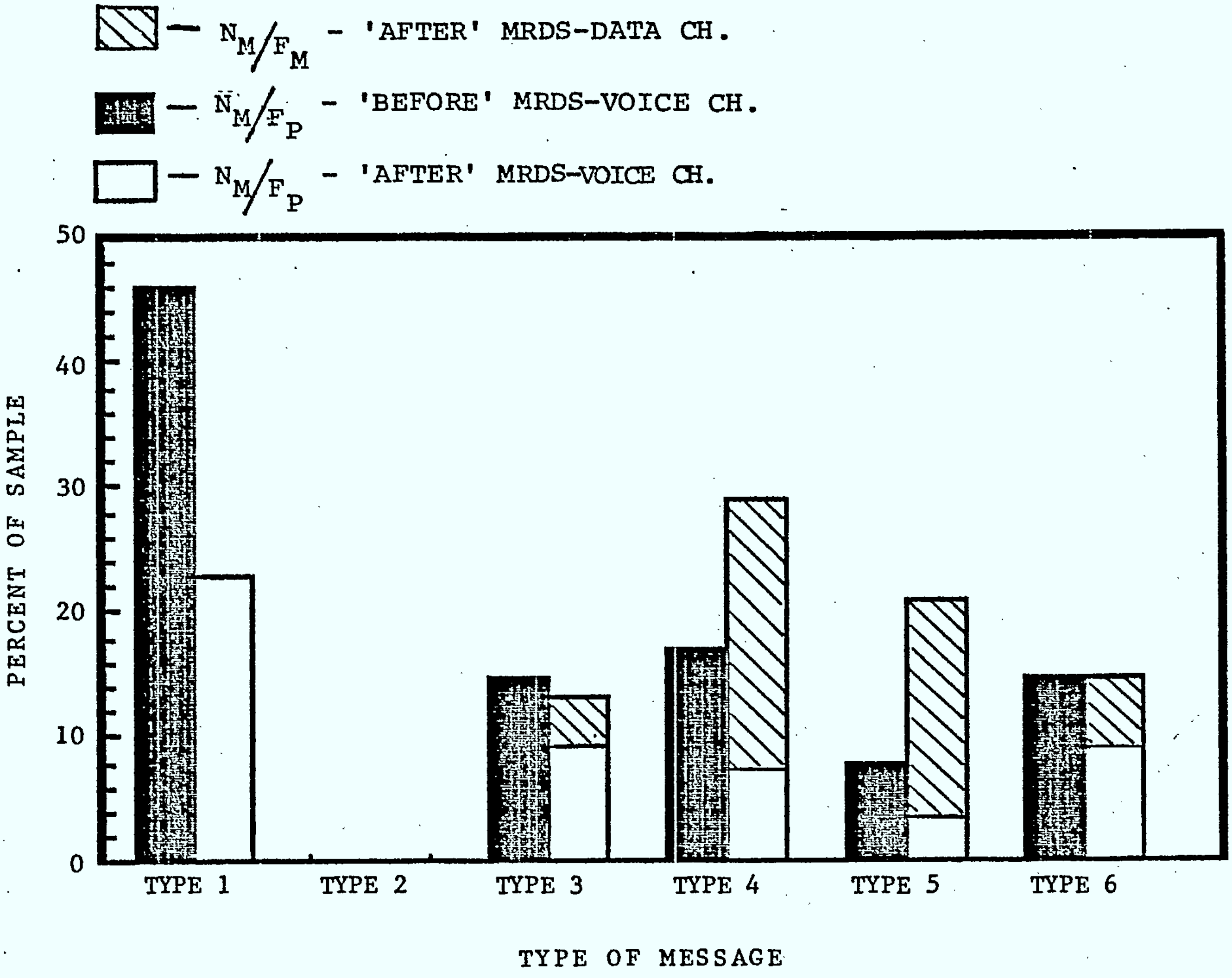


FIGURE 6-4 'BEFORE' AND 'AFTER' MRDS - Voice and Data Channels Combined. Sample Hourly Distribution of Messages ($N_M$) Per Unit and Type of Message.

# 'AFTER' MRDS - 1982

## RADIO CHANNELS __DATA ONLY___

Average number of messages carried on the data channels from terminals assigned to Policing Districts 1 & 3 (includes message Types 3 through 6 and Error messages) $\overline{N}_M = 97.0$

Average number of MRDS terminals assigned to Policing Districts 1 & 3 $\overline{F}_M = 16.6$

Average number of messages per terminal (Types through 6 only) $\overline{N}_M / \overline{F}_M = 5.4$

Average message length $\overline{T}_M = 0.33$ s

$\sigma = 0.05$ s

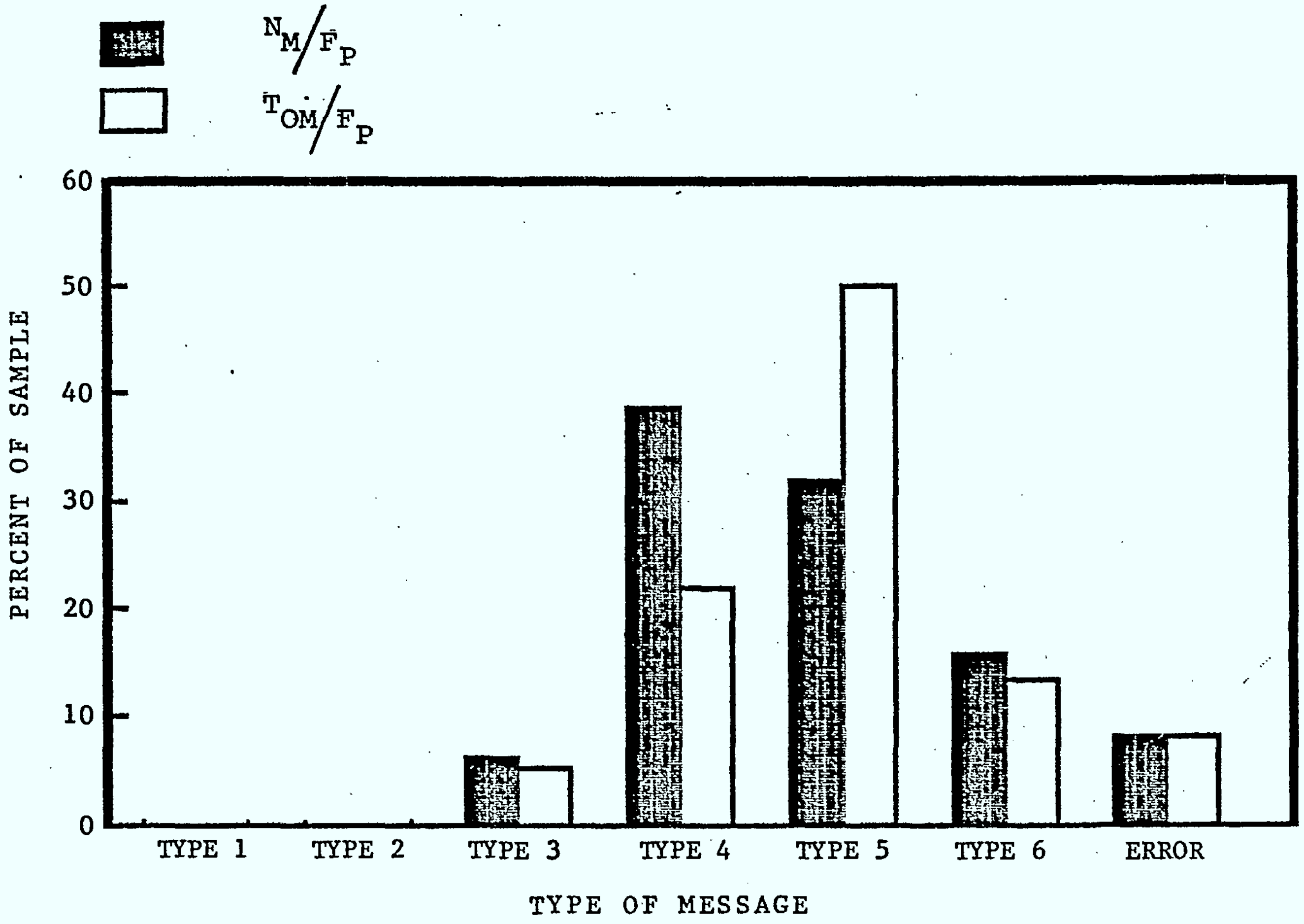
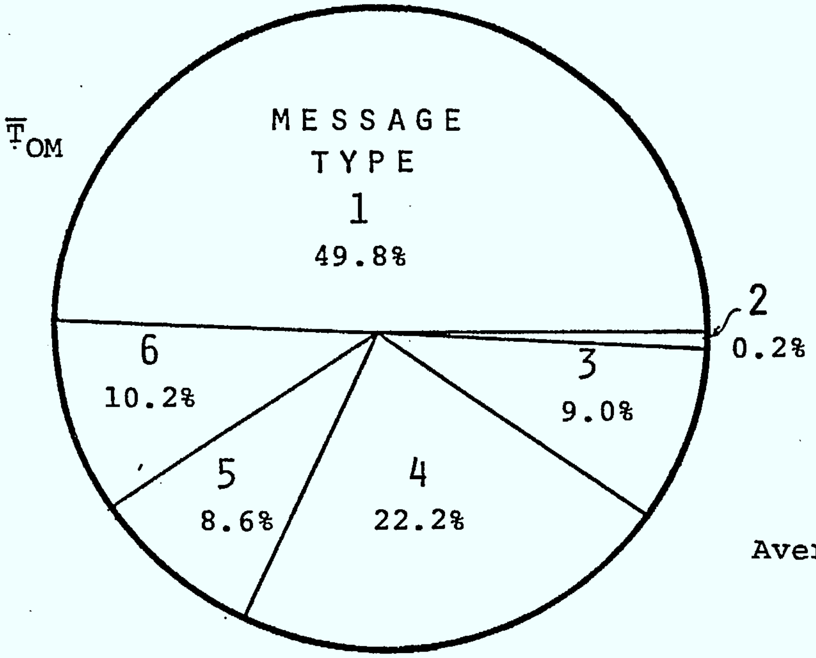


FIGURE 6-5 'AFTER' MRDS - Data Channel Only
Sample Hourly Distribution of Messages ($N_M$) and Air-Time Occupancy ($\overline{T}_{OM}$) Per Unit versus Type of Message.

'BEFORE' MRDS



$\overline{T}_{OM} = 1610.0$ s

$\overline{T}_{OT} = 1048.8$ s

$\overline{T}_{OM}/\overline{F}_P = 94.7$ s

$\overline{T}_{OT}/\overline{F}_P = 61.7$ s

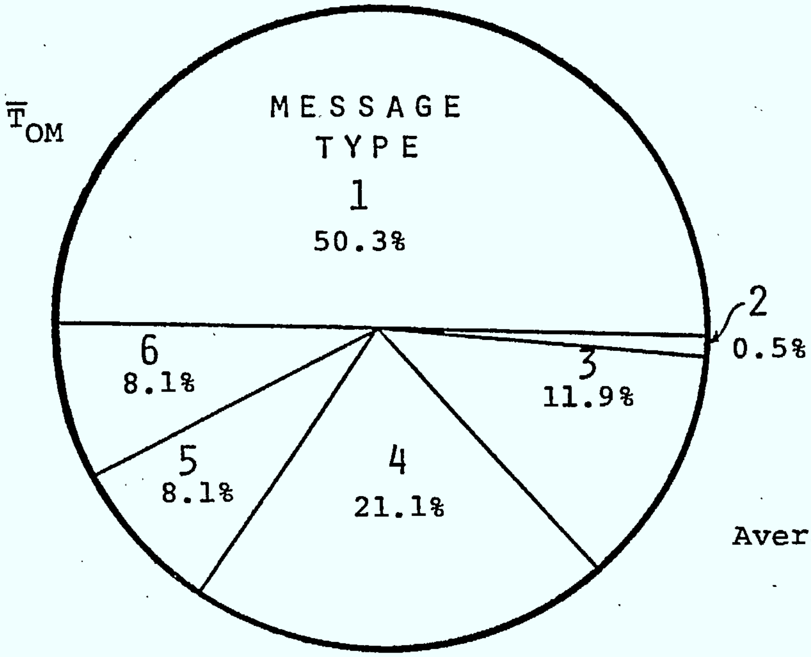
No. of hours sampled = 34

Average no. of units, $F_P$ = 17

MESSAGE TYPES:

Type 1 - Dispatch
Type 2 - Tactical
Type 3 - Status
Type 4 - Data Base Requests
Type 5 - Data Base Responses
Type 6 - Descriptive/Narrative

'AFTER' MRDS



$\overline{T}_{OM} = 1727.4$ s

$\overline{T}_{OT} = 1116.2$ s

$\overline{T}_{OM}/\overline{F}_P = 61.6$ s

$\overline{T}_{OT}/\overline{F}_P = 39.9$ s

No. of hours sampled = 42

Average no. of units, $F_P$ = 28

FIGURE 6-6 'BEFORE' AND 'AFTER' MRDS COMPARISON

Content of the average voice channel busy hour by message air-time occupancy ($T_{OM}$)

To provide additional insight into the frequency time distribution of the number of messages and air-time occupancy of different types of messages on voice and data channels, histograms 6-14 to 6-47 have been prepared and are located in Appendix G.

'Before' and 'after' comparison of the peak busy hour values is shown in Table 6-1 for: total and per unit number of messages per hour, average message length, channel message occupancy time and channel air-time occupancy. For the data channel, message and air-time occupancy are equivalent and thus message time only is indicated. It should be noted that because of the small sample of type 2 message, standard deviation is large and the average values shown in the table are not too meaningful.

Corresponding values for the data channel are summarized in Table 6-2 with message occupancy per unit also included. Columns labeled channel 1-4 show the characteristics for the combined traffic generated by all four policing districts. While those labeled channel 1 & 3 provide estimated values for traffic from districts 1 and 3.

An assumption was made that all terminals originate messages at a uniform rate. The traffic in districts 1 and 3 was then determined by taking the ratio of terminals in those two districts to the total number in service during a particular hour. No other means is available at present of discriminating between traffic generated by the different policing districts.

TABLE 6-1 'BEFORE' AND 'AFTER' COMPARISON OF AVERAGE MESSAGE ASSOCIATED VALUES

| Type of Message | $\overline{N}_M$ | | | $\overline{N}_M$/unit | | | $\overline{T}_M$ (sec) | | | $\overline{T}_{OM}$ (sec) | | | $\overline{T}_{OT}$ (sec) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Before | After | | Before | After | | Before | After | | Before | After | | Before | After |
| | Voice | Voice | Voice & Data | Voice | Voice | Voice & Data | Voice | Voice | Data | Voice | Voice | Data | Voice | Voice |
| ALL value | 148.3 | 158.1 | 203.1 | 8.7 | 5.7 | 11.1 | 10.9 | 10.9 | 0.3 | 1610.0 | 1727.4 | 14.8 | 1048.8 | 1116.2 |
| σ | 31.1 | 25.7 | 32.1 | - | - | - | - | - | - | 281.3 | 292.0 | 6.2 | 197.8 | 222.3 |
| 1 value | 67.6 | 71.9 | 71.9 | 4.0 | 2.6 | 2.6 | 11.8 | 12.2 | - | 801.0 | 869.4 | - | 532.8 | 588.4 |
| σ | 27.2 | 28.3 | 28.3 | - | - | - | - | - | - | 288.3 | 379.2 | - | 197.7 | 272.0 |
| 2 value | 0.5 | 0.9 | 0.9 | 0.03 | 0.03 | 0.03 | 14.3 | 7.9 | - | 3.8 | 7.2 | - | 2.1 | 4.6 |
| σ | 2.0 | 2.0 | 2.0 | - | - | - | - | - | - | 14.4 | 16.1 | - | 8.1 | 11.2 |
| 3 value | 22.6 | 29.6 | 32.9 | 1.3 | 1.1 | 1.5 | 6.4 | 7.0 | 0.2 | 144.2 | 206.3 | 0.7 | 80.7 | 123.0 |
| σ | 8.2 | 8.5 | 8.7 | - | - | - | - | - | - | 51.6 | 73.9 | 0.5 | 29.3 | 46.6 |
| 4 value | 25.0 | 25.8 | 44.6 | 1.5 | 0.9 | 3.2 | 14.4 | 14.1 | 0.2 | 358.2 | 363.2 | 3.8 | 228.4 | 229.1 |
| σ | 10.0 | 11.0 | 13.5 | - | - | - | - | - | - | 170.4 | 162.0 | 1.6 | 120.3 | 106.5 |
| 5 value | 11.2 | 11.0 | 26.4 | 0.7 | 0.4 | 2.2 | 13.0 | 12.9 | 0.5 | 138.8 | 140.7 | 8.3 | 107.1 | 92.8 |
| σ | 7.0 | 6.5 | 11.4 | - | - | - | - | - | - | 110.4 | 105.0 | 5.2 | 80.6 | 69.8 |
| 6 value | 21.4 | 18.9 | 26.4 | 1.3 | 0.7 | 1.6 | 7.6 | 7.5 | 0.3 | 164.0 | 140.6 | 2.1 | 89.5 | 78.3 |
| σ | 8.5 | 6.6 | 6.7 | - | - | - | - | - | - | 71.7 | 66.4 | 1.3 | 42.2 | 37.8 |

TABLE 6-2 'AFTER' MRDS DATA CHANNEL MESSAGE CHARACTERISTICS

| | | $\bar{N}_M$ | | $\bar{T}_{OM}$ (sec) | | $\bar{N}_M/\bar{F}_M$ | | $\bar{T}_{OM}/\bar{F}_M$ (sec) | | $\bar{T}_M$ (sec) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | CHANNEL | | CHANNEL | | CHANNEL | | CHANNEL | | |
| CLASS | | 1 & 3 | 1 - 4 | 1 & 3 | 1 - 4 | 1 & 3 | 1 - 4 | 1 & 3 | 1 - 4 | |
| 3 | value | 6.6 | 15.6 | 1.4 | 3.3 | 0.4 | 0.4 | 0.1 | 0.1 | 0.2 |
| | σ | 3.9 | 7.4 | 1.0 | 1.9 | - | - | - | - | - |
| 4 | value | 37.5 | 90.7 | 7.5 | 18.2 | 2.3 | 2.3 | 0.5 | 0.4 | 0.2 |
| | σ | 15.8 | 30.5 | 3.1 | 5.9 | - | - | - | - | - |
| 5 | value | 30.8 | 75.0 | 16.6 | 40.7 | 1.8 | 1.8 | 1.0 | 1.0 | 0.5 |
| | σ | 18.7 | 44.2 | 10.3 | 25.9 | - | - | - | - | - |
| 6 | value | 15.0 | 37.4 | 4.2 | 10.6 | 0.9 | 0.9 | 0.3 | 0.3 | 0.3 |
| | σ | 8.3 | 21.0 | 2.6 | 6.5 | - | - | - | - | - |
| E | value | 7.1 | 16.5 | 2.2 | 6.3 | 0.4 | 0.4 | 0.1 | 0.2 | 0.4 |
| | σ | 7.3 | 15.4 | 2.1 | 4.2 | - | - | - | - | - |
| ALL | value | 97.0 | 235.2 | 32.4 | 79.2 | 5.8 | 5.8 | 2.0 | 2.0 | 0.3 |
| | σ | 38.4 | 66.7 | 13.1 | 26.8 | - | - | - | - | - |

| TERMINAL DISTRIBUTION | Ch. 1 & 3 | | Ch. 1 - 4 | |
|---|---|---|---|---|
| | $\bar{F}_M$ | $F_O$ | $F_M$ | $F_O$ |
| No. of terminals | 16.6 | 12.6 | 40.7 | 29.0 |
| σ | 4.8 | 3.6 | 8.2 | 5.4 |

Note: the value for $F_O$ (the number of terminals which have originated messages during the hours sampled) was obtained from the data base.

The average terminal distribution relative to the policing districts is shown at the bottom of Table 6-2. Hourly distribution is included in Appendix E. $F_M$ corresponds to the number of terminals in active patrol cars while $F_O$ indicates the number of terminals that have originated messages during the hours sampled. This latter quantity is available in the output of the MAGSTAT program described in Appendix D.

## 6.3 Channel Utilization

### 6.3.1 Channel Occupancy

The study appears to show that changes in the operation and method of policing in the Vancouver Police Department have not materially affected the average voice radio channel occupancy. There has been however some increase in the dispersion of the peak busy hour occupancy as is indicated by an increased standard deviation. This is summarized in Table 6-3.

What is not evident from the results is that the frequency of occurrence of the peak busy hours is greater now than before the reorganization. i.e. there are now more peak busy hours in a given time interval. This is borne out by the long term records maintained by the Department.

TABLE 6-3 Average Peak Busy Hour Occupancy Measures - Voice Channels

| Occupancy Measure | | Peak Busy Hour Occupancy (seconds) | |
|---|---|---|---|
| | | 'Before' MRDS | 'After' MRDS |
| Total Message Time, $T_{OM}$ (Message occupancy) | value | 1610 | 1727 |
| | $\delta$ | 281 | 291 |
| Channel Use, $T_{CU}$ | value | 1257 | 1274 |
| | $\delta$ | 222 | 283 |
| Total Transmission Time, $T_{OT}$ (Transmission Occupancy) | value | 1049 | 1116 |
| | $\delta$ | 198 | 222 |
| $T_{OM} - T_{OT}$ | | 561 | 611 |
| $T_{CU} - T_{OT}$ | | 208 | 158 |

From the sample examined during the study, maximum value of the peak hour message occupancy ($T_{OM}$) is 2230 sec 'before' and 2530 sec 'after'.

In Table 6-3 the difference between $T_{OM}$ and $T_{OT}$ represents the channel idle time made up of gaps between transmissions in individual messages. Note, however, that the radio channel is inactive for only a portion of this time and the difference between $T_{CU}$ and $T_{OT}$ represents the time interval when the radio carrier is keyed on but no voice activity takes place.

With improved mobile radio design, where voice activation is used, this time difference would probably decrease and it might be feasible to use gaps in voice communications for service, time shared with data considering that the average data message length is only 0.3 sec. From Table 6-4 the average duration of gaps in one message is 3.8 sec and the time of average individual gap is $T_G/N_G$ = 1.6 sec, long enough to accomodate at least one data message.

It should be noted that the above discussion deals with average values only. A number of questions still arise: would data and voice be able to operate on the same channel during the peak time of a busy hour?; would not the probability of voice and data collisions be quite high?; do intra- and inter-message gaps offer the same potential for increased channel use? Before seriously considering sharing of radio channels by voice and data in practice, additional studies would be required to resolve these questions.

Average ratios of interest in assessing the voice channel occupancy have been summarized in Table 6-4. For the data channel equivalent values are not readily available and could not be determined within the scope of the study.

TABLE 6-4 'Before' and 'After' MRDS - Voice Channel Occupancy - Values of Interest

| Message Type | $T_G$ (seconds) | | $T_G/T_M$ | |
|---|---|---|---|---|
| | Before | After | Before | After |
| All Combined | 3.8 | 3.8 | 0.35 | 0.35 |
| Type 1 | 3.9 | 4.0 | 0.33 | 0.33 |
| Type 2 (note 1) | 10.1 | 2.8 | 0.71 | 0.35 |
| Type 3 | 2.8 | 2.8 | 0.44 | 0.40 |
| Type 4 | 5.5 | 5.2 | 0.38 | 0.37 |
| Type 5 | 4.2 | 4.5 | 0.32 | 0.35 |
| Type 6 | 3.4 | 3.4 | 0.45 | 0.45 |
| | $T_D/T_U$ | | $T_T/T_M$ | |
| All Combined value | 0.94 | 0.81 | 0.65 | 0.64 |
| $\sigma$ | 0.19 | 0.19 | 0.02 | 0.04 |
| | $N_G$ | | $N_T$ | |
| All Combined value | 2.35 | 2.49 | 3.35 | 3.49 |
| $\sigma$ | 0.25 | 0.26 | 0.25 | 0.26 |

Note 1: only a small number of samples of this message type was encountered during the study.

### 6.3.2 Variability of Message Content

It was of interest to determine for voice channels whether the voice message content of peak busy hours varied as a function of total message occupancy ($T_{OM}$) and were there any trends evident. For that purpose Figures 6-7 to 6-10 have been prepared which along the abscissa show the message occupancy of the busy hour and along the ordinate the percentage content. Figure 6-7 and 6-8 show the 'before' and 'after' time occupancy of the busy hour with transmission occupancy of messages separated into two

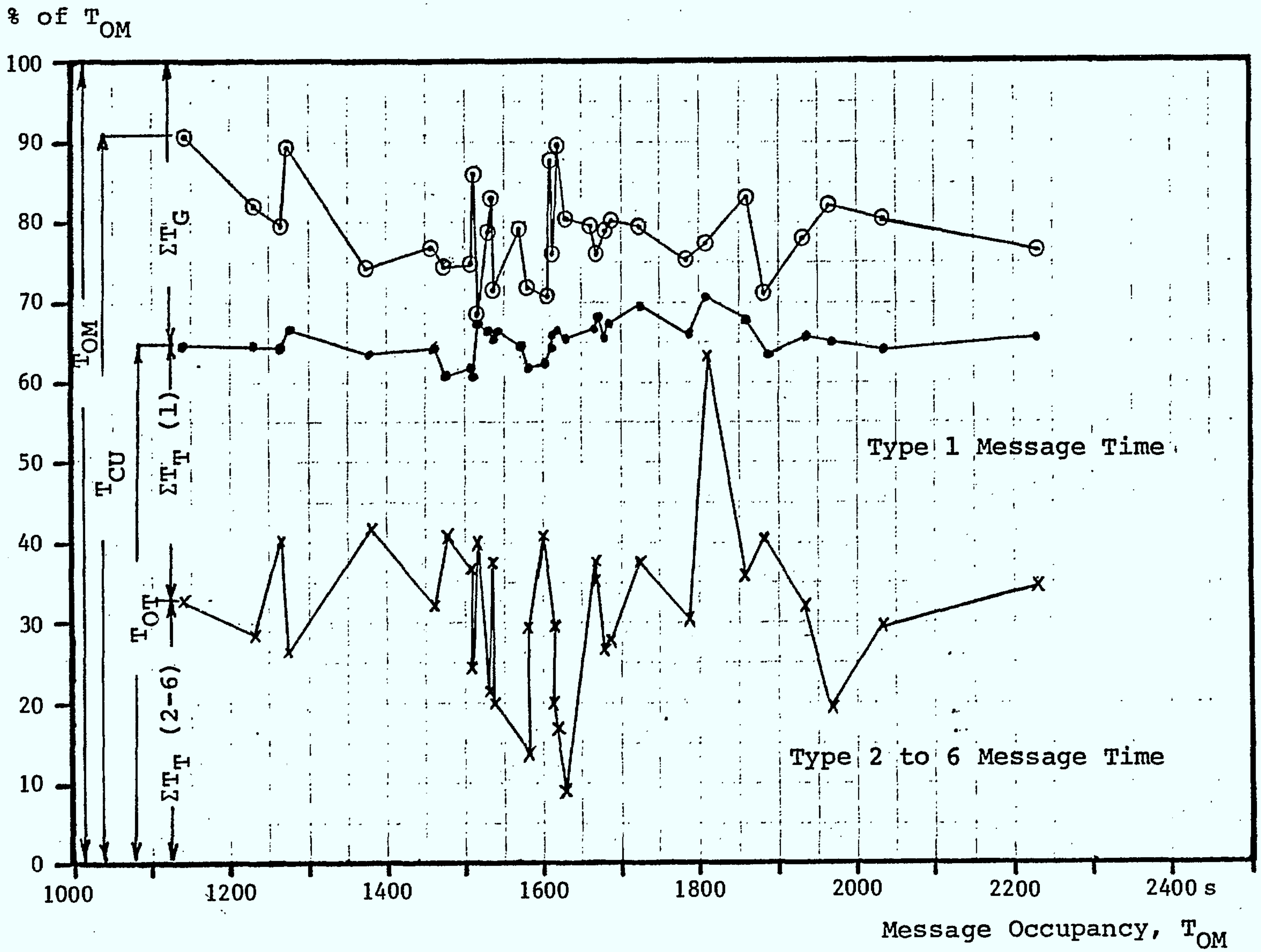


FIGURE 6-7 'BEFORE' MRDS. Variability of Voice Channel Content of the Busy Hour as a Function of Channel Message Time Occupancy ($T_{OM}$).

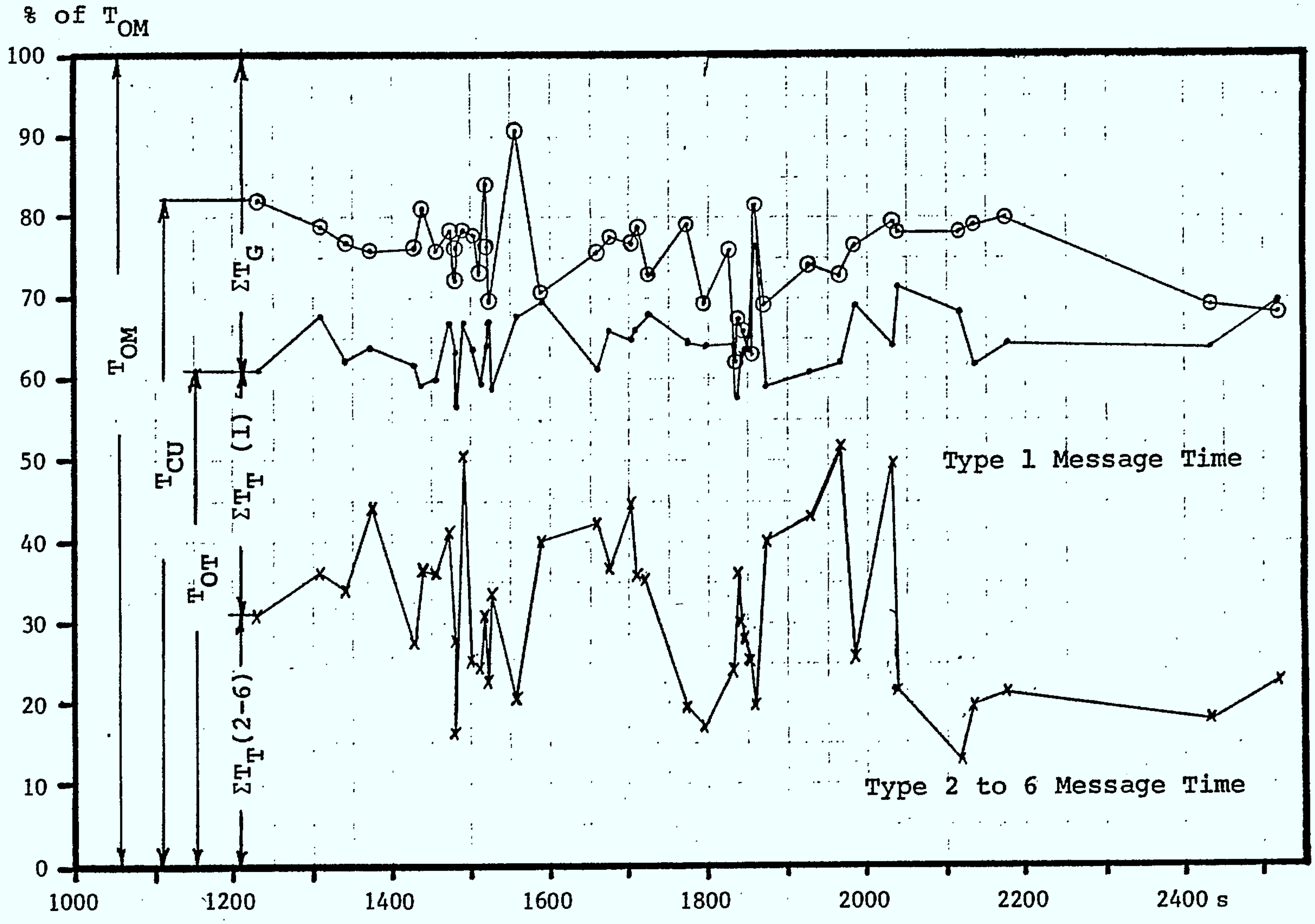


FIGURE 6-8 'AFTER' MRDS. Variability of Voice Channel Content of the Busy Hour as a Function of Channel Message Time Occupancy ($T_{OM}$).

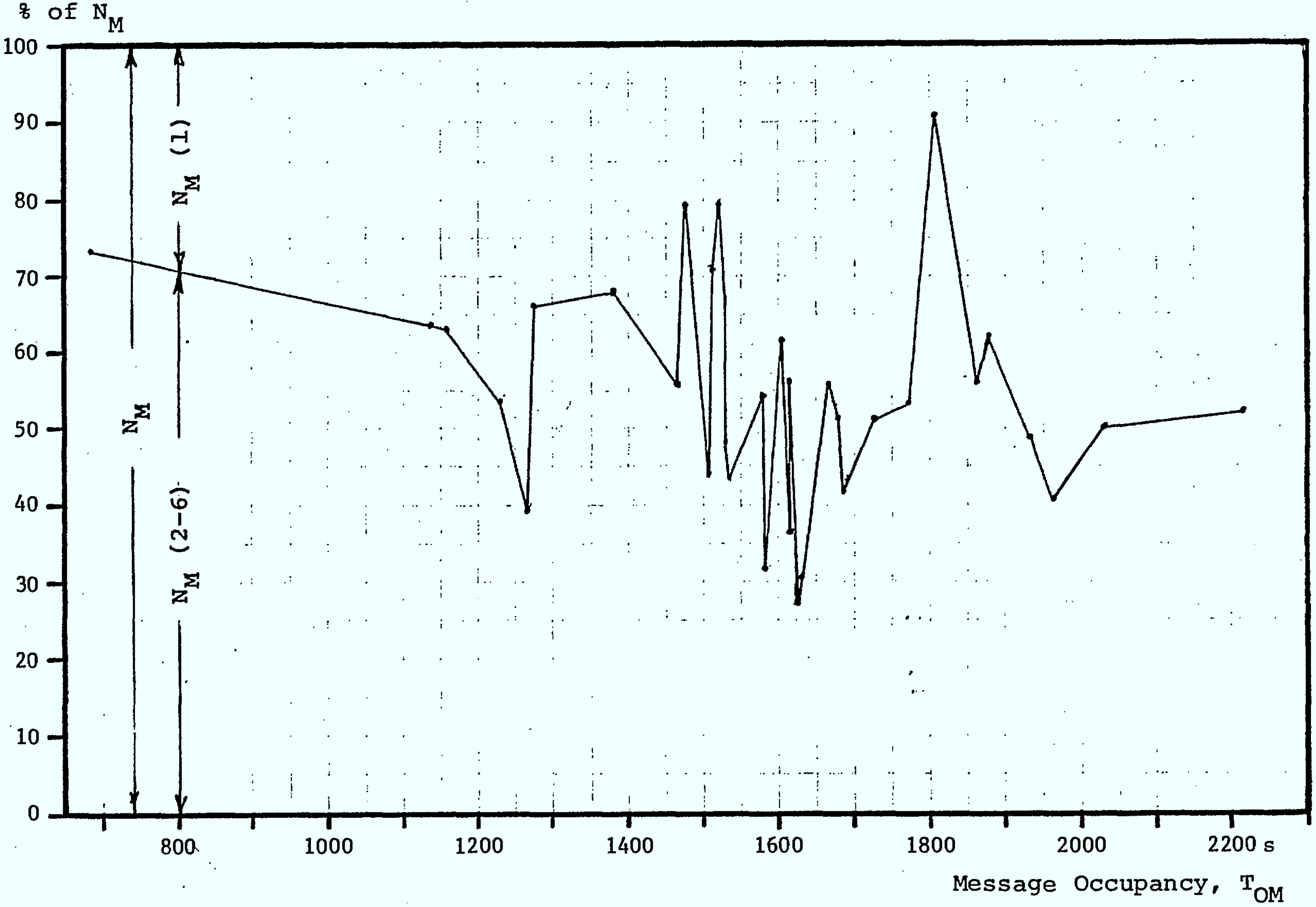


FIGURE 6-9 'BEFORE' MRDS. Variability of Voice Message Content (Type 1 and Type 2 to 6 Combined) of the Busy Hour as a Function of Channel Message Time Occupancy ($T_{OM}$).

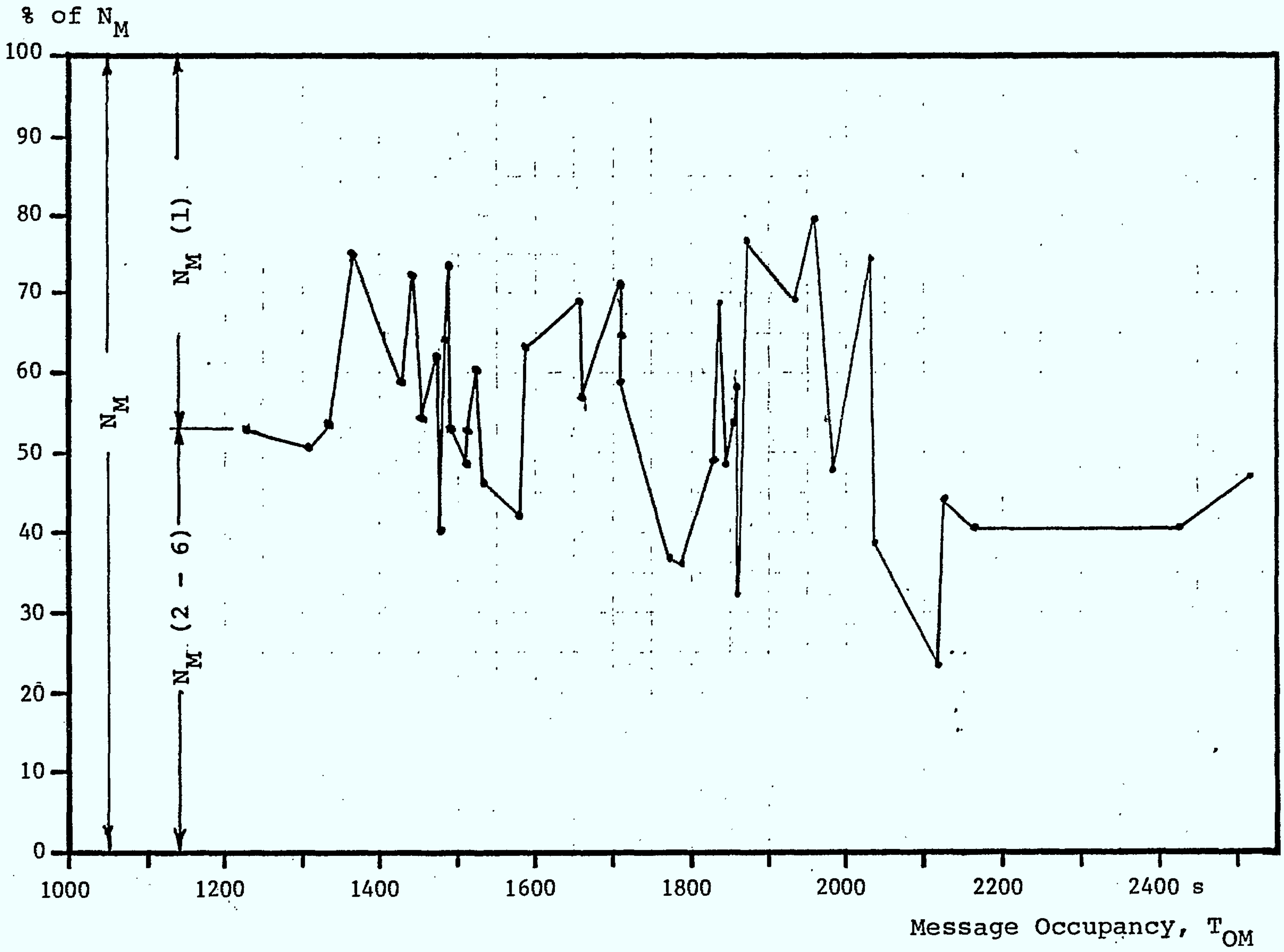


FIGURE 6-10 'AFTER' MRDS. Variability of Voice Message Content (Type 1 and Type 2 to 6 Combined) of the Busy Hour as a Function of Channel Message Time Occupancy ($T_{OM}$).

groups: Type 1 and Types 2 to 6 combined. In addition the channel use ($T_{CU}$) as percentage of the total message occupancy is also plotted in those figures. No particular trends can be detected from this analysis either 'before' or 'after' MRDS.

Similarly Figures 6-9 and 6-10, which show how the total message count breaks down into dispatch and other types of communications (type 2 to 6) as a function of the channel message occupancy ($T_{OM}$), do not contribute any insight into the causes for variation of occupancy during a peak busy hour.

Finally an attempt was made to examine only the query type traffic (types 4 & 5) to determine whether its intensity varied as a function of the total message activity of the busy hour. This time the message volume was nomalized to a 'per unit' basis since the average number of patrol units 'before' and 'after' was different. The results are plotted in Figures 6-11 and 6-12 and again no indication can be obtained from these figures whether the activity of a busy hour is in any way related to the query traffic. Figure 6-12 does show once again, however, the stimulation of increased query/response messages as a result of having the MRDS capability.

### 6.3.3 Spectrum Utilization Aspects

**Voice Channels**

A measure of spectrum utilization of radio voice channels is the message occupancy averaged over a period of time. Police systems must be designed to handle the peak policing activity and it is for this reason that peak busy hours as defined in section 4.2 are of interest. The study has shown that, at the present time in the Vancouver System, an average peak busy hour is occupied by messages for 48% of the time, as compared to 45% in the period 'before' MRDS. However between these periods the number of patrol units has increased by 65% from 17 to 28 per channel.

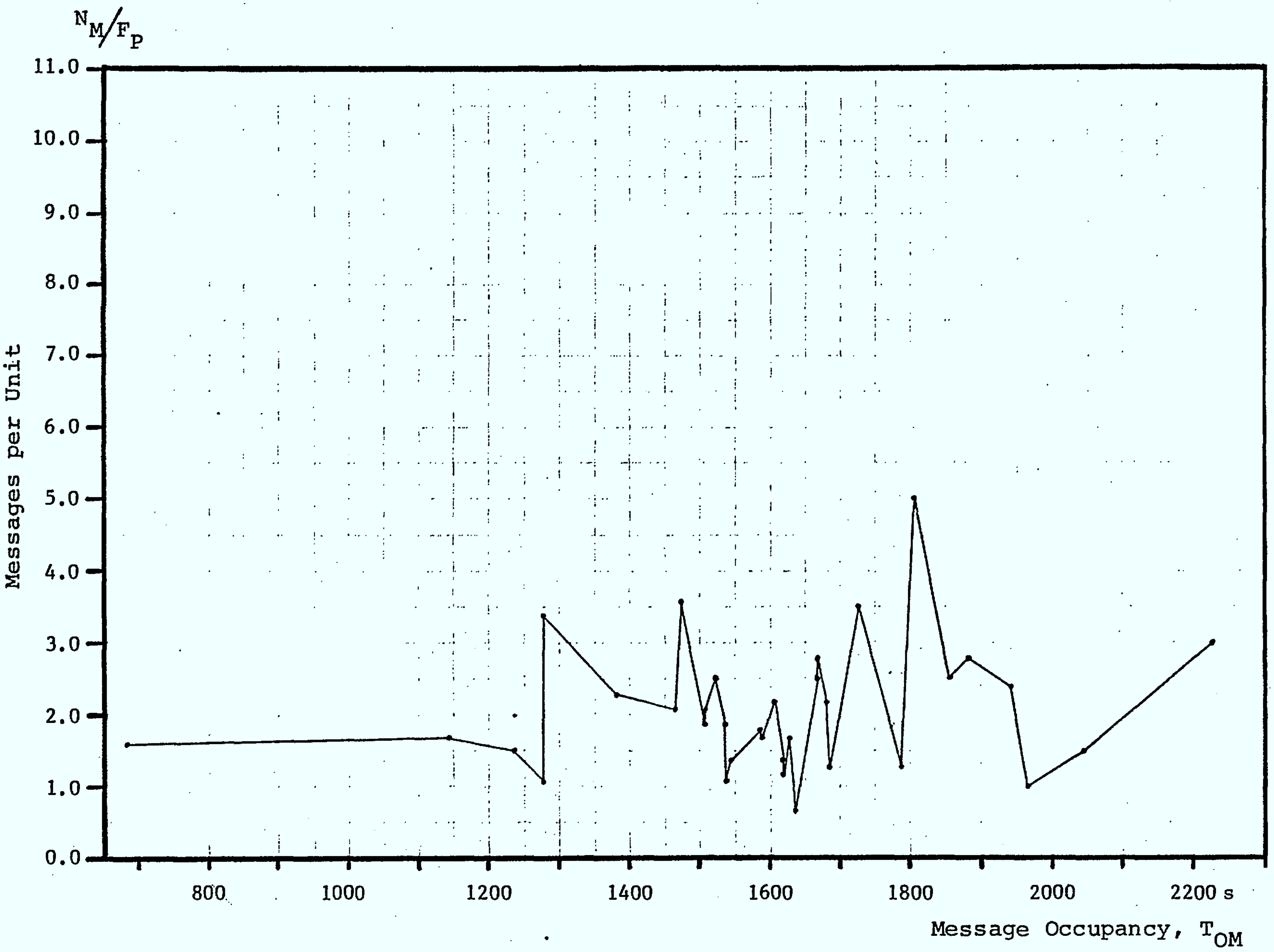


FIGURE 6-11 'BEFORE' MRDS. Variability of Voice Channel Query Traffic (Type 4 and 5 only) of the Busy Hour as a Function of Channel Message Time Occupancy ($T_{OM}$).

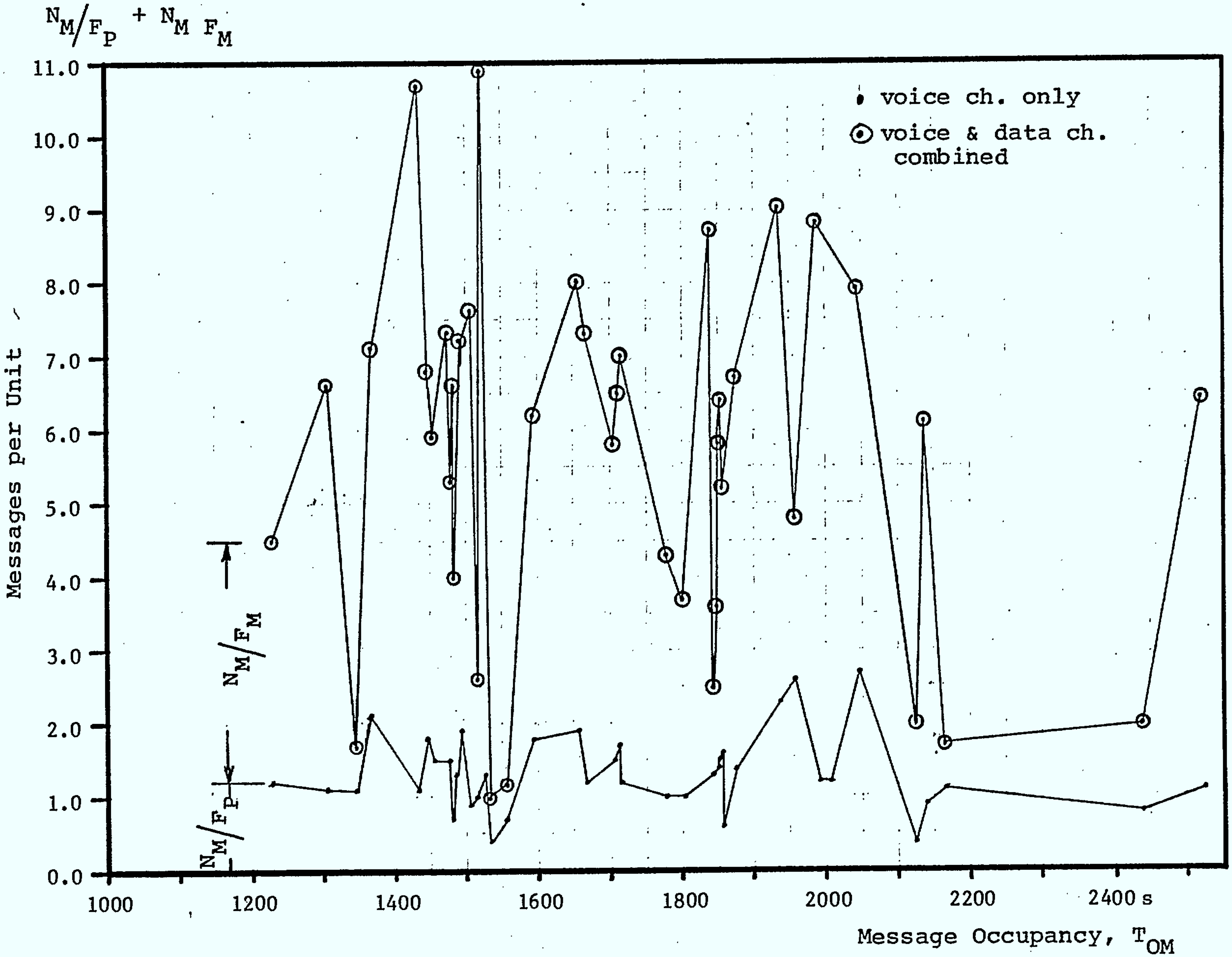


FIGURE 6-12 'AFTER' MRDS. Variability of Voice and Data Channel Query Traffic (Type 4 and 5 only) of the Busy Hour as a Function of Channel Message Time Occupancy ($T_{OM}$).

This tends to suggest that a saturation level for Vancouver is being reached and that the average peak busy hour occupancy may not increase with additional patrol units. This may be true even though the variability of message occupancy of the peak busy hour is somewhat greater 'after' than 'before' and that the maximum observed peak value 'after' is 2530 seconds as compared to 2230 seconds as 'before'.

Operators who have captured the data from tapes seem to agree that the really busy hours are not caused by large numbers of non-related crime occurrences but rather by events usually involving a number of units at one time.

More often than not it is one or a number of such events as break and entry, bomb threats, parties out of hand, fights, etc., that cause the message occupancy to peak. The chief dispatcher frequently pre-empts the channel under these circumstances and communicates with a small group of units virtually excluding those not associated with the situation from using the channel. More than one such event, following each other in sequence during a busy hour, will cause the message occupancy to peak significantly. Grade of service for units not involved probably drops considerably depending on the nature of the incident.

Based on the observations collected during the study the following hypothesis is proposed for the Vancouver Police System:

- the saturation level of radio channels is a message content representing approximately 50% message occupancy of the hour

- this saturation level occurs when the message traffic results from a large number of unrelated crime events

- the saturation level is primarily influenced by what one dispatcher can handle on a continuous basis - dispatcher's decision time becomes shorter as the hour becomes busier

- the saturation level is exceeded, peaking-up to 75% of the hour or 2700 sec channel use, as a result of one or more multi-unit events occuring in series

- increasing the number of MRDS terminals will not significantly reduce the average peak message occupancy of the busy hour message occupancy but it will improve the overall grade of service for patrol units in the field and their ability to fulfill the policing function. Some reduction may result from reduction of the CPIC queries currently handled by voice.

More observations over a longer period of time would be required to fully confirm the above hypothesis, although even with the information currently available there are strong indications that this could be true.

### Data Channels

Occupancy statistics show that the data channel is carrying messages from all four districts on the average for 79.2 sec. This does not include channel air-time occupied by retransmissions due to propagation errors, control messages, automatic acknowledgements and form requests. As discussed in Appendix F an appropriate allowance. for these factors is 65% of the basic message occupancy increasing it to 130 sec. The total occupancy of the data channel in the 1st quarter 1982 is thus estimated at approximately 130 sec.

Note, however, that there are two radio frequencies in use: one on the outbound direction which is 'on' continuously and the other inbound accessed by terminals on a contention basis. This results in time overlap of messages in the two directions. In real time the data channel is not occupied for 130 seconds because of this overlap. Messages type 3 and 4 and probably 'error' are primarily carried on the inbound frequency while type 5 on the outbound frequency. Type 6, of which a large number are unit to unit narrative, are probably equally split between the two directions.

Based on the above and using Table 6-2, an approximate occupancy of the two directions of the data channels during the voice peak busy hour has been computed as follows:

- inbound direction 54 s
- outbound direction 76 s

These are small values by any standard indicating an apparent spectrum underutilization and a significant growth capability.

However another perspective on spectrum utilization would be to consider what does the data channel occupancy represent in terms of equivalent message time on voice channels. Taking the 'before' values from Table 6-1 for average lengths of type 3 to type 6 voice messages and applying them to the average hourly distributions of the number of messages on the data channel (Table 6-2) results in an equivalent per channel message occupancy of 2665 sec generated by terminals in all four districts. It must be remembered that these are average values and therefore larger peak values could be expected to occur. If each district was generating the same amount of traffic this would correspond to an equivalent per voice channel load of 666 sec.

This extra message load could not be accomodated by the system as it is presently configured. Most likely an additional two voice channels would have to be provided for this purpose. It is from this point of view that the impact on improved spectrum utilization of establishing a police MRDS type system becomes apparent, although the conversion is not necessarily one to one because the data channel is full duplex while voice is half-duplex.

This, of course, assumes the necessity of the messages transmitted and the attendant increased effectiveness of the police operations. This latter aspect is outside the terms of reference for this study.

## 6.4 Traffic Assessment

As discussed in previous sections, the average message traffic on voice channels has increased only marginally: from 148.3 'before' to 158.1 messages per hour 'after' or by 6.6%. The distribution of traffic by message type within the hour has also remained substantially the same.

It is the traffic on the data channel that is primarily responsible for the overall increase in message traffic and in particular the type 4 and 5 which are CPIC data base queries and responses. From Table 6-2 these amount to 165.7/hr for all the MRDS terminals in the system during the average peak busy hour. Since analysis of periods outside the peak busy hours was not the subject of this study, it was not possible from available data to relate the average peak busy hour traffic to other hours during the day or week.

Records maintained by CPIC on data base enquiries from patrol units indicate that there has been a substantial increase of the average monthly traffic between 1980 and 1981, the year when MRDS terminals in large numbers first came into use. Figure 6-13 has been prepared, using data derived from references 1 and 2, to show the long term growth in CPIC query traffic orignated by the Vancouver Police Department. The growth line in the figure has been drawn using the least squares fit.

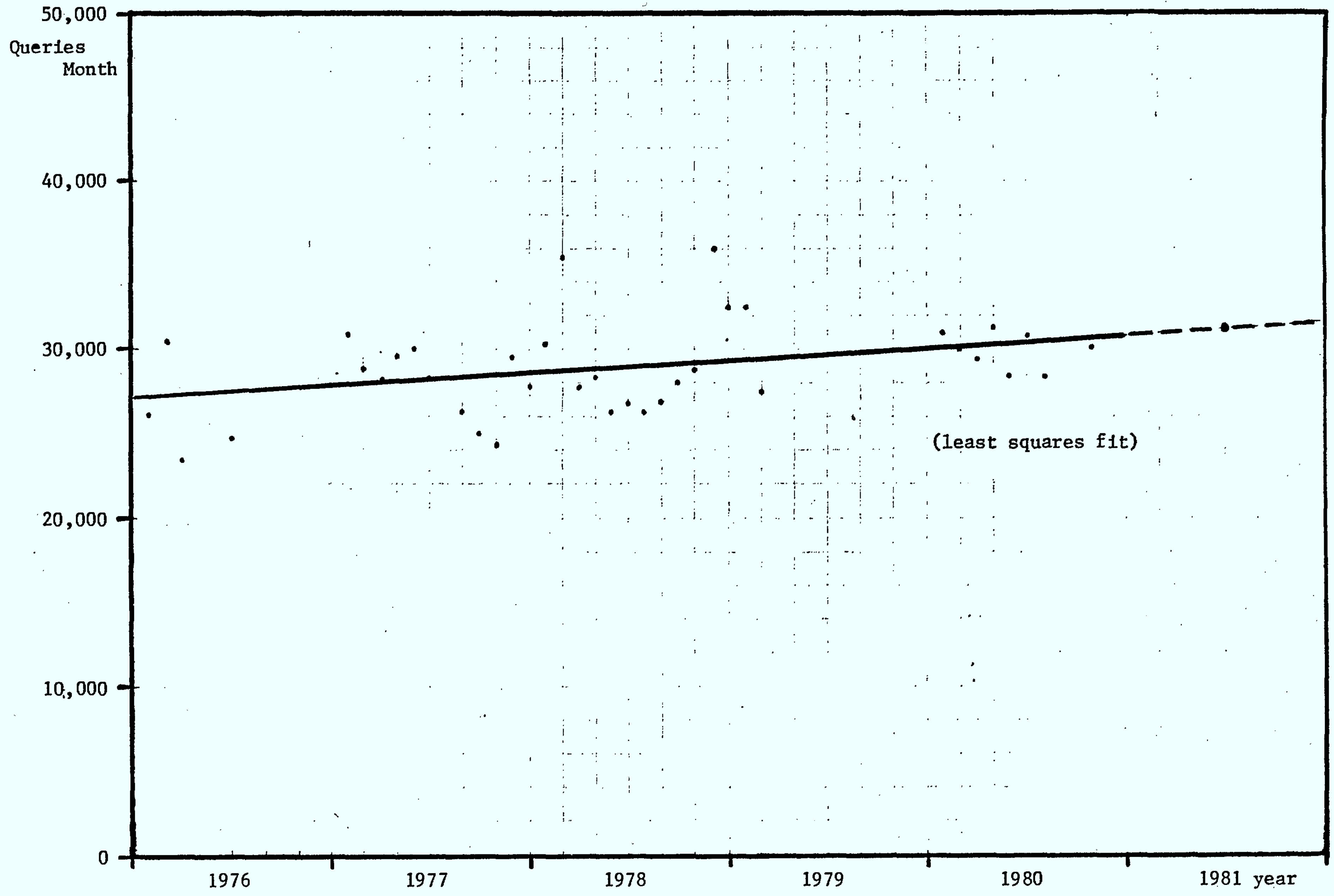


FIGURE 6-13 Long Term CPIC Query Growth for the Vancouver Police System; 1976 - 1980. (Persons and Vehicles Only)

Without MRDS terminals the average monthly values for 1981 extrapolated from the figure would have been 31,500 queries per month. The actual value from CPIC records is 57,900 per month of which 19,500 are attributable to MRDS terminals. From this the hourly average is 79 per hour overall and 27 per hour due to mobile terminals.

The number of terminals in Vancouver in 1981 were as follows: 10 from January 1 to June 21 and a gradually increasing number from June 22 to December 31, 1981 up to approximately the number encountered in the study. Averaging this throughout the year gives 27 terminals. The hourly rate per terminal thus becomes 27/27 or 1.0 queries averaged over a full year for each of the 24 hours during the day or what is probably more representative 2.0 queries averaged during the typically twelve busy policing hours of the day.

CPIC queries as reported in their statistics consider an enquiry and a reponse as one query. Therefore to relate the 2.0 hourly rate in the preceeding paragraph to that in the study it should be multiplied by a factor of two and becomes 4.0 messages per terminal per hour. If this rate were also maintained throughout February and March then the average for 42.7 terminals as found during the study would be 42.7 x 4.0 = 170.8 messages per hour. This is slightly higher than the average peak busy hour value of 165.7 messages determined from this study and indicates that there may be hours during the day outside of those sampled when voice channels are relatively idle but data channels peak perhaps higher than that value.

There are no CPIC query statistics for 1982 available at this time to expose what is now regarded as a stabilized situation relative to terminal installation. Without this information any projections for growth on the data channel in future years would not have a sound basis.

Regarding the present system loading on the data channel there appears a significant spare capability left for it to handle the data traffic during policing activities corresponding to the peak busy voice hours as shown in Table 6-5 and as the system grows to its design target under the VPD column.

The average level of data traffic achieved by the VPD system even if scaled up to 100 terminals from an average of about 41 indicates a level of utilization substantially below the VPD design target values for the different message types. This difference may be explained partly by some operational considerations which tend to inhibit use of the terminals for some message types. For example, the status message is not used as expected since its value has been determined to be small in the absence of both a full cad-system implementation and all terminal-equipped units in the field. The smaller use of query/response messages is somewhat more surprising though a partial explanation is that not all units with terminals necessarily handle data during the policing busy hour. See the chart in Table 6-2 (on page 51) showing terminals in service ($F_M$) and terminals handling data traffic ($F_O$). Also, during the busy hour it is found that dispatch type messages using the voice channel predominate and that data messages may substantially increase in the voice non-busy periods. This aspect as well as behavioural influences regarding data terminal utilization are not covered within this study and are suitable topics for future research.

TABLE 6-5 Comparison of MRDS System Design Values and Those Encountered During Peak Busy Voice Hour - Data Channel all Four Districts Combined

| VARIABLE | HOURLY DATA TRAFFIC | | | |
|---|---|---|---|---|
| | System Design Target(1) | | Peak Busy Policing Hour | |
| | MRDS overall | VPD | Average Levels Feb/Mar 82(2) | Max. Level Feb/Mar 82(3) |
| MESSAGES | | | | |
| Type 3 - Status | 1600 | 125 | 15.6 | 6 |
| Type 4 - Requests | 1500 | 700 | 90.7 | 131 |
| Type 5 - Responses | 1500 | 700 | 75.0 | 132 |
| Type 6 - Narrative | 900 | 240 | 37.4 | 53 |
| All Combined | 5500 | 1765 | 218.7 | 322(4) |
| TIME | | | | |
| Estimated Message Occupancy, $T_{OM}$(sec) | 2220 | 587(5) | 72.9 | 124.6(4) |
| Average Message Length, $T_M$(sec) | 0.80 | 0.23 | 0.33 | - |
| Estimated Total(6) Air-time (sec) | 3660 | 970 | 130 | 206 |
| TERMINALS | 100 | 100 | 40.7 | 57.0(4) |

Notes:

(1) System Design Target values: MRDS overall - from reference 10;
Vancouver Police Department (VPD) target - from reference 11

(2) Obtained from Table 6-2

(3) Obtained from study data

(4) These values are for 20th of February, 1982

(5) Estimated using average message lengths ($T_M$) from Table 6-2

(6) Estimated $T_{OM}$ occupancy does not include messages in error form, requests, acknowledgements and control messages and retransmissions. These consume additional air-time and increase the channel air time. An allowance of 65% of $T_{OM}$ was used to arrive at this value (Appendix F). In the case of MRD System design target, the value of 3660 seconds does not necessarily represent a requirement for more than one channel because of inbound/outbound message overlap.

## 7.0 CONCLUSIONS AND RECOMMENDATIONS

A study of traffic and spectrum utilization during peak busy hours in the Vancouver Police Department MRDS System has resulted in the following conclusions:

1. Introduction of MRDS terminals has caused little change to the average message content of a voice channel either by volume or by air-time. On the average these two values have increased by over 6%. However long term Vancouver Police Department records indicate that since the reorganization of June 1981 more peak busy hours occur during any given period then prior to this time.

2. The average voice message length has not changed as a result of MRDS – it remains at 10.9 seconds.

3. The air-time occupancy during an average peak busy hour is approximately 50% peaking up to 75%. It is hypothesized that when the number of non-related crime events is large, approximately 50% represents the saturation level of voice radio channel in the Vancouver System. Peaks up to 75% occur as a result of events of longer duration such as break and entry, street fights, etc.

4. Study observations tend to indicate that in the 'after' situation the grade of service for all types of communications has deteriorated for patrol units not equipped with a MRDS terminal. This may be partly due to increase in the average patrol units per radio channel from 17 to 28 and partly due to the capability of a single dispatcher handling a given peak load. For units equipped with terminals, capability to handle queries has improved greatly.

5. On the sample studied there is limited relationship between the level of radio channel activity and message content.

6. At the traffic level the data chanel is primarily responsible for most of the increase from 'before' to 'after'. In particular the hourly query/response traffic has on the average increased by 100%.

7. The average message occupancy of the inbound and outbound directions of the data channel is under 130 seconds. In real time this is even less because of message overlap in the two directions. This appears as poor utilization until it is determined that the traffic carried by it, has an equivalent voice channel occupancy of 2665 seconds or approximately two regular voice channels.

8. The data channel has adequate capacity to handle the existing policing peak busy policing hour traffic however nothing is known of the data traffic outside of those hours. CPIC query statistics suggest that hours other than those studied may contain the peak busy hour data traffic.

The recommendations resulting from the study include:

1. That Vancouver Police sample the traffic on data channel at various hours throughout the week on a regular basis. This will give an insight into how peaky is the hourly traffic.

2. That an attempt be made to determine the ratio of queries originated by patrol cars equipped with terminals versus those without them. This along with the background information from this study will help to determine whether the grades of service for the two cases are the same.

3. That an attempt be made to find out whether the terminals are used to their full extent or are there impediments to this during periods of high stress caused by policing peak busy periods. This would be done through a behavioural type study.

4. That it would be useful to develop an improved tool for sampling the message characteristics from voice tapes. The present manual techniques are too time consuming and not well adapted for use within operational environments.

- END -

## 8.0 ACKNOWLEDGEMENTS

The author wishes to acknowledge the co-operation of all those whose contributions made possible a successful completion of this study. Specifically we are grateful to the following:

- Mr. R. Fujaros of DOC/CRC for the technical guidance and for contribution made to section 3 of the report.
- Cpl. C.D. Lea of the City of Vancouver Police Department for logistics support, for his willingness to assist in solving problems as data was being captured and for making vital information available to the study regarding the operations of patrols in the field.
- Staff Sgt. D. Kristjanson and all the staff members of the Vancouver Police Communications centre for their co-operation and patience in tolerating our presence during the data capture phase.
- Mr. D. Erickson of MRDS for assistance in resolving some software problems encountered on the Vancouver PDP 11/34 system.
- Mr. W. Strecko of IMDI for explanations of the protocol in use on the mobile data channel.
- Mr. P. Vanderwood of City of Vancouver, Research Department for helpful support with advice and information on the MRDS system.

## 9.0 REFERENCES

Ref. 1 MRDS CPIC statistics covering the period 80.12.08 to 81.04.30; source: Cpl. D. Lea, Vancouver Police.

Ref. 2 MRDS CPIC statistics 78.01 to 79.02; 75.08 to 76.08; 77.02 to 78.01; source: Mr. P. Vanderwood, City of Vancouver.

Ref. 3 MRDS Radio Coverage Tests - October 1979, Research Branch, Engineering Department, City of Vancouver, Mr. P. Vanderwood.

Ref. 4 Records of Radio Channel Use; source: Cpl. D. Lea, Vancouver Police.

Ref. 5 Description of MRDS System and its Error Control Strategy; source: Mr. R. Fujaros, DOC/CRC, Ottawa.

Ref. 6 CPIC/MRDS Definitions and Assumptions About Radio Traffic, B.T. Glenn, CPIC, March, 1976.

Ref. 7 MRDS-1 Project, Revised Traffic Models of a Mobile Radio Channel, Cantel Engineering Associates Ltd., June 1976.

Ref. 8 MRDS-1, Considerations Leading to Definition of Mobile Data Bit Rate, Cantel Engineering Associates Ltd., November 7, 1975.

Ref. 9 Vancouver Police Daily Duty sheets and Records of Assignment of MRDS Terminals to policing districts; source: Cpl. D. Lea, Vancouver Police.

Ref. 10 Mobile Radio Data System (MRDS), Pilot System for Canadian Policy Users Specification Number MRDS-5 November 19, 1976.

Ref. 11 City of Vancouver, Vancouver Police Department Specification, April 25, 1978 and amendment of July 6, 1979.

APPENDIX A

## MRDS TRAFFIC AND SPECTRUM USE STUDY

APPENDIX A

TO

REPORT R-276-001

## VANCOUVER POLICE DEPARTMENT RADIO SYSTEM DESCRIPTION

## A1.0 Introduction

This description of the Vancouver Police Department Mobile Radio System is intended to put into clear context the nature of the overall system under study. Two system situations were studied. The first one is the case characterized by all analog voice communications which existed before the introduction of data terminals into the patrol units. This is referred to as the 'before' situation. The second represents a time period following the introduction of digital commnications to augment the voice communications and is referred to as the 'after' case.

## A2.0 Communications System Before MRDS

Prior to the introduction of a digital radio commnications capability for communications between dispatchers in the communications centre and patrol units, the Vancouver Police Department nominally employed four analog voice radio channels, with each radio channel designated for use in one of the four defined policing zones or districts for the City of Vancouver. These channels were used to support all dispatch, status reporting, information support and other related functions. Incidents or events were typically collected via telephone from the public by complaint takers in the communications centre. The necessary information was recorded on hard copy and forwarded to the appropriate dispatcher personnel by way of a card conveyor system. A simplified illustration of this configuration is shown in Figure A2-1.

During busy hours four dispatchers were employed with each dispatcher responsible for one of the four zones and using one of the four dispatch channels. During non-busy hours two dispatchers were adequate to serve all four zones, (two zones per dispatcher) with capability at the dispatcher radio consoles allowing control over two or more of the radio channels as demanded by the situation.

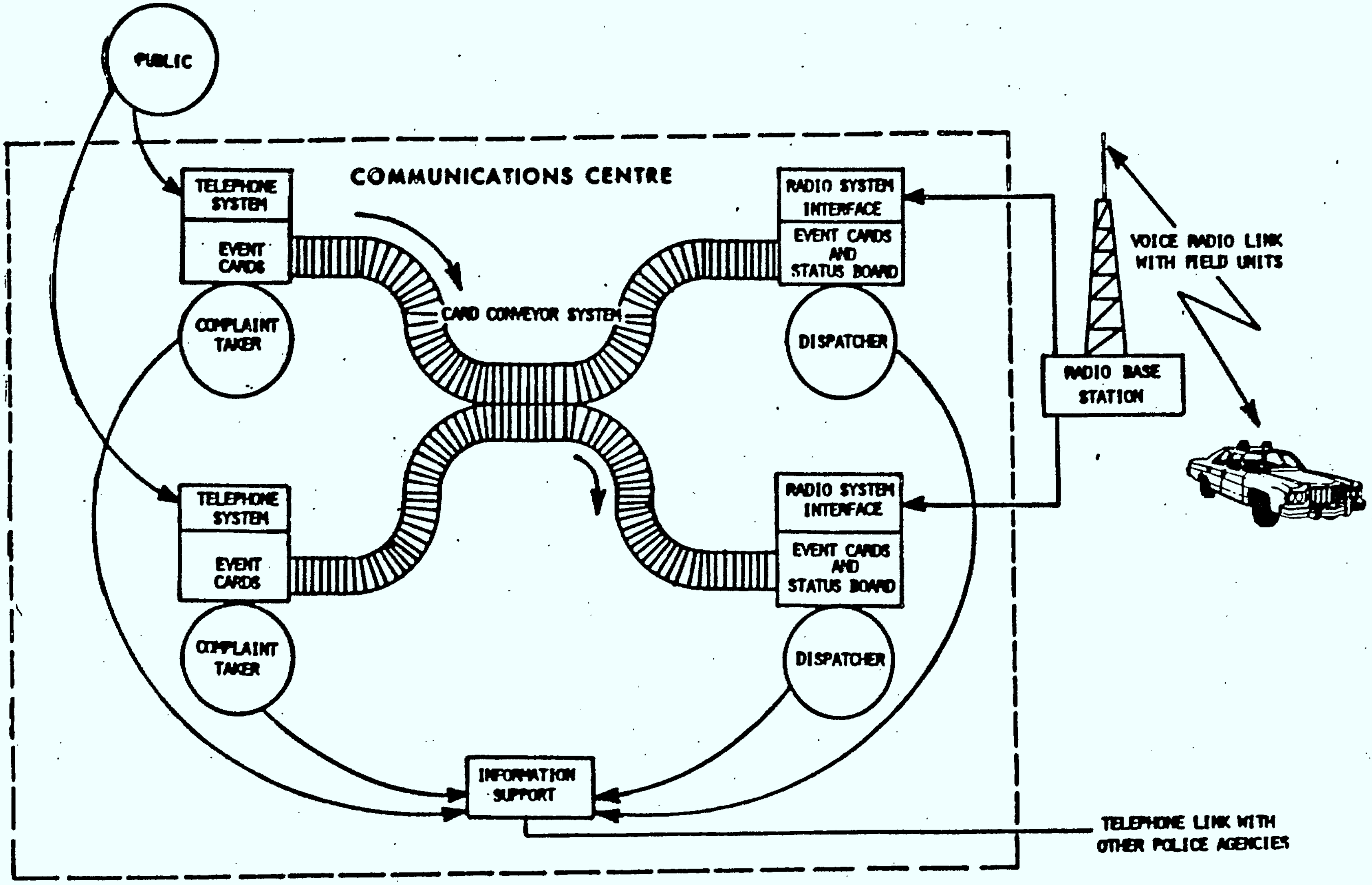


Figure A2-1 POLICE VOICE COMMUNICATIONS SYSTEM

For the case of the Vancouver Police Department teleprinter devices were also placed at the dispatcher radio consoles to enable the dispatcher to query the national and provincial (B.C.) computer data bases for desired information upon request of patrol personnel. Though the actual query by the dispatcher to the data base was carried out by means of conventional landline data base access from a remote terminal, the patrol unit request and corresponding dispatcher response was accomplished via voice communications using the voice radio channel discipline of the police department. Though the keyboard oriented input and printer output from the data base might be rapid, "voiceing in" the request and "voiceing out" the response was still a significant use of radio channel time. One rationale for introducing a data capability was to off-load the data base query/response function by voice from dispatcher personnel as much as possible.

## A3.0 Communications System with MRDS

The Mobile Radio Data System (MRDS) featuring the new mode of communicating known as data communications was introduced as an adjunct to existing voice radio systems for use by the police department. MRDS provides an alternate and more efficient means of communicating with patrol vehicles for certain types of messages. However, it is not intended to completely supplant existing voice radio channels. The existing four voice radio channels continue to be used by dispatchers.

The MRDS requires the addition of electronic equipment to enable this new mode of radio communications. Police personnel use electronic devices (data terminals) to interact with the system. For example, each dispatcher and most patrol vehicles will have their own terminal. Each terminal has a typewriter-style keyboard and a TV-like screen for displaying received messages in the form of alphanumeric characters.

A digital computer is required to interconnect the various data terminals and provide automatic handling of messages being forwarded within the MRD System.

Other equipment required includes radio equipment to support a radio channel for carrying the data-type messages to and from patrol units, the communication centre and other sources of data messages. This special radio channel (a dedicated radio channel for the Vancouver system) is automatically controlled by the MRDS computer and related equipment. The dispatcher continues to control all voice channels through his normal voice radio console.

The overlay of the MRD communication system upon the voice communication system is illustrated by Figure A3-1. The particular communication channels of interest to this study for analysis and comparison purposes are the two between the patrol vehicles (units) and the voice radio base station and data radio base station. For voice communication purposes the conventional two-way mobile radio is used, while for data communications the patrol unit uses the terminal device illustrated in Figure A3-2. These two channels operate independently from an electronic point of view.

Specific features of the MRDS are the following:

- High speed digital transmission carries more messages on the dedicated radio channel than similar voice channels.

- Delay in accessing a digital radio channel is shorter than for a voice channel and MRDS performs all radio operations automatically. The operators receive information more quickly.

- Patrol officers access various external data base files directly, using mobile terminals, without having to wait for assistance (by voice) from a dispatcher.

- Digital messages sent between mobile terminals and the communication centre are highly secure, as compared with conventional voice radio messages. Only designated terminal users recieve the digital messages.

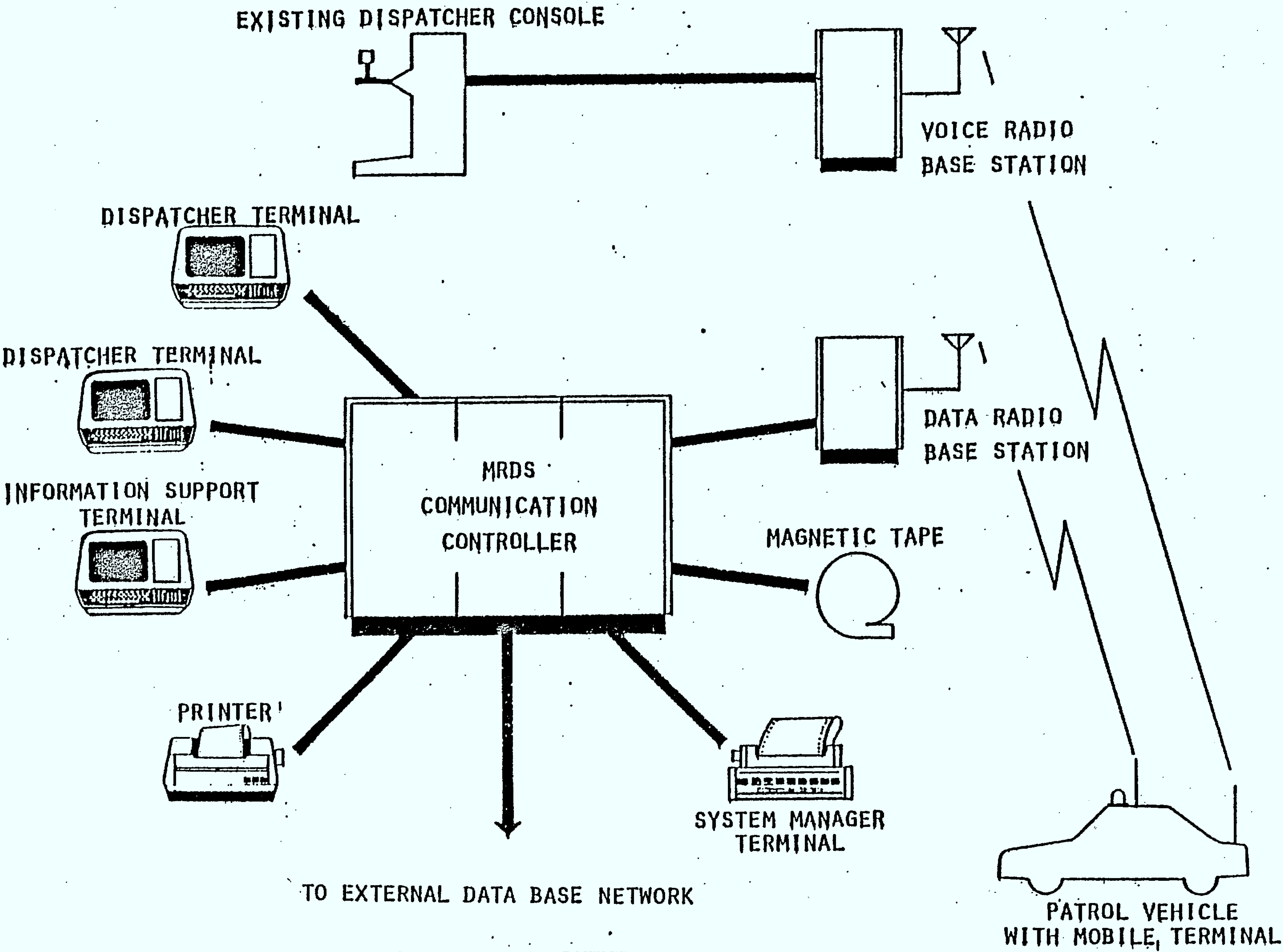


Figure A3-1 MRDS EQUIPMENT

MDI
INTERNATIONAL
MOBILE DATA INC.

Figure A3-2 MOBILE DATA TERMINAL

- Digital data is stored and displayed in readable form with a minimal chance for transmission errors. All messages can also be stored on magnetic tape and printed on paper for later review, when necessary.

Functionally the Vancouver MRD System is designed to support the following message types for communications with patrol units:

- query/response to central data base files (both national and provincial files) - typically by requesting and filling in an appropriate blank form

- status reporting may be entered with or without comments. Dedicated status keys on the terminal permit single key depression status reporting (eg. "en route" to an incident).

- narrative messages - may be sent to or received from mobile terminals

- emergency message indication by single key depression on the mobile terminal - this message has priority on the radio channel in the system

The primary emphasis for the police department needs is on the first item (data base query/response), with secondary emphasis on the latter three items (computer-aided command and control functions).

Due to the fact that not all patrol units are to be equipped with mobile data terminals and that foot patrol units will not have terminals, the teleprinter devices have been retained at the dispatcher positions in the communications centre to service voice radio requests for data base searches.

## A4.0 Operational Considerations

The MRDS capability was introduced in the Vancouver Police Department during the period 1979 - 1980 and final system acceptance tests were completed with twelve (12) data terminals in September, 1980. Thereafter, additional terminals were gradually installed into the patrol vehicles to the present level of approximately fifty (50) terminals. Ten (10) additional terminals are currently used for training purposs and held as spares for terminal servicing reasons.

Prior to the installation of mobile terminals (the 'before' period of study) the police department employed vehicular patrol unit shift schedules of 8-hour duration, with shift periods as follows:

0700-1500, 1000-1800, 1500-2300, 2000-0400, 2300-0700

Manpower was assigned to each of the four policing districts (representing an area of 44 square miles to be patroled) in accordance with zone size and the crime incidence/calls for services characteristics of the particular zone. However, patrol manpower allocation was typically relatively flat over the course of the working day. Personnel were assigned to two-men per vehicular patrol on the average 60% of the time. Analog voice magnetic tape records covering this environment were preserved for representative periods in 1980 (September, October, and November).

To account for evolving crime patterns and to pursue increased efficiency of resource utilization, the Vancouver Police Department recognized the need to alter the prevailing allocation practices of patrol personnel. An appropriate course of action was planned during the period of MRD System introduction and the "team policing" concept was modified and expanded in June, 1981. The concept included the extended use of overlapping shift schedules for patrol personnel to permit the peak demand for service to be better satisfied. A typical 24-hour day, for example might have officers report for 10-hour shifts, with 64 officers reporting at 7:00 a.m., 64 officers at 4:00 p.m., 24 officers at 5:00 p.m., 24 officers at 6:00 p.m. and 40 officers at 9:00 p.m..

Analog voice magnetic tapes and MRDS data magnetic tapes covering this changed operational environment were preserved for suitable periods in 1980 and 1982 to cover the 'after' period of study.

Clearly those changes to police operational practices which affect the intensity and character of communications, in particular during the peak hours of traffic to be studied, must be accounted for in the comparative analysis of radio channel use.

## A5.0 System Technical Parameters

**Voice Channels** (two frequency simplex)

| | |
|---|---|
| RF Frequency Band | VHF (high band) |
| Modulation | FM |
| Method of Operation | Push-to-Talk |

**Data Channel** (two frequency duplex)

| | |
|---|---|
| RF Frequency Band | VHF (high band) |
| Modulation | Baseband on FM |
| Data Rate | 4800 b/s |
| Throughput Efficiency | 48% min (in bound) |
| Displayed Errors | 1 in 10 messages |
| RF Signal Threshold | 6 dB above 12 dB SINAD |
| Fade Margin Required | 6 dB or less for 5% retransmission from moving vehicle |
| Base station Operation | Full-duplex |
| Mobile Terminal Operation | Half-duplex |

**Radio Coverage**

The Specification for the MRDS System contained the following requirements for radio coverage:

Specification Item F.1.

(j) The radio system shall provide the following mobile data coverage. Test of coverage standards shall be conducted with the system unloaded, with a single unit in randomly chosen locations on arterial routes and with full screen messages transmitted and received (239 characters).

i) VEHICLE PARKED (includes allowance for movement of up to one car length in either direction): Successful transmission and receipt of the first attempt shall be possible from 95% of locations in the City.

ii) VEHICLE MOVING (vehicular speeds between 5 and 80 km/h). Transmission and receipt of the message (including up to four automatic retries) shall be successful from 97% of any one block section in the City at vehicle speeds from 5 km/h to 80 km/h.

# MRDS TRAFFIC AND SPECTRUM USE STUDY

APPENDIX B

TO

REPORT R-276-001

# CLASSIFICATION OF COMMUNICATIONS CARRIED ON MOBILE RADIO CHANNELS

VANCOUVER POLICE DEPARTMENT

# CLASIFICATION OF COMMUNICATIONS CARRIED ON MOBILE RADIO CHANNELS

## Type 1 CALL DISPATCHING

1.1 Initial dispatch of call (Dispatcher or Unit) including acknowledgement and unit emergencies.
1.2 Supplementary call information including acknowledgement.
1.3 Unit clearing from an associated dispatch call.
1.4 Information request as part of an associated dispatch call.
1.5 Repeat broadcasts.

## Type 2 TACTICAL COMMUNICATIONS

Directing Tactical Forces

- Unplanned events (eg. hostage, bank hold-up)
- Planned events (eg. sea festivals, parades, etc.)

## Type 3 STATUS COMMUNICATIONS

3.1 Request for status
3.2 Request for location
3.3 Transmission of status
3.4 Transmission of location
3.5 Sign-on/Sign-off
3.6 Acknowledgements
- in one-to-one ratio in same mode as received

## Type 4 INFORMATION/ASSISTANCE REQUESTS

4.1 Information
- Functional - CPIC
- Operational
- Administrative

4.2 Assistance

## Type 5 DISSEMINATION OF INFORMATION

5.1 Vehicles - not on file
5.2 Vehicles - hit
5.3 Persons and others

## Type 6 DESCRIPTIVE/CONVERSATIONAL EXCHANGES

6.1 General broadcasts & bulletins
6.2 Narrative (non-functional or non-operational)

# MRDS TRAFFIC AND SPECTRUM USE STUDY

APPENDIX C

TO

REPORT R-276-001

## VOICE DATA CAPTURE PRODUCTIVITY

## VOICE DATA CAPTURE PRODUCTIVITY

The following time allocations were needed to capture the data from one channel hour of voice tape recording.

| | Operator Hours |
|---|---|
| (a) Message classifications; clocking of transmissions, gaps and the overall message | 6.3 |
| (b) Rests | 0.6 |
| (c) Set-up and change of tape | 0.1 |
| (d) Data entry to diskette | 2.0 |
| (e) Pro-rated allowance for: | |
| ( i) recording standby tapes | 0.3 |
| ( ii) data quality and reliability checks | 0.2 |
| (iii) filing, checking and miscellaneous tasks | 0.2 |
| Total Operator Hours | 9.7 hrs |

# MRDS TRAFFIC AND SPECTRUM USE STUDY

APPENDIX D

TO

REPORT R-276-001

## STATISTICAL SOFTWARE PRODUCED AS PART OF STUDY

## DATA CHANNEL SOFTWARE

### MAGSTAT

PURPOSE: MAGSTAT is a program written in Fortran which operates on the PDP 11/34 development system at the Vancouver City Police's MRDS site. It analyzes the digital record of messages as recorded on magnetic tape by the MRDS system. It statistically summarizes the messages as to type and duration over each discrete hour.

ENVIRONMENT: MAGSTAT is run interactively and requires the operator to mount the tape(s) as required. Several hours (files) may be run from one or more tapes, and a running summary is printed after each hour's printout.

Because of the uncertain nature of the tape files, this repeat of the summary after every file was required as any program termination would cause the summary to be lost.

OPERATION: Program operation is simple. Assuming the program has been made current in the user identification code, here are the run steps:

1. Obtain a directory of the tape(s) on which the file(s) reside.
   ```
   PIP MT:/LI
   ```

2. Count the sequential position that each file(s) is away from its predecessor (or beginning of tape).

3. Dismount the MT: (DMO MT:MRDS)

4. RUN MAGSTAT

5. Program will now prompt:
   ```
   ENTER LISTING DEVICE?LP:  (for line printer)
   ```

6. Now:

ENTER (O+STOP, 1=NEXT FILE, N=SKIP N FILES (READ Nth)
-N=MOUNT NEW TAPE AND READ Nth FILE)?12

(this would cause 11 files to be skipped, and the 12th to be read) This prompt is self explanatory. Remember to change the tape before returning the carriage after a -N prompt.

7. A further prompt gives the user a final degree of protection. The file name (hour/day) is printed on the terminal before processing continues in case the program was not far enough along the tape. If the tape has advanced too far though, it cannot be backed up, and must be rewound to start again. It is wise to guess a few files short, and then step ahead 1 at a time until the correct one is reached.

The prompt:

PROCESS=1, SKIP=0? allows the user to bail out of this file and not go through the analysis. The count of files as recorded by PIP'ing the tape, may not hold when MAGSTAT reads through them, and so this last step was included.

OUTPUT: Each hour (file) processed contributes statistics on the messages as to seconds of air time that each message took. This is calculated from the message length in bytes, and the type of message (Appendix F).

The categories of message type are uniquely identified along with number, mean and standard deviation of its length, and a frequency distribution in 1/10th second intervals.

For any one hour, the number of different vehicles involved in message activity is report as well.

Totals over all message classes are reported as well as a summary of all hours processed during that run, (also summarized over all classes).

## VOICE CHANNEL SOFTWARE

### VOICEDAT

This describes the ENTRY and REPORT programs which allow measurements collected from an audio tape log from a radio dispatch system (specifically a police system) to be entered into the computer readable form.

The computer which hosts this sytem is an Apple II+ with 48k, 2 disks. There are four separate programs; all are written in Basic.

1. ENTRY collects the data
2. LIST lists the entered data for manual checking
3. FIXER allows changes to be made to the data records
4. REPORT prints final analysis of the summarized data

### 1. ENTRY

This program is interactive, and allows the user to enter data onto a diskette, at the same time checking for valid message class, consistent time entries, and D/G/U designators (D=dispatcher, G=idle time gap, U=patrol unit).

The program is designed around the layout of the data coding sheet as shown in figure D-1. The sheet imposes a structure on the program's execution. This relates to the fact that each sheet has a set of global characteristics such as time of day (a range), channel, and tape number. This imposes a convenient buffer size on the entry of data on the diskette.

After the global information has been entered, then the 11 or 12 lines of message detail are keyed in. This data is held in core, and only dumped to the disk at the end of the page. This is a convenient place to have the Apple consume its several seconds of disk activity, as the user is manually preparing another page for entry. Each diskette holds about 700 records.

The system does not sort records, all data is managed in core, summarizing the data in arrays by time, period, channel, class, etc. in the report phase. ENTRY can be stopped at any time after a page has been entered. A next available record number is written away at each page refresh.

The only constraint that the system imposes is that of total number of discrete hours processed. If the program is to be used for much larger analyses, say for 100 hours and 5 channels, etc., then the data should be entered on the diskettes in a more or less ordered fashion. (channel 1 on one series, year 2 on another set, etc.). In this way, data analysis can proceed faster as the diskettes can be treated in batches.

The REPORT program has been built to process the data in separate channel/year conbinations. At run time the program prompts for year and channel (the current analysis called for 1980/1982 and channel 1/channel 3, but it would be relatively simple to adjust it for any other breakdowns. The program is self-documenting, all prompts are self explanatory. When entered in 10ths, appended by a 'G', 'D', or 'U' (gap/dispatch/unit), 12.5 seconds of gap would be 125G. A carriage return is entered after every entry with an 'X' signifying the end of this stream. If a stream continues on several lines, continue on as if it were on one line.

2. **LIST**

The program LIST merely dumps the contents of a data diskette created by ENTRY, on the printer for error checking etc.. Each record on the diskette contains 8 items of information, and LIST formats these (more or less) on a 132 column device.

3. **FIXER**

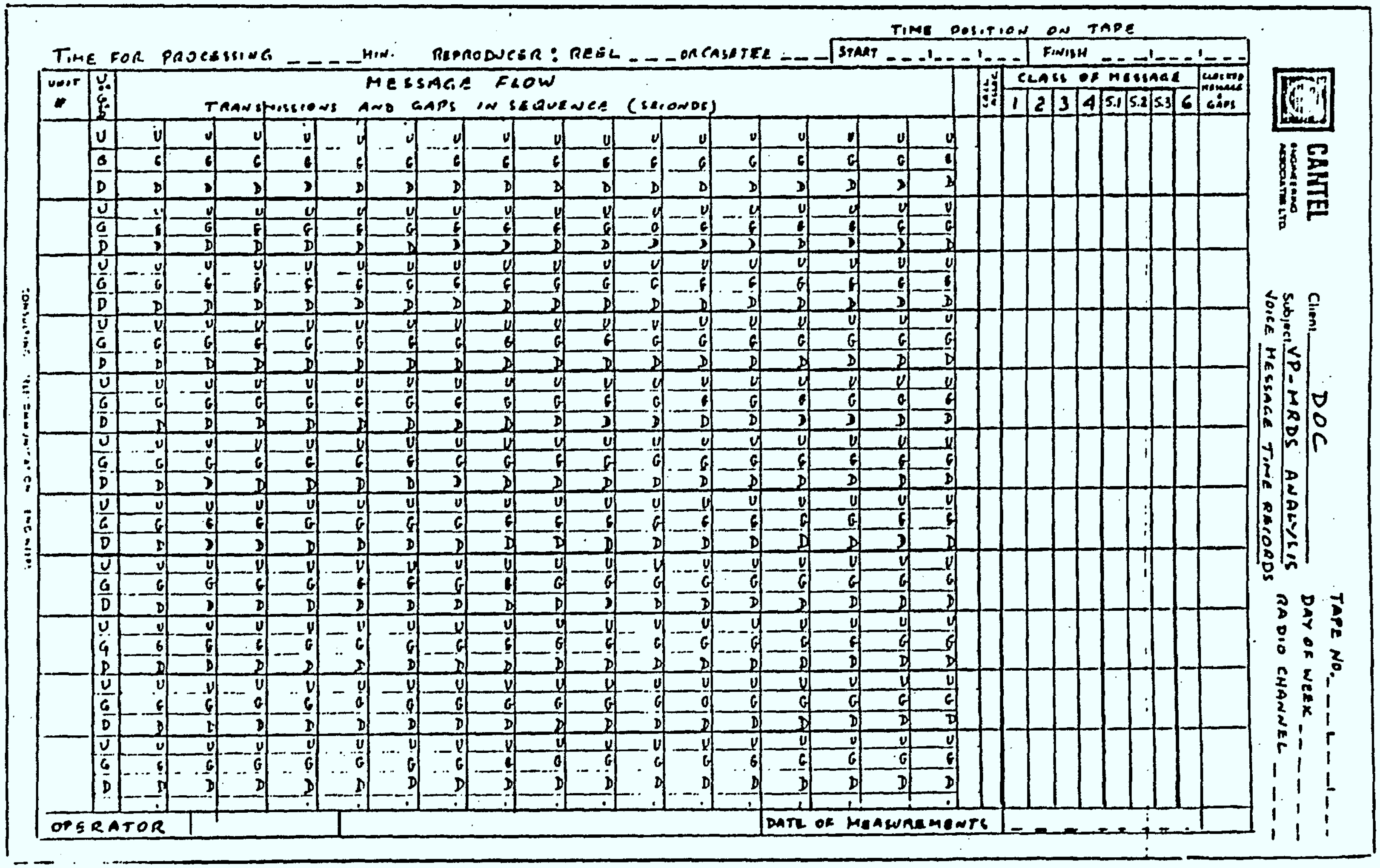
This program allows the user to access a particular record on a diskette and change discrete items on it. The program is self documenting, asking for the sequential record number and then displaying the eight items in the record. The item is re-typed by referencing its item number (1-8) and re-entereing the new string. The record number is the same as that appearing on the LIST printout.

## 4. REPORT

The REPORT program processes a series of data diskettes, accumulates the statistics thus obtained and prints out the summaries. As previously explained, each run of REPORT sets a year and channel for that run, and passes over any record that does not match that channel and year. In order to speed up the processing, if it is known that the target records (proper year and channel) occur only between say, records 99 thru 198, then a mechanism in the program allows only one section of the diskette to be read. This cuts down tremendously the time reqired to process the data.

The program prompts for STARTING, ENDING RECORDS?, and the appropriate entries are made. In order to process the entire diskette, enter 1,10000. Each time the diskette is processed a prompt for PRINT RESULTS(P) or LOAD NEW DISK(L) is issued.

To read a new disk enter L, to print out the statistical summaries, type P. The summary printed out is attached. In general it contains collective times and counts by class of message and length of message broken down further by hour. Dispatch, Unit and Gap portions of the messages as well as the overall elapsed time as measured independently are included in the analysis. No cosmetics were included in the output as there was a scarcity of core available. The results are readable enough so as to be transcribed into a report manually, or entered into a further computer run for plotting etc..



TIME POSITION ON TAPE

TIME FOR PROCESSING ____ MIN. REPRODUCER: REEL ___ OR CASSETTE ___ START __:__:__ FINISH __:__:__

UNIT #

U G D

MESSAGE FLOW

TRANSMISSIONS AND GAPS IN SEQUENCE (SECONDS)

CALL CODE

CLASS OF MESSAGE: 1 2 3 4 5.1 5.2 5.3 6

ISOLATED MESSAGE & GAPS

OPERATOR

DATE OF MEASUREMENTS __ __ __

CANTEL ENGINEERING ASSOCIATES LTD.

Client DOC

Subject VP-MRDS ANALYSIS

VOICE MESSAGE TIME RECORDS

TAPE NO. __ __ __

DAY OF WEEK __ __

RADIO CHANNEL __ __ __

FIGURE D-1 Voice Data Coding Sheet

# VOICE TRAFFIC STATISTICS (SAMPLE PRINTOUT

Month - Oct
Day 25th
Hour 23-24

Average Number per Message

Total for the hour

Average Duration per Message

Time in TENTHS of seconds

Records for 24th hour

Class of Message

No of Messages

Average Duration per Message in tenths of seconds

```
YEAR:-80  Month Day Hour
CHAN 3      ↓    ↓   ↓      N_D         N_U          N_G        N_M    T_D          T_U          T_G          T_CM.        Δ
PERIOD :-10.2523  1.5923913  1.63043478  2.22282609  184  28.9945652  31.0597826  36.2282609  90.6413043  5.75
↓ ↓ : T_M  T_G  (T_D+T_U)
1.1  14  175.5  69.3571429  113.714286
1.2  30  86.3333334  22.7333333  65.9
1.3  3  65  17  52
1.4  15  102.4  46.1333334  60.6666667
1.5  6  133.5  51.5  88
3  31  43.6451613  18.7096774  28.8064516
4  34  122.470588  45.1764706  84.4117647
5.1  4  26.25  16.5  15.5
5.3  11  71.0909091  27.9090909  55
6  36  74.8611111  40.8888889  40.4722222
PERIOD :-10.310  1.66891892  1.61486486  2.27702703  148  42.7837838  35.1891892  43.1486487  115.986486  5.46621622
1.1  22  142.454545  47.1818182  98.8181819
1.2  40  124.725  39.65  89.15
1.3  5  78.2  28  53
1.5  1  142  1  142
3  28  77.1071429  36.2857143  45.6071429
4  18  133.444444  56.9444444  85.7222222 ←
5.1  3  58  32.6666667  32
5.3  5  256.6  80.6  181.4
6  26  95.8461539  41.5  60.3846154
PERIOD :-11.010  1.66666667  1.63926941  2.30136986  219  33.0502283  33.456621  38.7534247  101.762557  4.68949772
1.1  37  108.891892  38.945946  72.4594595
1.2  38  99.5  34.631579  65.1578947
1.3  18  93.4444445  36.0555556  57.8333333
1.4  10  111.3  49  65.4
1.5  2  85  21.5  67.5
3  33  65.3636364  28.030303  41.6969697
4  39  137.615385  46.4871795  96.1025641
5.1  4  139.5  44.75  101.25
5.3  8  194.625  57.125  144.125
6  30  62.4  39.1333333  29.8666667
PERIOD :-11.011  1.52147239  1.45398773  1.95092025  163  36.2392638  30.7484663  38.7116564  102.570552  4.16564418
1.1  30  146.5  38.7333333  108.133333
1.2  43  94.3255814  31.6046512  65.1627907
1.3  6  77.6666667  24.8333333  53.8333333
1.5  1  104  1  104
3  20  70.85  32.15  43.05
4  28  152.75  62.8571429  93.6428572
5.1  4  24.75  11.5  16.25
5.3  4  163  109.75  58.75
6  27  46.4074074  27.9148148  24.2592593
PERIOD :-11.012  1  2  2  1  9  55  25  85  4
4  1  85  25  64
PERIOD :-11.0122  1.47222974  1.56410256  2.05769231  156  29.6538462  35.0833333  39.8846154  98.5320513  6.14102564
1.1  3  226.666667  51.3333333  175.333333
1.2  33  106.818182  31.6969696  75.1212121
1.3  4  140.5  63.25  80.5
```

```
3  21  83.047619  40.047619  43.5714286
4  25  177.933333  57.6666667  122.2
5.1  2  104.5  49.5  60.5
5.3  6  197.666667  66.5  139
6  14  83.9285714  31.1428572  58.8571429
PERIOD :-11.092  1.79310345  1.76551724  2.57241379  145  42.924138  39.9034483  50.9931035  129.751724  4.69655173
1.1  34  95.2647059  30.1764706  66.2941177
1.2  10  131.6  46.2  86.3
1.4  3  236.666667  104  130.333333
1.5  2  117.5  37.5  84
3  22  59.6818182  31.7727273  30.5
4  36  178.944444  71.6388889  113.611111
5.1  2  32  17.5  17
5.3  12  248.583333  100.583333  156.333333
6  18  74.0555556  33  48.3333333
```

SUMMARY FOR ALL ABOVE HOURS

218 → Aggregate time $\Sigma(T_D + T_U)$ in sec.

38 → Aggregate time $\Sigma T_G$ in sec

236 → Aggregate time $\Sigma T_M$ in sec

17 → No of messages

1 → Time interval 0 to 1 second

10 → >9 to 10 second

```
CLASS: 1.1
1  17  236  38  218
2  26  649  196  470
3  20  676  204  467
4  8  376  159  228
5  16  888  331  577
6  6  384  160  235
7  14  1060  375  682
8  11  933  332  588
9  10  941  443  544
10  7  739  248  501
11  9  1016  293  759
12  10  1236  330  916
13  6  793  330  473
14  6  853  402  469
15  2  300  52  249
20  24  4109  1235  2786
25  18  4037  1437  2637
30  10  2652  656  2001
35  1  318  92  228
40  4  1496  374  1133
45  2  851  141  713
65  3  2155  967  1209
CLASS: 1.2
1  13  214  42  190
2  32  808  228  619
3  26  892  224  685
4  31  1345  372  1025
5  21  1135  364  800
6  10  652  211  449
7  22  1617  495  1163
8  16  1369  458  926
9  21  1986  593  1420
10  17  1784  540  1281
11  19  2169  680  1559
12  14  1747  685  1145
13  13  1747  671  1143
14  10  1444  396  1070
15  1  150  21  128
20  41  7083  1855  5295
25  24  5454  1745  3754
30  18  4914  1362  3533
35  4  1257  229  1052
40  4  1482  466  1010
45  2  848  209  644
CLASS: 1.3
1  2  36  16  24
2  6  136  42  99
```

# PROGRAM LISTINGS

# MAGSTAT

```
FORTRAN IV      V01C-03        FRI 30-JUN-78 10:14:09          PAGE 001
CORE=15K, UIC=[2,10]                              MAG3:50,LP:/LI:SRC=MAG3:50

        C
        C      TITLE MAGTAPE TRANSLATOR       MAGSTAT
        C
        C      VERSION 002
        C
        C      MAG TAPE READ AND TRANSLATE PROGRAM
        C        TO COLLECT BASIC STATISTICS ON MESSAGE
        C        OCCURENCE, TYPE AND DURATION. IT WILL
        C        PROCESS ONE OR MORE FILES ON ONE OR MORE
        C        TAPES, MAINTAINING STATISTICS FOR EACH FILE
        C        AS WELL AGGREGATE STATS.
        C          NOTE- WHEN MOUNTING SECOND TAPE OR SUBSEQUANT
        C        TAPES, MOUNT TAPE BEFORE ANSWERING PROMPT 'ENTER (0=STOP    '
        C
        C
        C      PROGRAM FUNCTION:
        C          TO CONVERT BLOCKED MAGTAPES PRODUCED BY THE
        C      MRDSII-A MAGTAPE TASK PROGRAM NUMBER XX-XX-XXXR00
        C      INTO UNPACKED INTEGER VECTORS. 1024 BYTE FIXED
        C      LENGTH RECORDS ARE READ FROM THE TAPE. THE FIRST
        C      FOUR BYTES ARE ASCII DECIMAL DISTANCE TO THE
        C      FIRST VALID SFH. THIS IS USED FOR RESYNCHRONIZATION
        C      IF A BLOCK IS LOST.
        C
        C          THE TAPE CONTAINS 3 KINDS OF
        C      TRANSACTIONS:
        C          1) MESSAGE BUFFER QUEUE DATA
        C          -VARIABLE LENGTH DATA
        C          2) CHANNEL REQUEST QUEUE DATA
        C          -FIXED LENGTH ERROR CONDITION CODES
        C          3) NULL DATA
        C          -USED TO FILL OUT FIXED LENGTH
        C           RECORDS ON END OF FILE.
        C          TYPES 1 AND 2 ARE PUT INTO THE
        C      DATA VECTOR WITH NO PROCESSING EXCEPT
        C      EXTRACTION OF THE SFH. THE SFH IS
        C      PLACED IN THE SFH VECTOR INTEGER ALIGNED.
        C      A TYPE 3 MESSAGE CAUSES A SKIP TO
        C      THE NEXT RECORD.
        C
        C      OPERATING RESTRICTIONS:
        C
        C          THE FILE OPEN, GETBYTE AND
        C      PUTBYTE ROUTINES ARE OPERATING SYSTEM
        C      DEPENDENT, CURRENTLY CONFIGURED TO RUN
        C      UNDER RSX11M.
        C
        C
        C
        C      DATA STRUCTURES:
        C
        C      FILENAMES:
 0001          INTEGER  FNAME(16), FNUM
 0002          DATA FNAME(1)/'MT'/,FNAME(2)/'1'/
```

```
FORTRAN IV      V01C-03          FRI 30-JUN-78 10:14:09          PAGE 002
CORE=15K, UIC=[2,10]                               MAG3;50,LP:/LI:SRC=MAG3;50

0003          INTEGER LIST(2)
0004          DATA LIST(1)/'TI'/,LIST(2)/':'/
        C
        C     SFHVECTOR,DATAVECTOR,MAGTAPE BUFFER
        C
0005          INTEGER  SFHVEC(18),DATVEC(1680),MAGBUF(1024)
        C
        C     BYTE INDEX INTO MAGTAPE BUFFER,CONDITION CODE
        C
0006          INTEGER INDEX,CONDIT
0007          DATA        INDEX/4/, CONDIT/3/
        C
        C     MAGTAPE,CONSOLE LOGICAL UNIT NUMBERS
        C
0008          INTEGER MAGLUN, CONLUN
0009          DATA        MAGLUN/1/, CONLUN/5/, LISLUN/6/
        C
        C     CONDITION CODE VALUES:
        C
        C     A) TRANSACTION COMPLETE
        C     B) TRANSACTION NOT COMPLETE
        C     C) ERROR IN TRANSLATION
        C     D) RESYNCH REQUIRED
        C     E) IN THE SFH
        C     F) IN DATA
        C
0010          INTEGER CMPLT, NCMPLT, MAGERR, RESYNC, MAGSIZ
0011          INTEGER INSFH, INDATA, CURSIZ, CURBYT
0012          DATA        CMPLT/1/, NCMPLT/2/, MAGERR/-1/, RESYNC/3/
0013          DATA        INSFH/4/, INDATA/5/, CURSIZ/0/, CURBYT/0/
        C
        C     MAG TAPE BUFFERSIZE IN BYTES
        C
0014          DATA        MAGSIZ/2048/
        C
        C     IO RELATED DECLARATIONS
        C
0015          INTEGER QIOFLG, IORLB, DSW, EOF, EOT, IOST(2), IOPAR(6)
0016          INTEGER SKIP
0017            REAL CSUM(85),CSUM2(85),SUM(85),SUM2(85)
0018            INTEGER CNUM(85),NUM(85),OCC(12,85),COCC(12,85)
            1   ,TTOCC(11),UNIT(100),TOCC(11)
0019          DATA        QIOFLG/1/, IORLB/512/, EOF/'366/, EOT/'302/
        C
        C     COMMON BLOCK
        C
0020          COMMON CMPLT, NCMPLT, MAGERR, RESYNC, MAGSIZ
0021          COMMON INSFH, INDATA, CURSIZ, CURBYT, CONDIT
0022          COMMON /IOCOM/ IORLB, MAGLUN, QIOFLG, IOST, IOPAR, DSW, LISLUN
        C
        C     STARTUP ENTRY:
        C
0023          CALL GETADR(IOPAR(1),MAGBUF(1))
0024          IOPAR(2) =  2048
```

```
FORTRAN IV      V01C-03        FRI 30-JUN-78 10:14:09        PAGE 003
CORE=15K, UIC=[2,10]                               MAG3;50,LP:/LI:SRC=MAG3;50

0025           IOPAR(3) =  0
0026           IOPAR(4) =  0
0027           IOPAR(5) =  0
0028           IOPAR(6) =  0
        C
        C      PROMPT FOR MAGTAPE FILE NUMBER:
        C
0029           WRITE(CONLUN,90)
0030    90     FORMAT(' MAGTAPE PROGRAM VERSION 002 - STATS')
        C
        C      GET THE LISTING DEVICE
        C
0031           WRITE(CONLUN, 112)
0032    112    FORMAT(' ENTER LISTING DEVICE:')
0033             IFIRST=1
0034           READ(CONLUN, 114) (LIST(I), I=1,2)
0035    114    FORMAT(2A2)
        C
        C      OPEN MAG TAPE FOR READING
        C
0036           CALL OPEN(MAGLUN, FNAME)
0037           IF (MAGLUN .LT. 0) GO TO 8
        C
        C      OPEN LIST DEVICE
        C
0039           CALL OPEN(LISLUN, LIST)
0040           IF (LISLUN .LT. 0) GO TO 8
0042           GO TO 14
0043    8      CONTINUE
0044           WRITE(CONLUN,115)MAGLUN
0045    115    FORMAT(' ERROR IN FILEOPEN:',I5)
0046           CALL EXIT
0047    14       WRITE(5,131)
0048    131      FORMAT(' ENTER (0=STOP, 1=NEXT FILE ,N=SKIP N FILES(READ NTH)
              1, -N=MOUNT NEW TAPE READ NTH FILE)')
0049             READ (5,132)N
0050    132      FORMAT(I3)
0051             IF(N.EQ.0)GOTO153
0053             IF(N.LT.0)IFIRST=1
0055             FNUM=IABS(N)-1
0056             CONDIT=3
0057             INDEX=4
0058             CURBYT=0
0059             CURSIZ=0
        C
        C      SKIP N FILES
        C
0060    15     IF (SKIP(FNUM,MAGBUF,IFIRST) .LT. 0) GO TO 30
        C
        C LOOP UNTIL END OF FILE
        C
0062             IFIRST=0
0063             WRITE(5,17)
0064    17       FORMAT( ' PROCESS=1, SKIP=0')
```

```
FORTRAN IV      V01C-03         FRI 30-JUN-78 10:14:09          PAGE 004
CORE=15K, UIC=[2,10]                                MAG3;50,LP:/LI:SRC=MAG3;50

0065              READ(5,18)ISKIP
0066  18          FORMAT(I2)
0067                IF(ISKIP.EQ.0)GOTO10
0069  10        CALL WTQIO(IORLB, MAGLUN, QIOFLG,, IOST, IOPAR, DSW)
0070            IF (DSW .NE. 1) GO TO 30
0072              IF(IOST(1).EQ.EOF.AND.ISKIP.EQ.0)GOTO210
0074            IF (IOST(1) .EQ. EOF) GO TO 20
0076              IF(IOST(1).EQ.EOT.AND.ISKIP.EQ.0)GOTO10
0078                IF (IOST(1) .EQ. EOT) GO TO 40
0080            IF (IOST(1) .NE. 1) GO TO 30
0082              IF(ISKIP.EQ.0)GOTOIO
0084            GO TO 40
      C
      C END OF FILE ENCOUNTERED
      C
0085  20        WRITE(CONLUN,130)
0086  130       FORMAT(' FILE TRANSLATION COMPLETE')
0087              WRITE(6,209)
0088  209         FORMAT('     TYPE       NUM      MEAN       S.D.     <.11  <.21',
             1' <.31  <.41  <.51  <.61  <.71  <.81  <1.4  <2.1  >2.1')
0089              DO 200 J=1,84
0090              IF(NUM(J).EQ.0)GOTO200
0092              WRITE(6,201)J,NUM(J)
             1,SUM(J)/NUM(J),SQRT(ABS(SUM2(J)/NUM(J)-(SUM(J)/NUM(J))**2))
             2,(OCC(K,J),K=1,11)
0093  201         FORMAT(2I8,2F10.2,12I6)
0094              NTN=NTN+NUM(J)
0095              TS=TS+SUM(J)
0096              NUM(J)=0
0097              SUM2(J)=0
0098              DO 202 K=1,11
0099              TOCC(K)=TOCC(K)+OCC(K,J)
0100  202         OCC(K,J)=0
0101              SUM(J)=0.
0102  200         CONTINUE
0103              WRITE(6,205)NTN,TS/NTN,(TOCC(K),K=1,11),NUNITS
0104  205         FORMAT(8X,I8,F10.2,10X,12I6,'( NO. OF UNITS)')
0105              NUNITS=0
0106              UNIT(1)=0
0107              WRITE(6,154)
0108  154         FORMAT(1H1,////,' SUMMARY STATISTICS FOR ALL FILES'///)
0109              WRITE(6,209)
0110              DO 152 J=1,84
0111              IF(CNUM(J).EQ.0)GOTO152
0113              NNTN=NNTN+NTN
0114              TTS=TTS+TS
0115              TS=0
0116              NTN=0
0117              DO 206 K=1,11
0118              TTOCC(K)=TTOCC(K)+TOCC(K)
0119  206         TOCC(K)=0
0120              WRITE(6,201)J,CNUM(J)
             1,CSUM(J)/CNUM(J),SQRT(ABS(CSUM2(J)/CNUM(J)-(CSUM(J)/CNUM(J))**2))
             2,(COCC(K,J),K=1,11)
```

```
FORTRAN IV      V01C-03          FRI 30-JUN-78 10:14:09          PAGE 005
CORE=15K, UIC=[2,10]                                   MAG3;50,LP:/LI:SRC=MAG3;50

0121  152     CONTINUE
0122          WRITE(6,205)NNTN,TTS/NNTN,(TTOCC(K),K=1,11)
0123  210     CALL WTQIO(IORLB,MAGLUN,QIOFLG,,IOST,IOPAR,DSW)
0124          IF(DSW.NE.1)GOTO14
0126          IF(IOST(1).NE.EOF)GOTO210
0128          GOTO14
0129  153     WRITE(6,111)
0130  111     FORMAT(' THATS ALL FOLKS')
0131          CALL EXIT
      C
      C ERROR ENTRY
      C
0132  30    WRITE(CONLUN,140) IOST(1), IOST(2), DSW
0133  140   FORMAT(' FATAL READ ERROR:',O5, O5,'  DSW=',I5)
0134        CALL EXIT
      C
      C LOOP THROUGH RECORD A TRANSACTION AT A TIME
      C
0135  40    CALL TRANS(MAGBUF,SFHVEC,DATVEC,INDEX)
      C
      C ON ERROR EXIT
      C
0136        IF (CONDIT.NE.MAGERR) GO TO 50
0138        WRITE(CONLUN,160)MAGERR
0139  160   FORMAT(' ERROR IN TRANSLATION:',I5)
0140        CALL EXIT
      C
      C IF TRANSLATION NOT COMPLETE GET NEW RECORD
      C
0141  50    IF(CONDIT.NE.CMPLT) GO TO 10
      C
      C INSERT USER ROUTINE HERE:
      C
0143          J=SFHVEC(1)
0144          IF(SFHVEC(2).NE.0)J=SFHVEC(2)
      C   COUNT NO. OF DISCRETE UNITS THIS HOUR.
0146          DO 69 I=1,NUNITS
0147          IF(SFHVEC(15).EQ.UNIT(I))GOTO70
0149  69      CONTINUE
0150          NUNITS=NUNITS+1
0151          UNIT(NUNITS)=SFHVEC(15)
0152  70      CONTINUE
0153          IF(J.GT.84.OR.J.LT.1)GOTO77
0155          NBLKS=SFHVEC(18)/45
0156          IF(J.EQ.4.OR.J.EQ.24.OR.J.EQ.46.OR.J.EQ.47)GOTO76
0158          X=(NBLKS+1)*.092+.103
0159          GOTO75
0160  76      X=.103
0161  75      CONTINUE
0162          SUM(J)=SUM(J)+X
0163          NUM(J)=NUM(J)+1
0164          CSUM(J)=CSUM(J)+X
0165          CNUM(J)=CNUM(J)+1
0166          SUM2(J)=SUM2(J)+X*X
```

```
FORTRAN IV      V01C-03          FRI 30-JUN-78 10:14:09          PAGE 006
CORE=15K, UIC=[2,10]                                    MAG3;50,LP:/LI:SRC=MAG3;50

0167           CSUM2(J)=CSUM2(J)+X*X
0168           IR=X/.1+.9
0169           IF(X.GT..81.AND.X.LE.1.4)IR=9
0171           IF(X.GT.1.4.AND.X.LE.2.1)IR=10
0173           IF(X.GT.2.1)IR=11
0175           OCC(IR,J)=OCC(IR,J)+1
0176           COCC(IR,J)=COCC(IR,J)+1
0177   77      CONTINUE
       C LOOP TO NEXT TRANSACTION
       C
0178         IF (INDEX .LT. MAGSIZ) GO TO 40
0180         CONDIT = RESYNC
0181         GO TO 10
0182         CALL EXIT
0183         END
```

```
FORTRAN IV      V01C-03         FRI 30-JUN-78 10:16:35          PAGE 001
CORE=15K, UIC=[2,10]                         MAG3;50,LP:/LI:SRC=MAG3;50

      C      SUBROUTINE-TRANS   PERFORM TRANSLATION OF ONE TRANSACTION
      C
      C      TRANS A SUBROUTINE TO TRANSLATE ONE TRANSACTION
      C         FROM BYTE PACKED, BLOCKED MAGTAPE FORMAT
      C         TO AN INTEGER ALIGNED SFH, AND DATA
      C         VECTOR.
      C
      C      SETUP NONE
      C
      C      CALL  CALL TRANS(MAGTAPEBUFFER,SFHVECTOR,DATAVECTOR)
      C
      C      NOTES:
      C      RETURNS:
      C      CONDITION = TRANSACTION NOT COMPLETE
      C            = TRANSACTION COMPLETE
      C
      C
0001         SUBROUTINE TRANS(MAGBUF,SFHVEC,DATVEC,INDEX)
0002         INTEGER CONDIT, ZERO, INDEX
0003         INTEGER MAGBUF(1024), SFHVEC(18), DATVEC(1680), GETBYT
0004         INTEGER CMPLT, NCMPLT, MAGERR, RESYNC, MAGSIZ
0005         INTEGER INSFH, INDATA, CURSIZ, CURBYT
0006         INTEGER LISLUN
0007         DATA       ZERO/48/
0008         DATA LISLUN/6/
0009         DATA NULFUN /'255/
0010         COMMON CMPLT, NCMPLT, MAGERR, RESYNC, MAGSIZ
0011         COMMON INSFH, INDATA, CURSIZ, CURBYT, CONDIT
      C
      C
0012         IF(CONDIT.NE.RESYNC) GO TO 10
0014         INDEX=0
0015         DO 5 I=3,0,-1
0016           INDEX = INDEX*10+GETBYT(MAGBUF,I)-ZERO
0017  5      CONTINUE
      C
      C      SET INDEX AROUND THE SEQUENCE DIGITS
      C
0018         INDEX = INDEX + 4
0019  10     CONTINUE
0020         IF (CONDIT .EQ. INDATA) GO TO 30
      C
      C      UNPACK SFH
      C
0022         CALL UNPSFH(MAGBUF,SFHVEC,INDEX)
      C
      C      NULL HEADER
      C
0023         IF ( (SFHVEC(1) .EQ. NULFUN) .AND.
            *      (SFHVEC(2) .EQ. NULFUN) ) GO TO 11
0025         GO TO 15
0026  11     CONDIT = NCMPLT
0027         RETURN
0028  15     CONTINUE
```

```
FORTRAN IV      V01C-03         FRI 30-JUN-78 10:16:35          PAGE 002
CORE=15K, UIC=[2,10]                            MA03;50,LP:/LI:SRC=MAG3;50

0029            IF (CONDIT .NE. CMPLT) GO TO 20
0031            GO TO 30
0032      20    INDEX = 4
0033            RETURN
          C
          C     UNPACK THE DATA
          C
0034      30    CALL UNPDAT(MAGBUF,DATVEC,INDEX,SFHVEC(18))
0035            IF (CONDIT .NE. CMPLT) INDEX = 4
0037            RETURN
0038            END
```

```
FORTRAN IV      V01C-03         FRI 30-JUN-78 10:17:01          PAGE 001
CORE=15K, UIC=[2,10]                            MAG3:50,LP:/LI:SRC=MAG3:50

              C     SUBROUTINE UNPSFH -- UNPACK SFH
              C
              C     UNPSFH A SUBROUTINE TO UNPACK A STANDARD
              C         FUNCTION HEADER INTO AN INTEGER
              C         ARRAY
              C
              C     SETUP NONE
              C
              C     CALL UNPSFH(MAGBUF,SFHVEC,INDEX)
              C
              C
0001                SUBROUTINE UNPSFH(MAGBUF,SFHVEC,INDEX)
              C
              C
0002                INTEGER     MAGBUF(1024), SFHVEC(18), INDEX
0003                INTEGER GETBYT, W
0004                DATA W/'W'/
0005                INTEGER CMPLT, NCMPLT, MAGERR, RESYNC, MAGSIZ
0006                INTEGER INSFH, INDATA, CURSIZ, CURBYT, CONDIT
0007                COMMON CMPLT, NCMPLT, MAGERR, RESYNC, MAGSIZ
0008                COMMON INSFH, INDATA, CURSIZ, CURBYT, CONDIT
              C
              C
0009                INTEGER TYPE(18)
0010                DATA TYPE/6*'BB',2*'WW',6*'BB',4*'WW'/
              C
0011                IF (CONDIT .EQ. INSFH) GO TO 20
0013                    CURSIZ = 18*2
0014                    CURBYT = 0
0015          20    CONTINUE
0016                CONDIT = INSFH
0017                J = CURBYT
0018                K = CURBYT + CURSIZ
              C
              C
0019                DO 10 I = J,K
0020                    CALL PUTBYT(SFHVEC,CURBYT,GETBYT(MAGBUF,INDEX))
0021                    IF (GETBYT(TYPE,CURBYT) .EQ. GETBYT(W,0)) GO TO 30
0023                            CURSIZ = CURSIZ - 2
0024                            CURBYT = CURBYT + 2
0025                            GO TO 40
0026          30        CONTINUE
0027                            CURSIZ = CURSIZ - 1
0028                            CURBYT = CURBYT + 1
0029          40        CONTINUE
0030                    INDEX = INDEX + 1
0031                    IF (INDEX .EQ. MAGSIZ) GO TO 1000
0033                    IF (CURSIZ .EQ. 0) GO TO 100
0035          10    CONTINUE
0036          100   CONTINUE
0037                CONDIT = CMPLT
0038                RETURN
0039          1000  IF (CURSIZ .NE. 0) RETURN
0041                CONDIT = INDATA
```

```
FORTRAN IV      V01C-03          FRI 30-JUN-78 10:17:26          PAGE 001
CORE=15K, UIC=[2,10]                         MAG3;50,LP:/LI:SRC=MAG3;50

              C
              C
0001          SUBROUTINE UNPDAT(MAGBUF,DATVEC,INDEX,SIZE)
0002          INTEGER  MAGBUF(1024)
0003          INTEGER  DATVEC(1680)
0004          INTEGER  INDEX,SIZE
0005          INTEGER     GETBYT
0006          INTEGER CMPLT, NCMPLT, MAGERR, RESYNC, MAGSIZ
0007          INTEGER INSFH, INDATA, CURSIZ, CURBYT, CONDIT
0008          COMMON CMPLT, NCMPLT, MAGERR, RESYNC, MAGSIZ
0009          COMMON INSFH, INDATA, CURSIZ, CURBYT, CONDIT
              C
              C
0010          IF (SIZE .EQ. 0) GO TO 100
0012          IF (CONDIT .EQ. INDATA) GOTO 10
0014              CURBYT = 0
0015              CURSIZ = SIZE
0016    10    CONTINUE
0017          CONDIT = INDATA
0018          J = CURBYT
0019          K = CURBYT + CURSIZ - 1
              C
              C
0020          DO 20 I = J,K
0021              CALL PUTBYT(DATVEC,I,GETBYT(MAGBUF,INDEX))
0022              INDEX = INDEX + 1
0023              CURBYT = CURBYT + 1
0024              CURSIZ = CURSIZ - 1
0025              IF (CURSIZ .EQ. 0) GO TO 100
0027              IF (INDEX .EQ. MAGSIZ) RETURN
0029    20    CONTINUE
0030    100   CONTINUE
0031          CONDIT = CMPLT
0032          RETURN
0033          END
```

```
FORTRAN IV      V01C-03         FRI 30-JUN-78 10:17:41          PAGE 001
CORE=15K, UIC=[2,10]                                  MAG3;50,LP:/LI:SRC=MAG3;50

      C     SUBROUTINE-OPEN -- OPEN-A-FILE
      C
      C     OPEN A SUBROUTINE TO OPEN A FILE
      C
      C     SETUP NAME=FILENAME IN ASCII TERMINATED
      C         BY A NULL CHARACTER
      C         LUN=THE LUN TO USE
      C
      C     CALL  CALL OPEN(NAME,LUN)
      C
      C     NOTES:
      C     LUN RETURNS < 0 AND
      C         EQUAL TO ERROR CONDITION
      C         IF OPEN FAILS.
      C         HIGHLY OPERATING SYSTEM DEPENDENT
      C
      C
0001        SUBROUTINE OPEN(LUN, NAME)
      C
      C
0002        INTEGER     NAME(16), LUN
      C
      C CLEAR ERROR FLAGS
      C
0003        CALL ERRSNS
0004        CALL ASSIGN(LUN,NAME)
0005        CALL FDBSET(LUN,'READONLY')
0006        CALL ERRSNS(IERR)
0007        IF(IERR.EQ.0) RETURN
0009        LUN=-IERR
0010        RETURN
0011        END
```

```
FORTRAN IV      V01C-03         FRI 30-JUN-78 10:17:53          PAGE 001
CORE=15K, UIC=[2,10]                                MAG3;50,LP:/LI:SRC=MAG3;50

      C
      C      SKIP 'NUMBER' FILES ON THE TAPE
      C
0001         INTEGER FUNCTION SKIP(NUMBER,MAGBUF,IFIRST)
0002         INTEGER MAGBUF(1024)
0003         INTEGER NUMBER, LISLUN
0004         INTEGER IORLB, MAGLUN, QIOFLG, IOST(2), IOPAR(6), DSW
0005         INTEGER EOF
0006         DATA  EOF/"366/
0007         DATA LISLUN /6/
0008         COMMON /IOCOM/ IORLB, MAGLUN, QIOFLG,IOST, IOPAR, DSW
      C
      C      GET RID OF VOLUME LABEL
0009           IF(IFIRST.EQ.0)GOTO7
      C
0011         CALL WTQIO(IORLB,MAGLUN,QIOFLG,,IOST,IOPAR,DSW)
0012  7        CONTINUE
      C
      C      CHECK FOR FIRST FILE
      C
0013         IF (NUMBER .EQ. 0) GOTO 40
0015         DO 10 I = 1, NUMBER
      C
      C      THERE ARE THREE EOFS PER FILE
      C
0016             DO 20 J = 1,3
0017  30                 CALL WTQIO(IORLB,MAGLUN,QIOFLG,,IOST,IOPAR,DSW)
0018                     IF (DSW .NE. 1) GO TO 100
0020                     IF (IOST(1) .NE. EOF) GO TO 30
0022  20         CONTINUE
0023  10     CONTINUE
      C
      C      NOW GO OVER THE HEADERS
      C
0024  40     CONTINUE
0025         CALL WTQIO(IORLB,MAGLUN,QIOFLG,,IOST,IOPAR,DSW)
0026  200    FORMAT(1H1,///'-----------------LISTING OF FILE   ',7A2//)
0027            WRITE(LISLUN,200)(MAGBUF(I),I=3,9)
0028           WRITE(5,201)(MAGBUF(I),I=3,9)
0029  201      FORMAT(' FILE = ',7A2)
0030  50     CALL WTQIO(IORLB,MAGLUN,QIOFLG,,IOST,IOPAR,DSW)
0031         IF (DSW .NE. 1) GO TO 100
0033         IF (IOST(1) .NE. EOF) GO TO 50
0035  100    CONTINUE
0036         SKIP = DSW
0037         RETURN
0038         END
```

```
FORTRAN IV      V01C-03          FRI 30-JUN-78 10:18:26          PAGE 001
CORE=15K, UIC=[2,10]                                  MAG3:50,LP:/LI:SRC=MAG3:50

       C
       C FUNCTION GETBYT(ARRAY, BYTE,INDEX)
0001         INTEGER FUNCTION GETBYT(ARRAY, BYTE)
0002         INTEGER ARRAY(2000), BYTE
0003         INTEGER INDEX
       C
0004         INDEX = BYTE/2
0005           IF(INDEX.GE.2000)INDEX=I000
0007         GETBYT = ARRAY(INDEX+1)
0008         IF ( BYTE .NE. INDEX*2 ) GOTO 10
       C
       C         LOW ORDER BYTE
       C
0010             GETBYT = ISHFT(ISHFT(GETBYT,8),-8)
0011             GO TO 100
0012   10    CONTINUE
       C
       C         HIGH ORDER BYTE
       C
0013             GETBYT = ISHFT(GETBYT,-8)
       C
       C
0014   100   CONTINUE
0015             RETURN
0016         END
```

```
FORTRAN IV      V01C-03          FRI 30-JUN-78 10:18:14          PAGE 001
CORE=15K, UIC=[2,10]                          MAG3;50,LP:/LI:SRC=MAG3;50

      C
      C     SUBROUTINE 'MYROUTINE'
      C
      C       A ROUTINE TO EXTRACT HEADER DATA AND STORE IT
      C       EXTERNALLY FOR SUBSEQUENT ANALYSIS.
0001        SUBROUTINE MYROUT(SFHVEC, DATVEC,NXTAVL)
      C
0002        INTEGER      SFHVEC(18), DATVEC(1680)
0003        INTEGER      SIZE, LISLUN
0004        INTEGER CHAR, GETBYT, LITA, LITZ, BIGA, BIGZ
0005        INTEGER ZERO, NINE
0006        INTEGER BLANK
0007        INTEGER LOWER
0008        DATA LITA/'141/, LITZ/'172/, BIGA/'101/, BIGZ/'132/
0009        DATA ZERO/'060/, NINE/'071/
0010        DATA BLANK/'040/
0011        DATA         LISLUN/6/
      C
      C     WRITE THE SFH
      C
0012          NXTAVL=NXTAVL+1
0013          WRITE(3'NXTAVL)SFHVEC
0014          WRITE(LISLUN,100)(SFHVEC(I),I=9,14)
0015     100  FORMAT(6I4)
0016          RETURN
      C       EXIT FROM ROUTINE
0017          END
```

```
FORTRAN IV      V01C-03          FRI 30-JUN-78 10:18:35          PAGE 001
CORE=15K, UIC=[2,10]                                 MAG3;50,LP:/LI:SRC=MAG3;50

              C
              C      SUBROUTINE PUTBYT(ARRAY,BYTEINDEX, VALUE)
              C
0001                 SUBROUTINE PUTBYT(ARRAY, BYTE, VALUE)
0002                 INTEGER ARRAY(2000), BYTE, VALUE
0003                 INTEGER HIBYTE, LOBYTE, BYVAL, INDEX
0004                 INTEGER GETBYT
              C
              C
0005                 INDEX = BYTE/2
0006                 IF (INDEX*2 .NE. BYTE) GO TO  10
              C
              C      LOW ORDER BYTE
              C
0008                 HIBYTE = ISHFT(GETBYT(ARRAY,BYTE+1),8)
0009                 BYVAL  = ISHFT(ISHFT(VALUE,8),-8)
0010                 ARRAY(INDEX+1) = BYVAL + HIBYTE
0011                 RETURN
              C
              C      HIGH ORDER BYTE
              C
0012          10     CONTINUE
0013                 LOBYTE = GETBYT(ARRAY, BYTE-1)
0014                 BYVAL = ISHFT(VALUE, 8)
0015                 ARRAY(INDEX + 1) = BYVAL + LOBYTE
0016                 RETURN
0017                 END
```

# VOICEDAT

# VOICEDAT - ENTRY

```
]LIS

?SYNTAX ERROR
]LIST

2  DIM P$(30),UN$(15),AS$(15),ET(15),R$(15),CS(15)
5 MAXFILES = 5
7  ONERR  GOTO 50
10  HOME
20 B$ =  CHR$ (7)
25 BL$ = '
30 D$ =  CHR$ (4)
40  GOTO 80
50  HOME
55  VTAB 10: PRINT B$
60  PRINT "WRONG DISK DUMMY"
65  VTAB 12
70  GOTO 170
80  PRINT D$;"OPEN INDEX,L20,D1"
90  PRINT D$;"READ INDEX,R1"
100  INPUT NU$
110  INPUT DI$
120  INPUT TT$
130 NUM =  VAL (NU$)
140 DISK =  VAL (DI$)
150 TT =  VAL (TT$)
160  PRINT D$
170  PRINT "DISKETTE # ";DISK;" IS CURRENT"
180  PRINT "PLEASE LOAD IT IN UPPER DRIVE"
190  INPUT "WHEN READY- TYPE 'GO'";A$
200  PRINT D$;"OPEN FILE";DISK;",L150,D2"
210  PRINT D$,"READ FILE";DISK;",R1"
215  INPUT A$
217  PRINT D$
218  PRINT "CURRENT RECORD IS # ";NUM
219  INPUT "CONTINUE (Y/N)";A$: IF A$ = "N" GOTO 1250
220  HOME
225  POKE 216,0
230  INPUT "PAGE # ";PAG
240 I = 0
250  VTAB 3
260  INPUT "START HR,MIN,SEC ";H1,M1,S1
270  IF H1 < 0 OR H1 > 24 GOTO 310
280  IF M1 < 0 OR M1 > 60 GOTO 310
290  IF S1 < 0 OR S1 > 60 GOTO 310
300  GOTO 340
310  PRINT B$
320  GOTO 250
330  VTAB 4
340  INPUT "FINISH HR,MIN,SEC ";H2,M2,S2
350  IF H2 < 0 OR H2 > 24 GOTO 390
360  IF M2 < 0 OR M2 > 60 GOTO 390
370  IF S2 < 0 OR S2 > 60 GOTO 390
375 H1 = H1 + M1 / 60 + S1 / 3600
376 H2 = H2 + M2 / 60 + S2 / 3600
380  GOTO 410
390  PRINT B$
400  GOTO 330
410  VTAB 5
420  INPUT "TAPE # ";TN$
430  VTAB 5: HTAB 20: INPUT "CHANNEL # ";CH$
4[illegible]  VTAB 6
4[illegible]  INPUT "DAY (1-7) ";[illegible]
```

```
470  GOTO 430
480  REM  START
490 N = N + 1
500 ST$ = "NEW"
510 I = 0
511  VTAB 17: PRINT BL$
512  VTAB 15: PRINT BL$
513  VTAB 21: PRINT BL$
514  VTAB 18: PRINT BL$
515  VTAB 16: PRINT BL$
516  VTAB 10: PRINT BL$
517  VTAB 12: PRINT BL$
518  VTAB 14: PRINT BL$
519  VTAB 22
520  PRINT "RECORD # ";N;"    PAGE # ";PAGE
530  VTAB 21: PRINT "            "
540  VTAB 10: INPUT "UNIT # (OR STOP) ";UN$(N)
550 FL = I * 6 + 1
560  IF UN$(N) = "STOP" GOTO 900
570  HTAB 1
575  HTAB 30: VTAB 23: PRINT "FLD# ";I + 1
580  VTAB 12: HTAB FL
590  INPUT "";S$
600  IF S$ = "X" THEN I = 0: GOTO 780
610  IF S$ = "D" OR S$ = "DONE" GOTO 855
615  IF  LEN (S$) < 2 GOTO 700
620 LF$ =  RIGHT$ (S$,1)
630  IF LF$ = "7" OR LF$ = "8" OR LF$ = "9" GOTO 680
635  IF LF$ = "U" OR LF$ = "G" OR LF$ = "D" GOTO 690
640  PRINT B$
650  VTAB 21
655  FLASH
660  PRINT ".7 .8 OR .9 ??"
665  NORMAL
670  GOTO 550
680 T =  VAL ( LEFT$ (S$, LEN (S$) - 1))
690  IF T > 0 AND T < 999 GOTO 740
700  PRINT B$
710  VTAB 21
715  FLASH
720  PRINT "BAD NUMBER       "
725  NORMAL
730  GOTO 570
740  REM  FIX OR NEW
742  VTAB 21: NORMAL : PRINT BL$
750 F$(I) = S$
751 F$(I + 1) = ""
770 I = I + 1
780  GOTO 550
830  VTAB 21
840  PRINT BL$
850  GOTO 550
855  VTAB 21: PRINT BL$
860  VTAB 14: INPUT "ASSOC (A OR CR)";AS$(N)
865  IF  LEN (AS$(N)) < 2 GOTO 870
867  PRINT B$: GOTO 860
870  VTAB 16: INPUT "CLASS ";CL
875  GOTO 1220
880  VTAB 19: INPUT "ELAPSED TIME ";ET(N)
881 F$(N) = ""
882  FOR I = 0 TO 30
883  IF F$(I) = "" GOTO 890
884 F$(N) = F$(N) + " " + F$(I)
885  NEXT I
[illegible]
```

```
901  IF N = 0 GOTO 1250
902  IF H1 > H2 GOTO 920
910  GOTO 940
920 H2 = 24 + H2
930 SPLIT = 1
940  PRINT D$;"OPEN FILE";DISK;",L150,D2"
950  FOR J = 1 TO N
955 NJ = NUM + J
960  PRINT D$;"WRITE FILE";DISK;",R";NJ
970 H = (H2 - H1) / N * J + H1
980  IF H < 24 GOTO 1000
990 DA = DA + 1
991  IF DA > 7:DA = 1
995 H = H - 24
1000  PRINT TN$: PRINT  STR$ (DA): PRINT  STR$ (H)
1010  PRINT DN$(J): PRINT R$(J): PRINT AS$(J)
1020  PRINT  STR$ (CS(J)): PRINT  STR$ (ET(J))
1025  PRINT CH$
1030  NEXT J
1040  PRINT D$;"CLOSE DISK1"
1050  VTAB 21
1060  INPUT "ANOTHER PAGE (Y/N)";P$
1065 EN = 0
1070  IF P$ = "NO" OR P$ = "N" THEN EN = 1
1080 NUM = NUM + N
1085 TT = TT + N
1090 N = 0
1091  FOR K = 1 TO 30
1092 F$(K) = ""
1093  NEXT K
1120  IF NUM > 500 GOTO 1185
1130  PRINT D$;"OPEN INDEX,L20,D1"
1140  PRINT D$;"WRITE INDEX,R1"
1150  PRINT  STR$ (NUM): PRINT  STR$ (DISK)
1160  PRINT  STR$ (TT)
1170  PRINT D$
1180  IF EN = 1 GOTO 1250
1181  GOTO 220
1185  PRINT D$;"OPEN INDEX,L20,D1"
1186  PRINT D$;"WRITE INDEX,R1"
1190  PRINT "0": PRINT  STR$ (DISK + 1)
1200  PRINT  STR$ (TT)
1210  PRINT D$
1220  VTAB 19
1230  PRINT "DISKETTE # ";DISK;" IS FULL"
1240  PRINT "REMEMBER TO USE DISK ";DISK + 1;" NEXT TIME"
1245  GOTO 1251
1250  HOME
1251  VTAB 10: HTAB 10: PRINT "THAT'S ALL FOLKS"
1260  GOTO 1360
1280  REM  CHECK CLASS
1290  IF CL = 1 OR CL = 1.1 OR CL = 1.2 OR CL = 2 OR CL = 3 OR CL = 4 GOTO 1340
1295  IF CL = 1.3 GOTO 1340
1300  IF CL = 5.1 OR CL = 5.2 OR CL = 5.3 OR CL = 6 GOTO 1340
1301  IF CL = 1.4 OR CL = 1.5 OR CL = 1.6 OR CL = 1.7 OR CL = 1.8 OR CL = 1.9 GOTO 1340
1310  REM
1315  PRINT B$
1317  VTAB 21
1320  PRINT " CLASS ERROR
1330  GOTO 870
1340 CS(N) = CL
1345  VTAB 21: PRINT BL$
1350  GOTO 880
1360  END
```

```
]
]PRINT"
```

# VOICEDAT - LIST

```
]LIST

5  ONERR  GOTO 1000
10 DS$ =  CHR$ (4)
30  PRINT DS$;"OPEN FILE1,L150,D2"
35  FOR I = 1 TO 1000
40  PRINT DS$;"READ FILE1,R";I
50  INPUT A$
60  INPUT B$
70  INPUT C$
80  INPUT DD$
90  INPUT E$
100  INPUT F$
110  INPUT G$
120  INPUT H$
125  INPUT I$
126 U = 0:G = 0:D = 0
127  GOSUB 1270
129  IF  ABS ( VAL (H$) * 10 - D - U - G) / (D + U + G) > .2 THEN H$ = "***" + H$
130  PRINT  TAB( 1); RIGHT$ ("  " +  STR$ (I),3);
135 DD$ =  RIGHT$ ("      " + DD$,6)
140  PRINT  TAB( 5);DD$;: REM  UNIT NO.
150  PRINT  TAB( 10);A$;: REM  DATE
155 C$ =  RIGHT$ ("  " + C$,11)
160  PRINT  TAB( 13);C$;: REM  DECIMAL HDLR
165 G$ =  RIGHT$ ("   " + G$,4)
170  PRINT  TAB( 13);G$;: REM  CLASS
175 H$ =  RIGHT$ ("    " + H$,5)
180  PRINT  TAB( 6);H$;: REM  ELAPSED TIME
190  PRINT  TAB( 6);I$;: REM  CHANNEL
195 F$ =  RIGHT$ ("  " + F$,2)
200  PRINT  TAB( 3);F$;: REM  ASSOC
210  PRINT  TAB( 3);B$;: REM  DAY
215 E$ =  RIGHT$ ("     " +  STR$ (U),5) +  RIGHT$ ("     " +  STR$ (G),5) +  RIGHT$ ("     " +  STR$ (D),5
220  PRINT  TAB( 3);E$: REM  MESSAGE FLOW
900  NEXT I
1000  IF  PEEK (222) = 5 THEN  PRINT "END OF DATA": STOP
1010  PRINT "WHOOPS- SOMETHINGS WRONG": STOP
1270 EN =  LEN (E$)
1280  FOR J = 1 TO EN
1290 CH$ =  MID$ (E$,J,1)
1300  IF CH$ = " " GOTO 1330
1310 ST$ = ST$ + CH$
1315  IF J = EN GOTO 1330
1320  GOTO 1380
1330 LA$ =  RIGHT$ (ST$,1)
1335 AM$ =  LEFT$ (ST$, LEN (ST$) - 1)
1340  IF LA$ = "7" OR LA$ = "U" THEN U = U +  VAL (AM$): GOTO 1370
1350  IF LA$ = "8" OR LA$ = "G" THEN G = G +  VAL (AM$): GOTO 1370
1360  IF LA$ = "9" OR LA$ = "D" THEN D = D +  VAL (AM$): GOTO 1370
1370 ST$ = ""
1380  NEXT J
1390 ST$ = ""
1400  RETURN
6969  END

]
]PRINT"
```

# VOICEDAT - FIXER

```
]LIS

?SYNTAX ERROR
]LIST

4 R$(1) = "DATE":R$(3) = "HOUR":R$(7) = "CLASS":R$(8) = "ELAPSED TIME":R$(9) = "CHANNEL"
5 D$ =  CHR$ (4)
10  INPUT "RECORD #";REC%
20  PRINT D$;"OPEN FILE1,L150,D2"
30  PRINT D$;"READ FILE1,R";REC%
35  FOR I = 1 TO 9
40  INPUT A$(I)
45  NEXT I
50  PRINT D$;"CLOSE FILE1"
55  FOR I = 1 TO 9
60  PRINT I,A$(I)
70  NEXT I
80  INPUT "CORRECT RECORD (Y/N)";Y$
90  IF Y$ = "N" OR Y$ = "NO" GOTO 10
95  IF Y$ = "STOP" OR Y$ = "END" THEN  STOP
100  REM  CORRECT RECD
110  INPUT "WHICH ITEM(1....9)";N
120  IF N < 1 OR N > 9 GOTO 110
130  INPUT "ENTRY";E$
140  PRINT E$
150  INPUT "OK";Y$
160  IF Y$ = "N" OR Y$ = "NO" GOTO 110
170 A$(N) = E$
175  PRINT D$;"OPEN FILE1,L150,D2"
180  PRINT D$;"WRITE FILE1,R";REC%
190  FOR I = 1 TO 9
200  PRINT A$(I)
210  NEXT I
220  PRINT D$;"CLOSE FILE1"
230  INPUT "MORE";Y$
240  IF Y$ = "Y" OR Y$ = "YES" GOTO 10
250  PRINT "FINISHED"
260  STOP
500  IF  PEEK (222) = 5 THEN  PRINT "PAST END FILE": PRINT D$;"CLOSE FILE1": GOTO 10
510  PRINT D$;"CLOSE FILE1": PRINT "FATAL ERROR": STOP
```

# VOICEDAT - REPORT

[illegible]

```
]LIST

1  DIM NL(25),TL(25),TG(25),TD(25)
20 DS$ =  CHR$ (4)
30 T$ = "  "
40  DIM DT%(30),UT%(30),GT%(30)
50  DIM U%(30),D%(30),G%(30)
60  DIM TM%(30),DL%(30),NM%(30)
70  DIM NL%(12,25),TG%(12,25)
75  DIM TL%(12,25)
80  DIM TD%(12,25),NC%(30,12),NT%(30,12),ND%(30,12),NU%(30,12)
100  DIM R1(30),R2(30)
110  DIM R1$(30),R2$(30)
130  DIM C$(12)
132  INPUT "YEAR(80/82)";Y$
133  INPUT "CHANNEL(1/3)";CN$
140  FOR I = 0 TO 12
150  READ C$(I)
160  NEXT I
170  DATA  "1","1.1","1.2","1.3","1.4","1.5","2","3","4","5.1","5.2","5.3","6"
180  PRINT DS$;"OPEN FILE1,L150,D2"
185  INPUT "START,FINISH";I1,I2
190  FOR I = I1 TO I2
200  PRINT DS$;"READ FILE1,R";I
210  INPUT A$: REM  TAPE #
220  INPUT B$: REM  DAY
230  INPUT C$: REM  HR
240  INPUT DD$: REM  UNIT
250  INPUT E$: REM  MESSAGE STREAM
260  INPUT F$: REM  ASSOC
270  INPUT G$: REM  CLASS
280  INPUT H$: REM  ELAPSED TIME
290  INPUT I$: REM  CHANNEL
295  IF I$ <  > CN$ GOTO 790
300 HR =  VAL (C$):DA =  VAL (B$):HR = HR - .0001
310 PR$ =  RIGHT$ (A$,5) +  STR$ ( INT (HR))
320  IF  LEFT$ (A$,2) <  > Y$ GOTO 790
350 U = 0:G = 0:D = 0
360 NU = 0:NE = 0:ND = 0
370 G =  VAL (G$)
380  IF G = 1 THEN IC = 1: GOTO 520
390  IF G = 1.1 THEN IC = 1: GOTO 520
400  IF G = 1.2 THEN IC = 2: GOTO 520
410  IF G = 1.3 THEN IC = 3: GOTO 520
420  IF G = 1.4 THEN IC = 4: GOTO 520
430  IF G = 1.5 THEN IC = 5: GOTO 520
440  IF G = 2 THEN IC = 6: GOTO 520
450  IF G = 3 THEN IC = 7: GOTO 520
460  IF G = 4 THEN IC = 8: GOTO 520
470  IF G = 5.1 THEN IC = 9: GOTO 520
480  IF G = 5.2 THEN IC = 10: GOTO 520
490  IF G = 5.3 THEN IC = 11: GOTO 520
500  IF G = 6 THEN IC = 12: GOTO 520
510  GOTO 790
```

```
520  GOSUB 810
570  GOSUB 1440
580  IF K = 0 GOTO 790
590 PR = K
600 L = (D + U) / 10
610  IF L > 15 THEN L = L / 5 + 13
620  IF L > 25 THEN L = 25
630 DT%(PR) = DT%(PR) + ND
640 UT%(PR) = UT%(PR) + NU
650 GT%(PR) = GT%(PR) + NG
660 NM%(PR) = NM%(PR) + 1
670 NL%(IC,L) = NL%(IC,L) + 1
675 TL%(IC,L) = TL%(IC,L) +  VAL (H$) * 10
676 TG%(IC,L) = TG%(IC,L) + G
677 TD%(IC,L) = TD%(IC,L) + D + U
680 D%(PR) = D%(PR) + D
695 U%(PR) = U%(PR) + U
700 G%(PR) = G%(PR) + G
730 TM%(PR) = TM%(PR) +  VAL (H$) * 10
740 DL%(PR) = DL%(PR) +  ABS (10 *  VAL (H$) - D - U - G)
750 NC%(PR,IC) = NC%(PR,IC) + 1
752 NT%(PR,IC) = NT%(PR,IC) +  VAL (H$) * 10
754 ND%(PR,IC) = ND%(PR,IC) + G
756 NU%(PR,IC) = NU%(PR,IC) + D + U
770  REM  FIX UP
780  REM  FIXUP PRECEEDING
790  NEXT I
800  GOTO 970
810 EN =  LEN (E$)
820  FOR J = 1 TO EN
830 CH$ =  MID$ (E$,J,1)
840  IF CH$ = " " GOTO 880
850 ST$ = ST$ + CH$
860  IF J = EN GOTO 880
870  GOTO 940
880 LA$ =  RIGHT$ (ST$,1)
890 AM$ =  LEFT$ (ST$, LEN (ST$) - 1)
900  IF LA$ = "7" OR LA$ = "U" THEN U = U +  VAL (AM$):NU = NU + 1: GOTO 930
910  IF LA$ = "8" OR LA$ = "G" THEN G = G +  VAL (AM$):NG = NG + 1: GOTO 930
920  IF LA$ = "9" OR LA$ = "D" THEN D = D +  VAL (AM$):ND = ND + 1: GOTO 930
930 ST$ = ""
940  NEXT J
950 ST$ = ""
960  RETURN
970  PRINT D$;"CLOSE FILE1"
980  INPUT "LOAD NEXT DISK OR PRINT RESULTS (L/P)";A$
990  IF A$ = "L" GOTO 180
1000  PR# 1: PRINT "132N": PRINT  CHR$ (15)
1010  FOR I = 1 TO N1:R1(I) = I: NEXT I
1030  FOR I = 1 TO N1
1040  FOR J = I TO N1
1050  IF R1$(I) > R1$(J) THEN R$ = R1$(J):RF = R1(J):R1(J) = R1(I):R1$(J) = R1$(I):R1$(I) = R$:R1(I) = RF
```

```
1060  NEXT J
1070  NEXT I
1135  PRINT : PRINT "YEAR:-";Y$
1136  PRINT "CHAN ";CN$
1170  FOR I = 1 TO N1
1180 PR = R1(I):R$ = R1$(I)
1200 NM = NM%(PR): IF NM = 0 GOTO 1315
1210  PRINT "PERIOD :-";R$;T$;
1220  PRINT DT%(PR) / NM;T$;
1230  PRINT UT%(PR) / NM;T$;
1240  PRINT GT%(PR) / NM;T$;
1250  PRINT NM;T$;
1260  PRINT D%(PR) / NM;T$;
1270  PRINT U%(PR) / NM;T$;
1280  PRINT G%(PR) / NM;T$;
1290  PRINT TM%(PR) / NM;T$;
1300  PRINT DL%(PR) / NM;T$
1301  FOR IC = 1 TO 12
1302 NC = NC%(PR,IC): IF NC = 0 GOTO 1310
1303  PRINT C$(IC);T$;NC;T$;NT%(PR,IC) / NC;T$;ND%(PR,IC) / NC;T$;NU%(PR,IC) / NC
1310  NEXT IC
1315  NEXT I
1316  PRINT
1317  FOR IC = 1 TO 12
1318 FR = 1
1320  FOR L = 0 TO 25
1325  IF NL%(IC,L) = 0 GOTO 1350
1330 AL = L: IF L > 15 THEN AL = 5 * (L - 15) + 15
1334  IF FR = 0 GOTO 1340
1335  PRINT "CLASS: ";C$(IC):FR = 0
1340  PRINT AL;T$;NL%(IC,L);T$;TL%(IC,L);T$;TG%(IC,L);T$;TD%(IC,L)
1341 NL(L) = NL(L) + NL%(IC,L)
1342 TL(L) = TL(L) + TL%(IC,L)
1343 TG(L) = TG(L) + TG%(IC,L)
1344 TD(L) = TD(L) + TD%(IC,L)
1350  NEXT L
1390  NEXT IC
1395  PRINT : PRINT "SUMMARY ALL CLASSES"
1397  FOR L = 0 TO 25
1398  PRINT L;T$;NL(L);T$;TL(L);T$;TG(L);T$;TD(L)
1399  NEXT L
1420  PRINT "SUCCESS!"
1430  STOP
1440  REM  CALC PERIOD
1460  IF N1 = 0 THEN K = 1: GOTO 1500
1470  FOR K = 1 TO N1
1480  IF R1$(K) = PR$ THEN  RETURN
1490  NEXT K
1500 R1$(K) = PR$
1510 N1 = K
1520  PRINT N1,R1$(N1)
1530  RETURN
```

APPENDIX E

# MRDS TRAFFIC AND SPECTRUM USE STUDY

APPENDIX E

TO

REPORT R-276-001

## SUMMARY OF PEAK BUSY HOURS
## SAMPLED AS PART OF THE STUDY

## SUMMARY OF ACTUAL PEAK BUSY HOURS SAMPLED AS PART OF THE STUDY 'BEFORE' MRDS

| | CALENDAR DATE | | | | TAPE CODE | | | | NUMBER OF PATROL UNITS | | ANALYSIS OF VOICE TAPES | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Day of Week | Year | Month | Day | Hour | Year | Month | Day | Hour | D#1* | D#3 | Ch 1 | Ch 3 |
| Sat | 80 | 09 | 13 | 00.00-01.00 | 80 | 09 | 13 | 01 | 15 | - | x | |
| Fri | 80 | 09 | 12 | 14.00-15.00 | 80 | 09 | 13 | 15 | 10 | - | x | |
| Fri | 80 | 10 | 17 | 21.00-22.00 | 80 | 10 | 18 | 22 | - | 14 | | x |
| Sat | 80 | 10 | 18 | 01.00-02.00 | 80 | 10 | 18 | 02 | 14 | - | x | |
| Sat | 80 | 10 | 18 | 02.00-03.00 | 80 | 10 | 18 | 03 | 14 | - | x | |
| Sun | 80 | 10 | 19 | 01.00-02.00 | 80 | 10 | 19 | 02 | 10 | - | x | |
| Fri | 80 | 10 | 24 | 23.00-24.00 | 80 | 10 | 25 | 24 | - | 20 | | x |
| Fri | 80 | 10 | 24 | 00.00-01.00 | 80 | 10 | 24 | 01 | 15 | - | x | |
| Sat | 80 | 10 | 25 | 16.00-17.00 | 80 | 10 | 26 | 17 | 11 | - | x | |
| Sat | 80 | 10 | 25 | 20.00-21.00 | 80 | 10 | 26 | 21 | 16 | - | x | |
| Sat | 80 | 10 | 25 | 21.00-22.00 | 80 | 10 | 26 | 22 | 16 | - | x | |
| Sun | 80 | 10 | 26 | 01.00-02.00 | 80 | 10 | 26 | 02 | - | 14 | | x |
| Tues | 80 | 10 | 28 | 23.00-24.00 | 80 | 10 | 29 | 24 | 18 | 19 | x | x |
| Wed | 80 | 10 | 29 | 23.00-24.00 | 80 | 10 | 30 | 24 | 20 | - | x | |
| Wed | 80 | 10 | 29 | 01.00-02.00 | 80 | 10 | 29 | 02 | 20 | - | x | |
| Thurs | 80 | 10 | 30 | 19.00-20.00 | 80 | 10 | 31 | 20 | 14 | - | x | |
| Thurs | 80 | 10 | 30 | 21.00-22.00 | 80 | 10 | 31 | 22 | 20 | - | x | |
| Thurs | 80 | 10 | 30 | 23.00-24.00 | 80 | 10 | 31 | 24 | 20 | - | x | |
| Fri | 80 | 10 | 31 | 20.00-21.00 | 80 | 11 | 01 | 21 | - | 20 | | x |
| Fri | 80 | 10 | 31 | 23.00-24.00 | 80 | 11 | 01 | 24 | - | 22 | | x |
| Fri | 80 | 10 | 31 | 00.00-01.00 | 80 | 10 | 31 | 01 | - | 22 | | x |
| Fri | 80 | 10 | 31 | 02.00-03.00 | 80 | 10 | 31 | 03 | 18 | - | x | |
| Sat | 80 | 11 | 01 | 00.00-01.00 | 80 | 11 | 01 | 01 | - | 17 | | x |
| Sat | 80 | 11 | 01 | 01.00-02.00 | 80 | 11 | 01 | 02 | - | 17 | | x |
| Sun | 80 | 11 | 02 | 02.00-03.00 | 80 | 11 | 02 | 03 | - | 11 | | x |
| Thurs | 80 | 11 | 06 | 00.00-01.00 | 80 | 11 | 06 | 01 | - | 21 | | x |
| Thurs | 80 | 11 | 06 | 01.00-02.00 | 80 | 11 | 06 | 02 | - | 21 | | x |
| Sat | 80 | 11 | 08 | 00.00-01.00 | 80 | 11 | 08 | 01 | 14 | - | x | |
| Sat | 80 | 11 | 08 | 02.00-03.00 | 80 | 11 | 08 | 03 | - | 18 | | x |
| Sun | 80 | 11 | 09 | 00.00-01.00 | 80 | 11 | 09 | 01 | - | 18 | | x |
| Sun | 80 | 11 | 09 | 02.00-03.00 | 80 | 11 | 09 | 03 | - | 18 | | x |
| Fri | 80 | 10 | 31 | 22.00-23.00 | 80 | 11 | 01 | 23 | - | 20 | | x |
| Fri | 80 | 11 | 07 | 00.00-01.00 | 80 | 11 | 07 | 01 | - | 19 | | x |

* D indicates policing district

## SUMMARY OF ACTUAL PEAK BUSY HOURS SAMPLED AS PART OF THE STUDY
## 'AFTER' MRDS

| | CALENDAR DATE | | | | VOICE TAPE CODE(1) | | | | NUMBER OF | | | | ANALYSIS OF | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | PATROL UNITS | | TERMINALS | | VOICE TAPES | | DATA TAPES |
| Day of Week | Year | Month | Day | Hour | Year | Month | Day | Hour | D#1(2) | D#3 | D1&3 | D1-4 | Ch 1 | Ch 3 | D1-4 |
| Thurs | 82 | 02 | 18 | 20.00-21.00 | 82 | 02 | 19 | 21 | 27 | 29 | 13 | 21 | x | x | x |
| Sat | 82 | 02 | 20 | 00.00-01.00 | 82 | 02 | 20 | 01 | 29 | 32 | 9 | 34 | x | x | x |
| Sat | 82 | 02 | 20 | 22.00-23.00 | 82 | 02 | 21 | 23 | 28 | 27 | 20 | 34 | x | x | x |
| Sun | 82 | 02 | 21 | 01.00-02.00 | 82 | 02 | 21 | 02 | 28 | 27 | 16 | 39 | x | x | x |
| Thurs | 82 | 02 | 25 | 21.00-22.00 | 82 | 02 | 26 | 22 | 27 | 26 | 16 | 38 | x | x | x |
| Thurs | 82 | 02 | 25 | 22.00-23.00 | 82 | 02 | 26 | 23 | 27 | 26 | 12 | 38 | x | x | x |
| Thurs | 82 | 03 | 04 | 20.00-21.00 | 82 | 03 | 05 | 21 | 32 | 24 | 16 | 33 | x | x | x |
| Fri | 82 | 03 | 05 | 23.00-24.00 | 82 | 03 | 06 | 24 | 34 | 28 | 19 | 41 | x | x | x |
| Sat | 82 | 03 | 06 | 21.00-22.00 | 82 | 03 | 07 | 22 | 32 | 29 | 19 | 41 | x | x | x |
| Sat | 82 | 03 | 06 | 22.00-23.00 | 82 | 03 | 07 | 23 | 32 | 29 | 19 | 41 | x | x | x |
| Sat | 82 | 03 | 08 | 23.00-24.00 | 82 | 03 | 07 | 24 | 32 | 29 | 12 | 41 | x | x | x |
| Sun | 82 | 03 | 07 | 00.00-01.00 | 82 | 03 | 07 | 01 | 32 | 29 | 12 | 36 | x | x | x |
| Sun | 82 | 03 | 07 | 02.00-03.00 | 82 | 03 | 07 | 03 | 21 | 20 | 19 | 36 | x | x | x |
| Fri | 82 | 03 | 12 | 22.00-23.00 | 82 | 03 | 13 | 23 | 31 | 25 | 19 | 51 | x | x | x |
| Fri | 82 | 03 | 12 | 23.00-24.00 | 82 | 03 | 13 | 24 | 31 | 25 | 19 | 51 | x | x | x |
| Sat | 82 | 03 | 13 | 00.00-01.00 | 82 | 03 | 13 | 01 | 31 | 25 | 27 | 57 | x | x | x |
| Sat | 82 | 03 | 13 | 22.00-23.00 | 82 | 03 | 14 | 23 | 31 | 25 | 27 | 57 | x | x | x |
| Fri | 82 | 03 | 19 | 23.00-24.00 | 82 | 03 | 20 | 24 | 29 | 25 | 18 | 43 | x | x | x |
| Sat | 82 | 03 | 20 | 22.00-23.00 | 82 | 03 | 21 | 23 | 27 | 26 | 14 | 39 | x | x | x |
| Sat | 82 | 03 | 27 | 00.00-01.00 | 82 | 03 | 27 | 01 | 30 | 24 | 16 | 42 | x | x | x |
| Sat | 82 | 03 | 27 | 01.00-02.00 | 82 | 03 | 27 | 02 | 30 | 24 | 16 | 42 | x | x | x |

Notes: (1) Indicates voice tape code as found in project records
(2) D indicates policing district

# MRDS TRAFFIC AND SPECTRUM USE STUDY

APPENDIX F

TO

REPORT R-276-001

# CONVERSION OF DATA MESSAGE LENGTHS TO RADIO CHANNEL TIME OCCUPANCY

A review of the data radio channel protocol (ref. 5) and the results of MRDS radio coverage tests (ref. 3) has resulted in formulating the following approach for conversion of data message length (in characters) to radio channel occupancy (in seconds).

### F1.0 Scaling Factors

The scaling factors developed for conversion of digital message length in characters to radio air time are as follows:

(i) Header type messages require 0.103 sec of radio transmission time. The following function numbers (decimal) are considered as Header type messages: 3, 4, 5, 24, 46, 47 (see table 4-1).

(ii) Text type messages require $T_T = 0.103 + (0.092 N)$ sec of radio time. N is the number of 45 character blocks (one character = 7 bits at 4800 b/s) in a text message rounded off to the next higher integer. For CPIC formatted positive responses and registered owner responses the radio time calculations are adjusted as indicated in 2(b) and 2(c) below.

The function numbers (decimal) falling in the Text message category are: 6, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 21, 23, 25, 26, 27, 28, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 48, 58, 59, 62 (see table 4-1).

### F2.0 Transmission of Text Messages

Text messages are blocked into pages up to 315 characters in length. The pages up to 30 in number are stored in the host ready to be sent out when requested by the terminal. No records are kept showing what percentage of these multipaged messages is transmitted to the terminal in their entirety as it depends very much on the nature of information contained in them. Through discussions with Cpt. D. Lea of Vancouver Police and a review of CPIC message statistics the following has been judged as being representative of the actual situation:

(a) Positive CPIC responses for vehicles, boats, property and unformatted messages are in each case requested and read in their entirety.

TABLE 4-1 Functions (Page 1 of 3)
(excerpted from MRDS System Documentation)

| (DECIMAL) | FUNCTION NUMBER (OCTAL) | FUNCTION CODE | COMMAND CODE | DESCRIPTION |
|---|---|---|---|---|
| | 1 | DON | | Dispatcher On Duty |
| | 2 | DOFF | | Dispatcher Off Duty |
| | 3 | MON | | Mobile On Duty By Dispatcher |
| | 4 | MOF | | Mobile Off Duty By Dispatcher |
| | 5 | MTA | | Mobile Terminal Assignment |
| | 6 | CFQ | | CPIC Limited Free Format Query |
| | 7 | DSC | | Status Change by Dispatcher |
| 8 | 10 | NRT | | Narrative from Work Station |
| 9 | 11 | NMT | | Narrative to Team |
| 10 | 12 | NTA | | Narrative to Group/All Call |
| 11 | 13 | CPY | | Copy |
| 12 | 14 | CFP | | CPIC Formatted Person Query |
| 13 | 15 | CFV | | CPIC Formatted Vehicle Query |
| 14 | 16 | CFT | | CPIC Formatted Property Query |
| 15 | 17 | CFB | | CPIC Formatted Boats Query |
| 16 | 20 | BCL | | B.C. Licence Query |
| 17 | 21 | BCD | | B.C. Drivers Licence Query |
| 18 | 22 | CBR | | B.C. Registration Number Query |
| 19 | 23 | ISN | | IST On Duty |
| 20 | 24 | ISF | | IST Off Duty |
| 21 | 25 | CPN | | CPIC Narrative |
| 22 | 26 | CHC | | CPIC Hit Confirmation |
| 23 | 27 | CMT | | CPIC Total Free Format Transaction |
| 24 | 30 | MSC | | Status Change by Mobile |
| 25 | 31 | ON | | Mobile Sign On |
| 26 | 32 | MMF | | Mobile Sign Off |
| 27 | 33 | NMC | | Mobile to Dispatcher Narrative |
| 28 | 34 | NMG | | Mobile to Mobile Narrative |
| 29 | 35 | MEV | | Modify Trace Function |
| 30 | 36 | MUR | | Modify Unit Record |
| 31 | 37 | CUN | | Create Unit Record |

TABLE 4-1 Functions (Page 2 of 3)

| | FUNCTION NUMBER | FUNCTION CODE | COMMAND CODE | DESCRIPTION |
|---|---|---|---|---|
| 32 | 40 | MDF | | Modify Function Table |
| 33 | 41 | SSN | | System Manager Sign On |
| 34 | 42 | MWS | | Modify Workstation Record |
| 35 | 43 | DTM | | Set Date/Time |
| 36 | 44 | RFP | | CPIC Formatted Pos. Resp.-Persons |
| 37 | 45 | RFV | | -Vehicle |
| 38 | 46 | RFB | | -Boats |
| 39 | 47 | RFT | | -Property |
| 40 | 50 | RNP | | CPIC Formatted Neg. Resp.-Persons |
| 41 | 51 | RNV | | -Vehicle |
| 42 | 52 | RNB | | -Boats |
| 43 | 53 | RNT | | -Property |
| 44 | 54 | CUR | | CPIC Unformatted Response |
| 45 | 55 | IUR | | ICBC Response |
| 46 | 56 | MEM | | Emergency |
| 47 | 57 | MAK | | Manual Acknowledgement |
| 48 | 60 | SE1 | | Error Message - Class 1 |
| 49 | 61 | SE2 | | Error Message - Class 2 |
| 50 | 62 | SE3 | | Error Message - Class 3 |
| 51 | 63 | FVE | | Field Validation Error |
| 52 | 64 | CVE | | Command Validation Error |
| 53 | 65 | TEL | | Telephone Monitor Interface |
| 54 | 66 | CLD | | Cold Start |
| 55 | 67 | RSD | | Restart from Diskette |
| 56 | 70 | RSW | | Restart from Diskette |
| 57 | 71 | RSC | | Power Fail Restart |
| 58 | 72 | LGC | | Log Channel Statistics |
| 59 | 73 | LGQ | | Log Queue Statistics |
| 60 | 74 | EVT | | Event Trace Log |
| 61 | 75 | DUR | | Delete Unit Record |
| 62 | 76 | UIP | | Unsolicited CPIC Response |

TABLE 4-1 Functions (Page 3 of 3)

| | FUNCTION NUMBER | FUNCTION CODE | COMMAND CODE | DESCRIPTION |
|---|---|---|---|---|
| 63 | 77 | SYS | | System Startup Message |
| 80 | 100 | OPN | | Open Channel |
| 81 | 101 | CLS | | Close Channel |
| 82 | 102 | ENB | | Enable Channel |
| 83 | 103 | DSB | | Disable Channel |
| 84 | 104 | EXT | | EXIT (Diagnostic Command) |

(b) For positive CPIC responses on persons, first page is requested and read in all cases. The seconds and third pages are always requested in "hit" situations.

This is taken as 12% of the positive replies. The remaining pages in positive replies are probably only read for 50% of cases.

(c) The first three pages of registered owner replies are read for 80% of the cases. The remaining pages are read for 50% of cases.

## F3.0 Overhead Messages and Collisions

In addition to the message types shown in table 4-1 there are a number of control messages, automatic acknowledgments and form requests which occupy radio air-time but cannot be easily accounted for.

Further, the throughput of the inbound channel is a function of the particular method used by the MRDS terminals in accessing that channel. This method, referred to as "Digital Sense Multiple Access", depends on the terminal accurately sensing the condition of data channel: idle or busy. If the channel is sensed idle, the terminal transmits a message, if not the transmission is inhibited.

It takes a finite amount of time to sense the time from when one transmitter in the system starts to radiate energy to the time when all other transmitters are inhibited. This time is referred to as the "busy sensing and signalling delay" or "collision interval." Should a terminal be instructed to transmit a message during this interval, it will do so causing a collision at the base station receiver. Automatic acknowledgement will not be received and a retransmission will be attempted.

The number of potential collisions on the channel increases with the number of messages attempted by the terminals in the system. When the number of terminals is large and attempted traffic heavy retransmission due to collisions can add significantly to the total channel message occupancy time and hence reduce the throughput. However with the present number of terminals in the Vancouver System and the relatively small data traffic during the voice peak busy hour it is felt that the effect of collision on total message occupancy time is small.

Consideration of all the above factors with the assistance of references has led to an allocation of the 65% of the data channel message occupancy time ($T_{OM}$) as representing the time contributed by messages and retransmission due to collisions.

## F4.0 Propagation Factors

It is not possible to determine from the available data how many messages were subject to retransmission due to propagation errors. Radio coverage tests undertaken by the City of Vancouver (Reference 3) indicate that because of the excellent radio coverage experienced this factor is be significant. Specification requirements outlined in Appendix A were met or exceeded, making this factor very small in the overall computation of data channel message occupancy. It is felt that the 65% allocated in F3.0 above can also be considered to include whatever small value that results from retransmission due to propagation errors.

# MRDS TRAFFIC AND SPECTRUM USE STUDY

## APPENDIX G

TO

REPORT R-276-001

## SAMPLE FREQUENCY DISTRIBUTIONS

### VOICE CHANNELS:

1. Number of Messages ($N_M$) and Message Air-Time Occupancy ($T_{OM}$) as a function of Message Time ($T_M$).
2. Number of Messages ($N_M$) and Transmission Air-Time Occupancy ($T_{OT}$) as a function of Transmission Time ($T_T$).

### DATA CHANNELS:

1. Message Air-Time Occupancy ($T_{OM}$) as a function of Data Message Time ($T_M$).

## G1.0 INTRODUCTION

This Appendix contains detailed frequency-time distribution of the message content in both voice and data channels. These distributions are included on Figures 6-14 to 6-47 and show the behaviour of all message types combined as well as for each individual type 'before' and 'after' MRDS.

It should be noted that the number of voice hours sampled (42 hrs) is twice that of the data hours (21 hrs) - as explained in the report this is because the records for voice channels are available on a per district basis while the data record is a composite for traffic generated by all four districts.

## G2.0 Voice Channel Distributions - (Figures 6-14 to 6-41)

Each figure contains a summary data for the average values that characterize the message type and a histogram showing the sample distribution. The abscissa of each voice histogram has 5-second time increments from 0 to 60. The percentage of sample with duration greater than 60 is shown as one value.

To expose the finer structure of message distribution in the time interval 0 to 15 a smaller histogram is included as an insert to the larger one. As discussed in section 5.1.3 of the report there is less confidence in the accuracy of this finer distribution because of message classification problems which the operators experienced.

To locate a specific distribution refer to table G2-1.

Table G2-1 Summary of Sample Distributions included in Appendix G

| DISTRIBUTION | | | FIGURE NUMBER | |
|---|---|---|---|---|
| | | | 'Before' | 'After' |
| VOICE | MESSAGE TIME ($T_M$) | All Combined | Fig. 6-14;p. G- 4 | Fig. 6-15;p. G- 5 |
| | | Type 1 - Dispatch | Fig. 6-16;p. G- 6 | Fig. 6-17;p. G- 7 |
| | | Type 2 - Tactical | Fig. 6-18;p. G- 8 | Fig. 6-19;p. G- 9 |
| | | Type 3 - Status | Fig. 6-20;p. G-10 | Fig. 6-21;p. G-11 |
| | | Type 4 - Data Requests | Fig. 6-22;p. G-12 | Fig. 6-23;p. G-13 |
| | | Type 5 - Base Responses | Fig. 6-24;p. G-14 | Fig. 6-25;p. G-15 |
| | | Type 6 - Descriptive/Narrative | Fig. 6-26;p. G-16 | Fig. 6-27;p. G-17 |
| | TRANSMISSION TIME ($T_T$) | All Combined | Fig. 6-28;p. G-18 | Fig. 6-29;p. G-19 |
| | | Type 1 - Dispatch | Fig. 6-30;p. G-20 | Fig. 6-31;p. G-21 |
| | | Type 2 - Tactical | Fig. 6-32;p. G-22 | Fig. 6-33;p. G-23 |
| | | Type 3 - Status | Fig. 6-34;p. G-24 | Fig. 6-35;p. G-25 |
| | | Type 4 - Data Requests | Fig. 6-36;p. G-26 | Fig. 6-37;p. G-27 |
| | | Type 5 - Base Responses | Fig. 6-38;p. G-28 | Fig. 6-39;p. G-29 |
| | | Type 6 - Descriptive/Narrative | Fig. 6-40;p. G-30 | Fig. 6-41;p. G-31 |
| DATA | MESSAGE TIME ($T_M$) | All Combined | N/A | Fig. 6-42;p. G-32 |
| | | Type 3 - Status | N/A | Fig. 6-43;p. G-33 |
| | | Type 4 - Data Requests | N/A | Fig. 6-44;p. G-34 |
| | | Type 5 - Base Responses | N/A | Fig. 6-45;p. G-35 |
| | | Type 6 - Descriptive/Narrative | N/A | Fig. 6-46;p. G-36 |
| | | Type E - Error | N/A | Fig. 6-47;p. G-37 |

# VOICE CHANNEL FREQUENCY DISTRIBUTIONS

## 'BEFORE' MRDS - 1980

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE ALL COMBINED

Number of hours sampled (H) 34
Average Number of patrol units ($F_P$) 17

$\overline{N}_M$ 148.3
$\overline{N}_M/\overline{F}_P$ 8.7

$\overline{T}_M$ 10.9 s
$\overline{T}_{OM}$ 1610.0 s
$\overline{T}_{OM}/\overline{F}_P$ 94.7 s

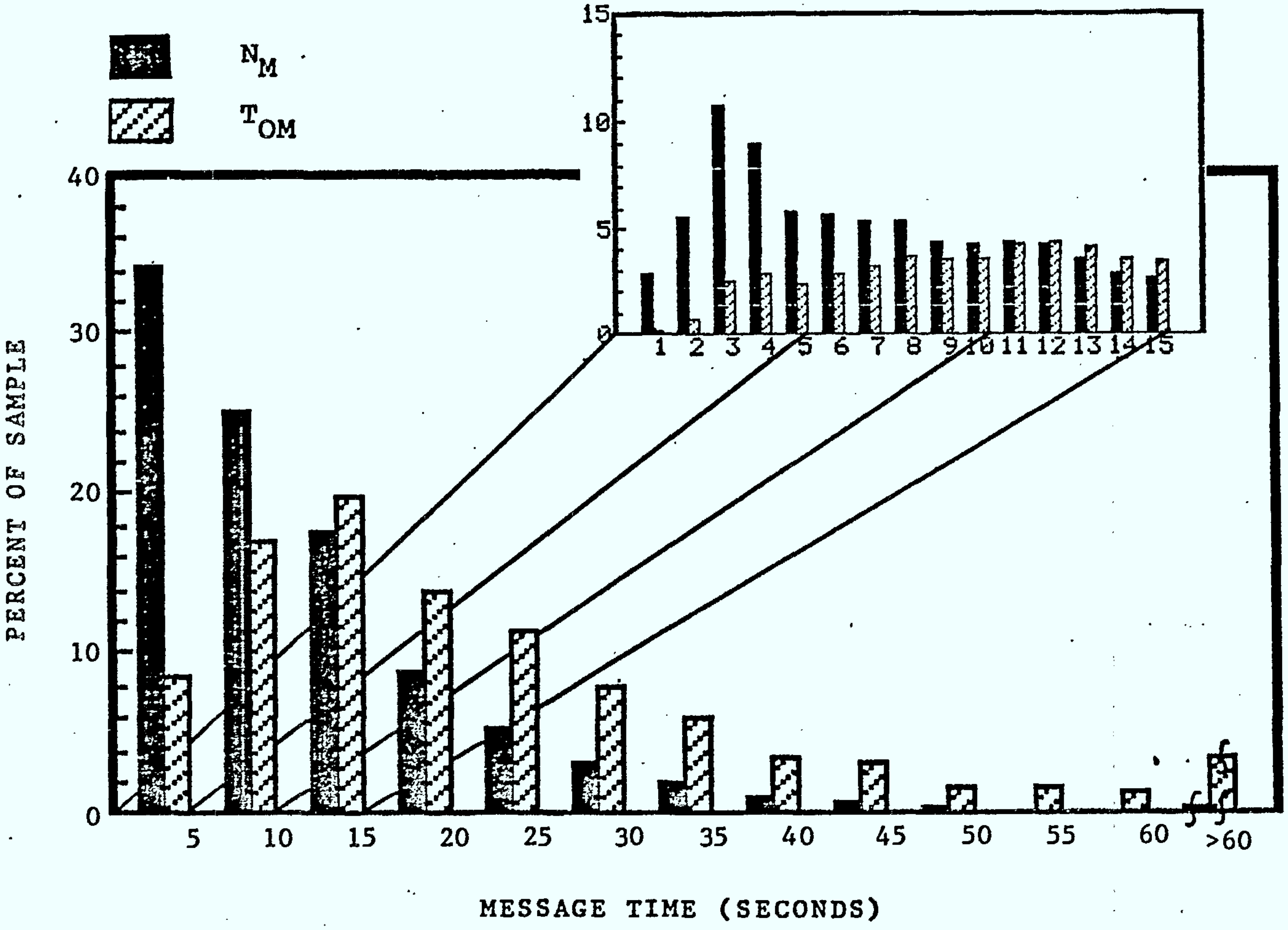


FIGURE 6-14 'BEFORE' MRDS - All Message Types Combined
Sample Distribution of Number of Messages ($N_M$) and Message Air-Time Occupancy ($T_{OM}$) Per Hour.

# 'AFTER' MRDS - 1982

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE ALL COMBINED

Number of hours sampled (H) 42
Average number of patrol units ($F_P$) 28

$\overline{N}_M$ 158.1
$\overline{N}_M / \overline{F}_P$ 5.7

$\overline{T}_M$ 10.9 s
$\overline{T}_{OM}$ 1727.4 s
$\overline{T}_{OM} / \overline{F}_P$ 61.7 s

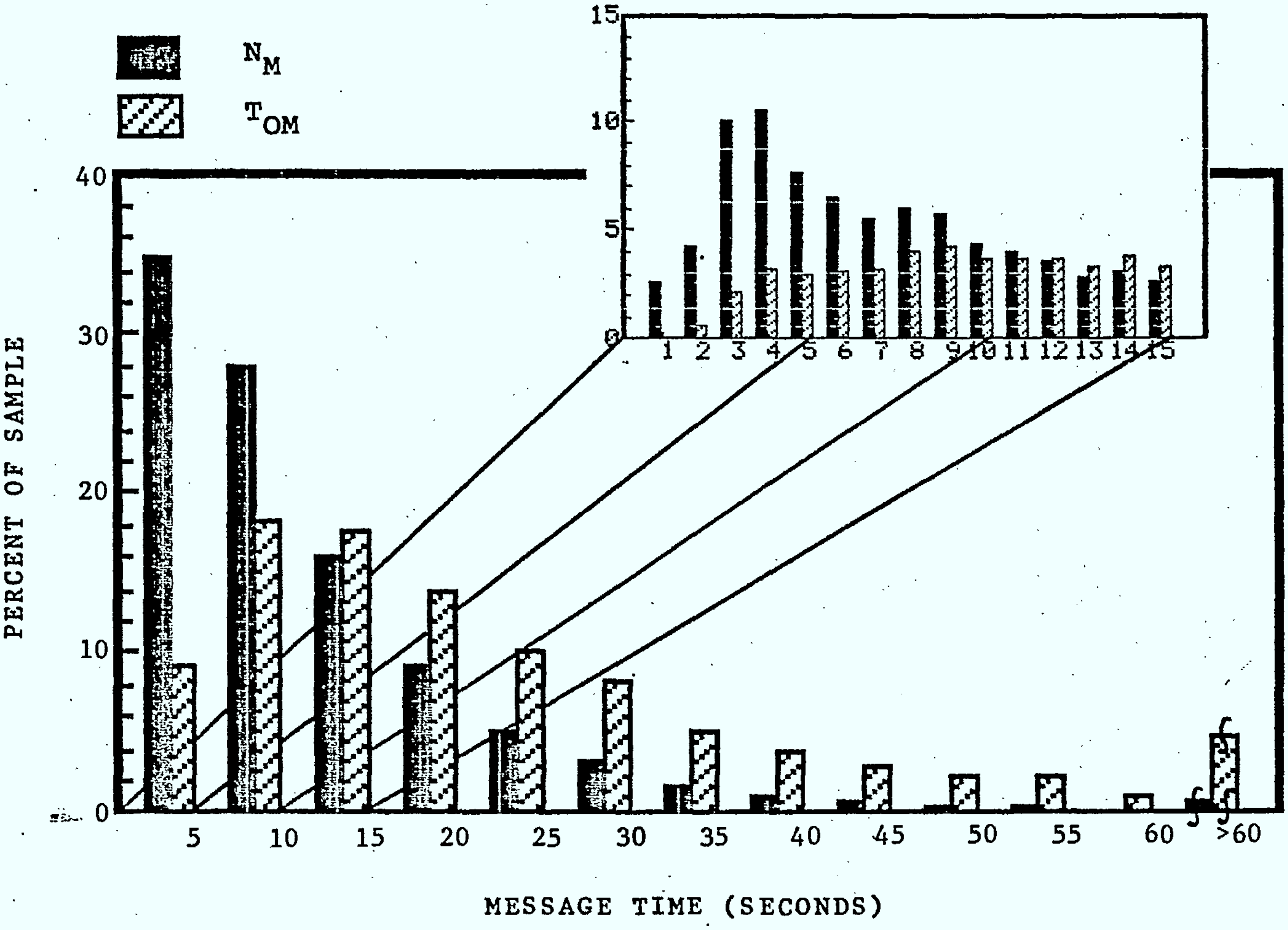


FIGURE 6-15 'AFTER' MRDS - All Message Types Combined
Sample Distribution of Number of Messages ($N_M$) and
Message Air-Time Occupancy ($T_{OM}$) Per Hour.

## 'BEFORE' MRDS - 1980

RADIO CHANNELS 1 & 3 COMBINED

TYPE OF MESSAGE 1

Number of hours sampled (H) 34

Average number of patrol units. ($F_P$) 17

$\overline{N}_M$ 67.6

$\overline{N}_M/\overline{F}_P$ 4.0

$\overline{T}_M$ 11.8 s

$\overline{T}_{OM}$ 801.0 s

$\overline{T}_{OM}/\overline{F}_P$ 47.1 s

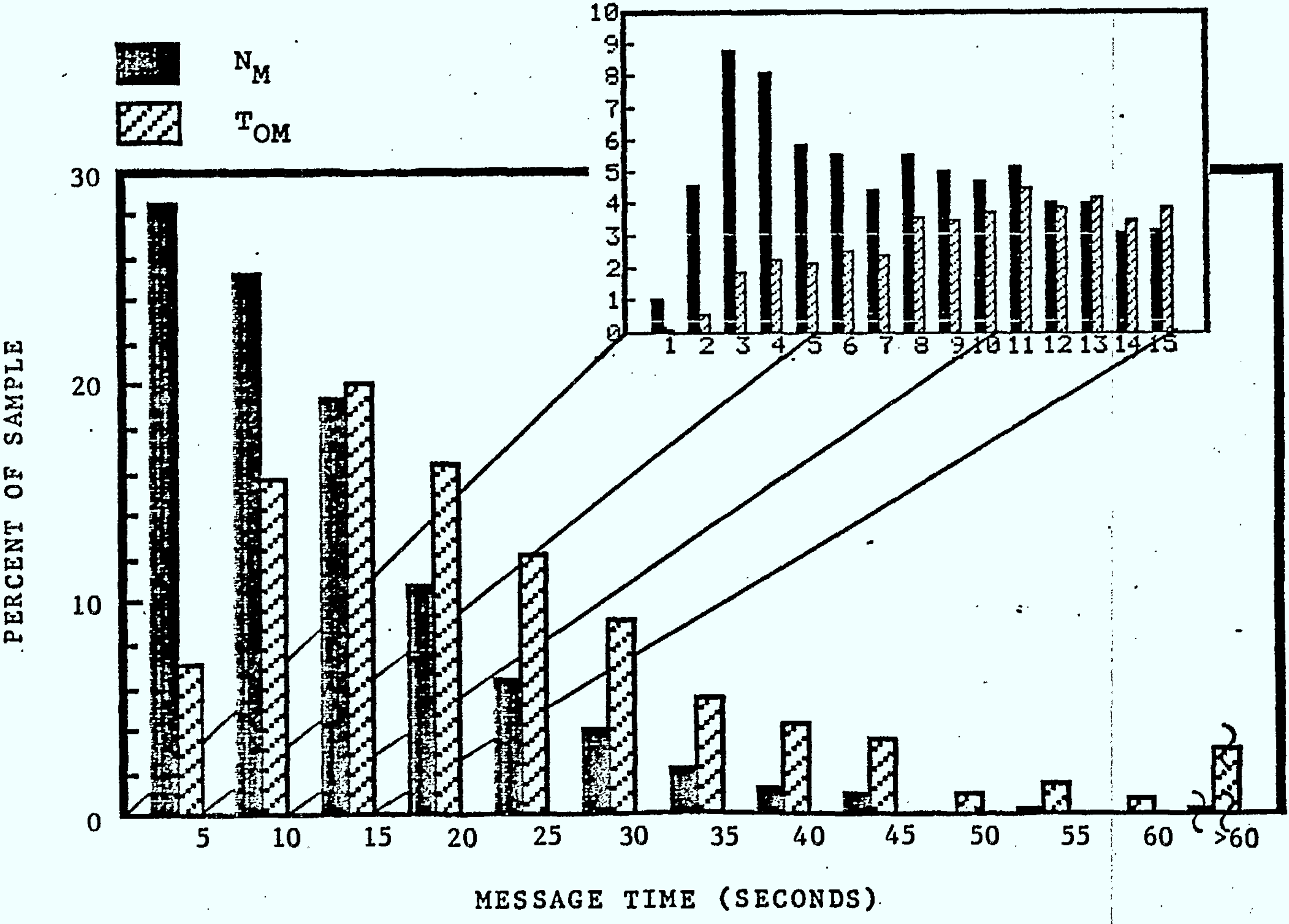


FIGURE 6-16 'BEFORE' MRDS - Message Type 1

Sample Distribution of Number of Messages ($N_M$) and Message Air-Time Occupancy ($T_{OM}$) Per Hour.

# 'AFTER' MRDS - 1982

RADIO CHANNELS _ 1 & 3 COMBINED_
TYPE OF MESSAGE _ _ _ _ _ 1 _ _ _ _ _

Number of hours sampled (H) _ _ _ _ _ _ _ 42 _ _ _
Average number of patrol units ($F_P$) _ _ _ 28 _ _ _

$\overline{N}_M$ _ _ _ 71.9 _ _ _ $\overline{T}_M$ _ _ _ 12.2 s _
$\overline{N}_M / \overline{F}_P$ _ 2.6 _ _ _ $\overline{T}_{OM}$ _ _ 869.4 s _
$\overline{T}_{OM} / \overline{F}_P$ _31.1 s _

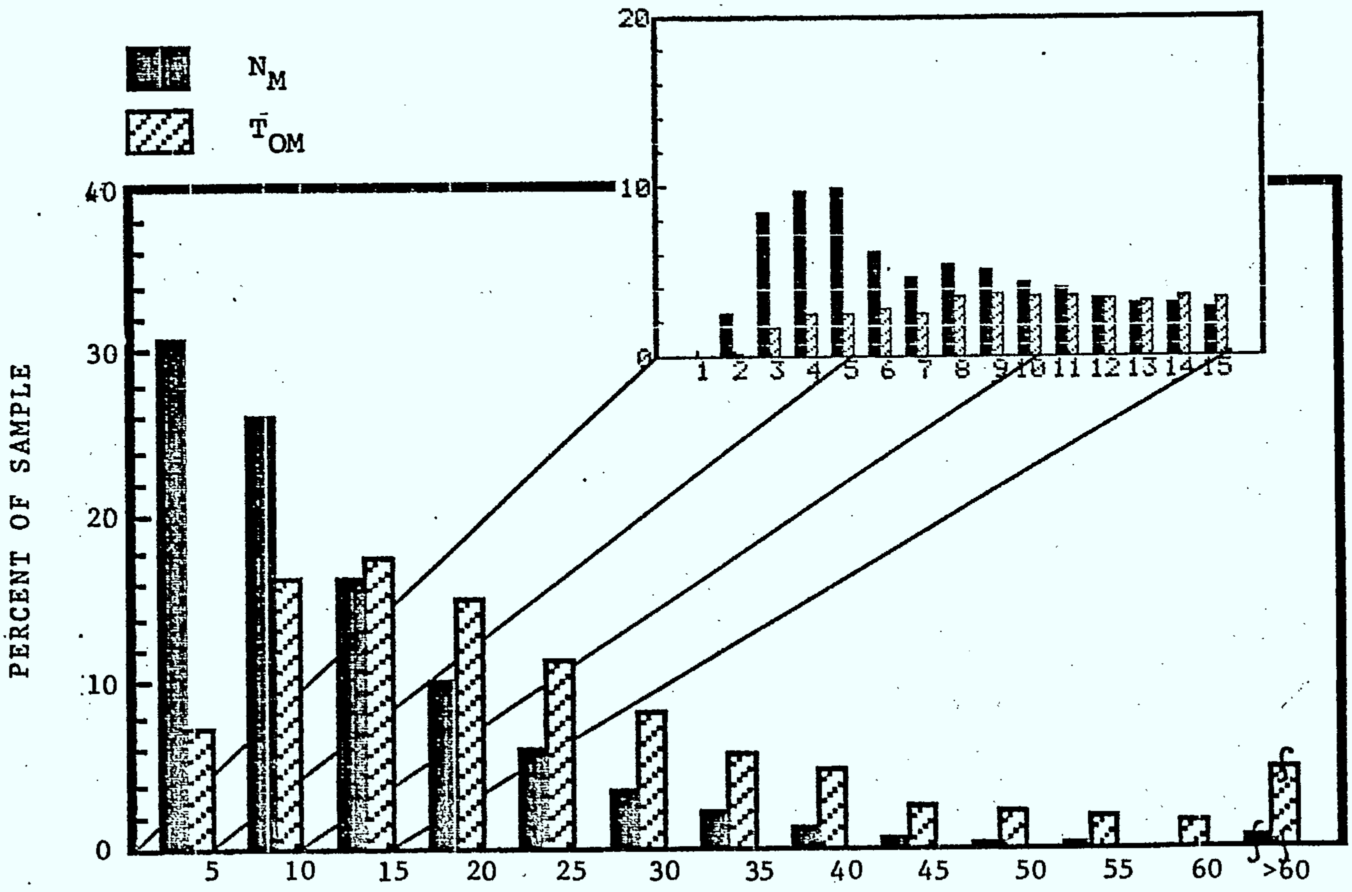


FIGURE 6-17 'AFTER' MRDS - Message Type 1
Sample Distribution of Number of Messages ($N_M$) and Message Air-Time Occupancy ($T_{OM}$) Per Hour.

## 'BEFORE' MRDS - 1980

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE 2

Number of hours sampled (H) 34
Average number of patrol units ($\overline{F}_P$) 17

$\overline{N}_M$ 0.5
$\overline{N}_M / \overline{F}_P$ 0.03
$\overline{T}_M$ 14.3 s
$\overline{T}_{OM}$ 3.8 s
$\overline{T}_{OM} / \overline{F}_P$ 0.2 s

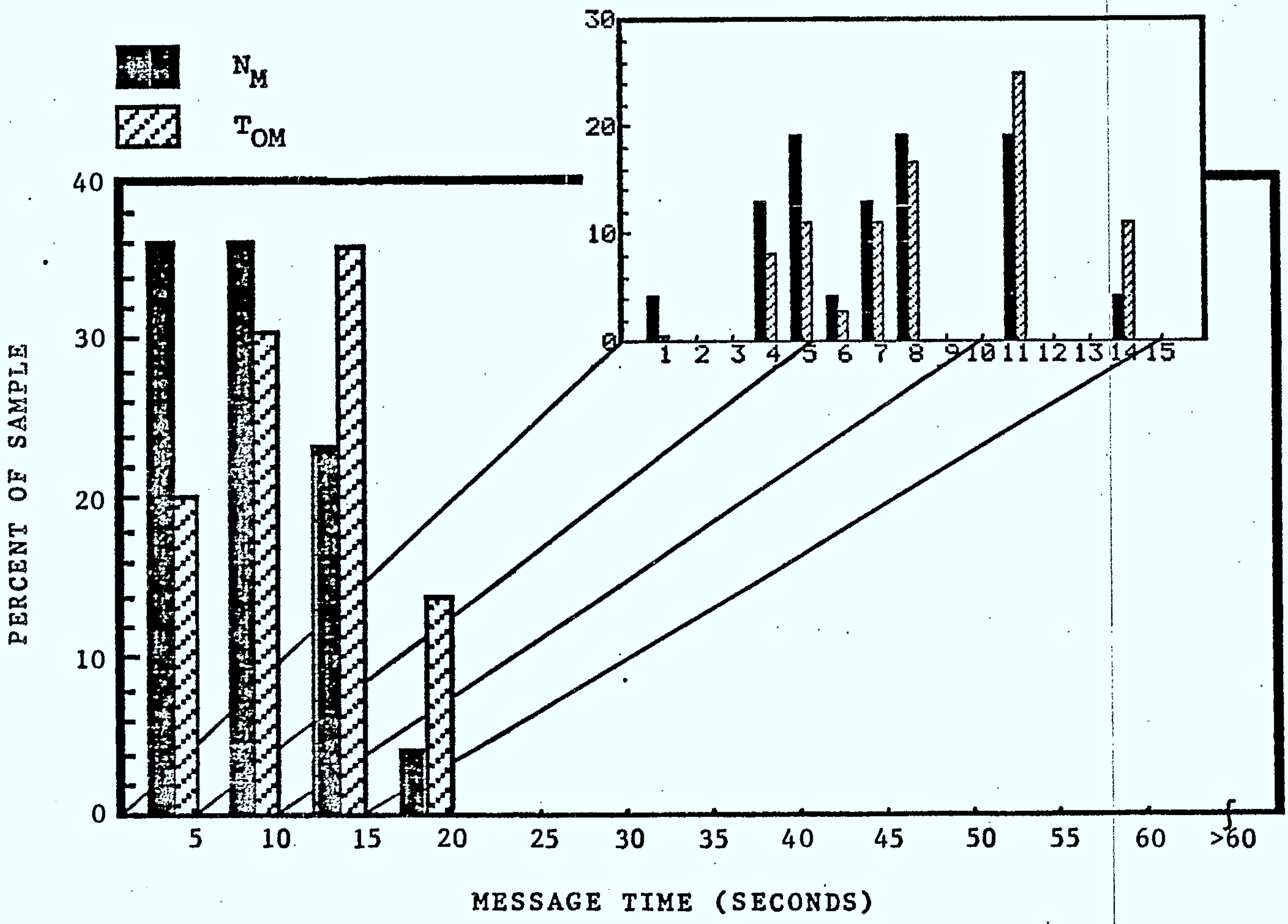


FIGURE 6-18 'BEFORE' MRDS - Message Type 2
Sample Distribution of Number of Messages ($N_M$) and Message Air-Time Occupancy ($T_{OM}$) Per Hour.

## 'AFTER' MRDS - 1982

RADIO CHANNELS 1 & 3 COMBINED

TYPE OF MESSAGE 2

Number of hours sampled (H) 42

Average number of patrol units ($F_P$) 28

$\overline{N}_M$ 0.9

$\overline{N}_M / \overline{F}_P$ 0.03

$\overline{T}_M$ 7.9 s

$\overline{T}_{OM}$ 7.2 s

$\overline{T}_{OM} / \overline{F}_P$ 0.3 s

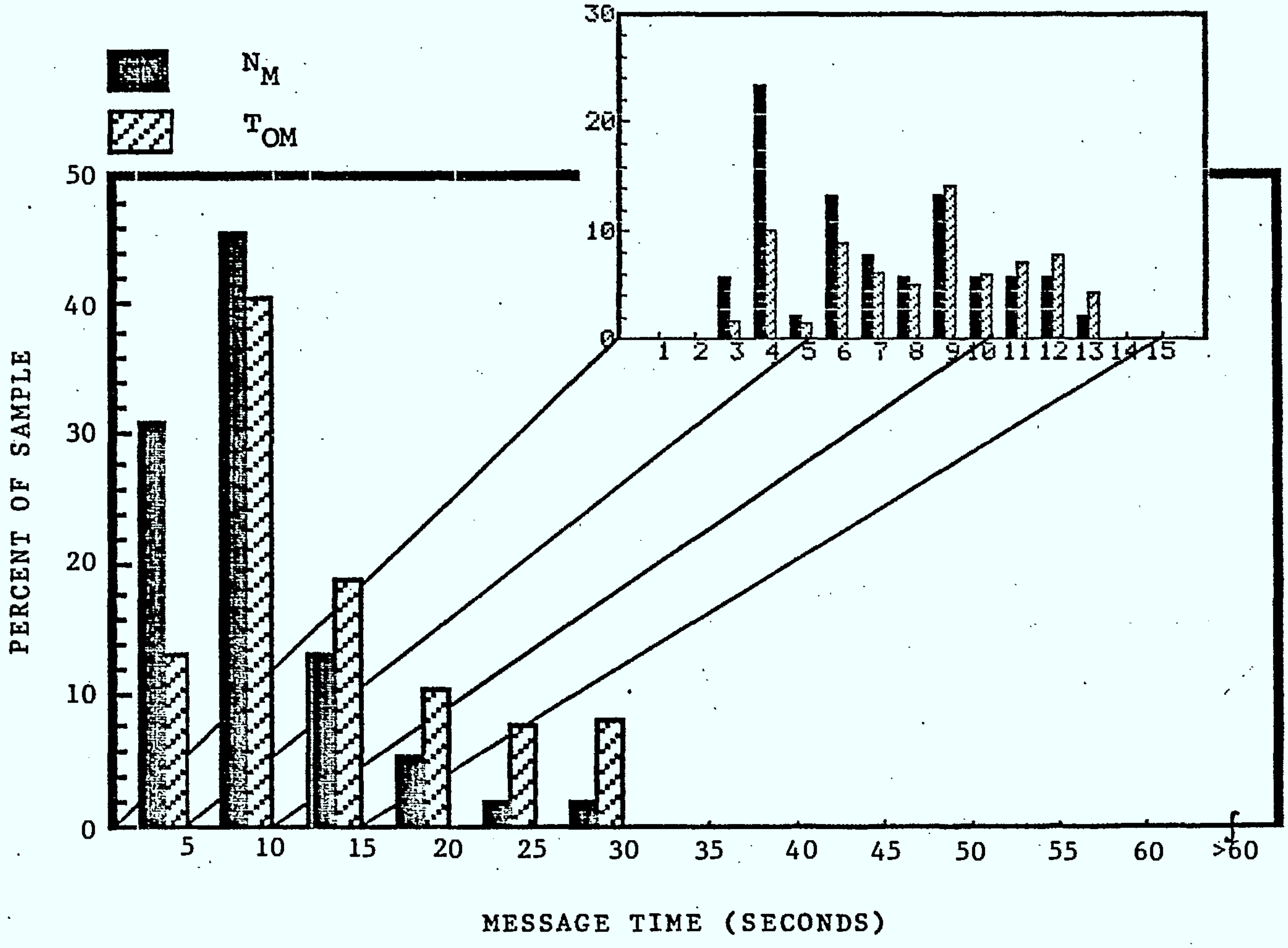


FIGURE 6-19 'AFTER' MRDS - Message Type 2
Sample Distribution of Number of Messages ($N_M$) and Message Air-Time Occupancy ($T_{OM}$) Per Hour.

## 'BEFORE' MRDS - 1980

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE 3

Number of hours sampled (H) 34
Average number of patrol units ($F_P$) 17

$\overline{N}_M$ 22.6
$\overline{N}_M/\overline{F}_P$ 1.3

$\overline{T}_M$ 6.4 s
$\overline{T}_{OM}$ 144.2 s
$\overline{T}_{OM}/\overline{F}_P$ 8.5 s

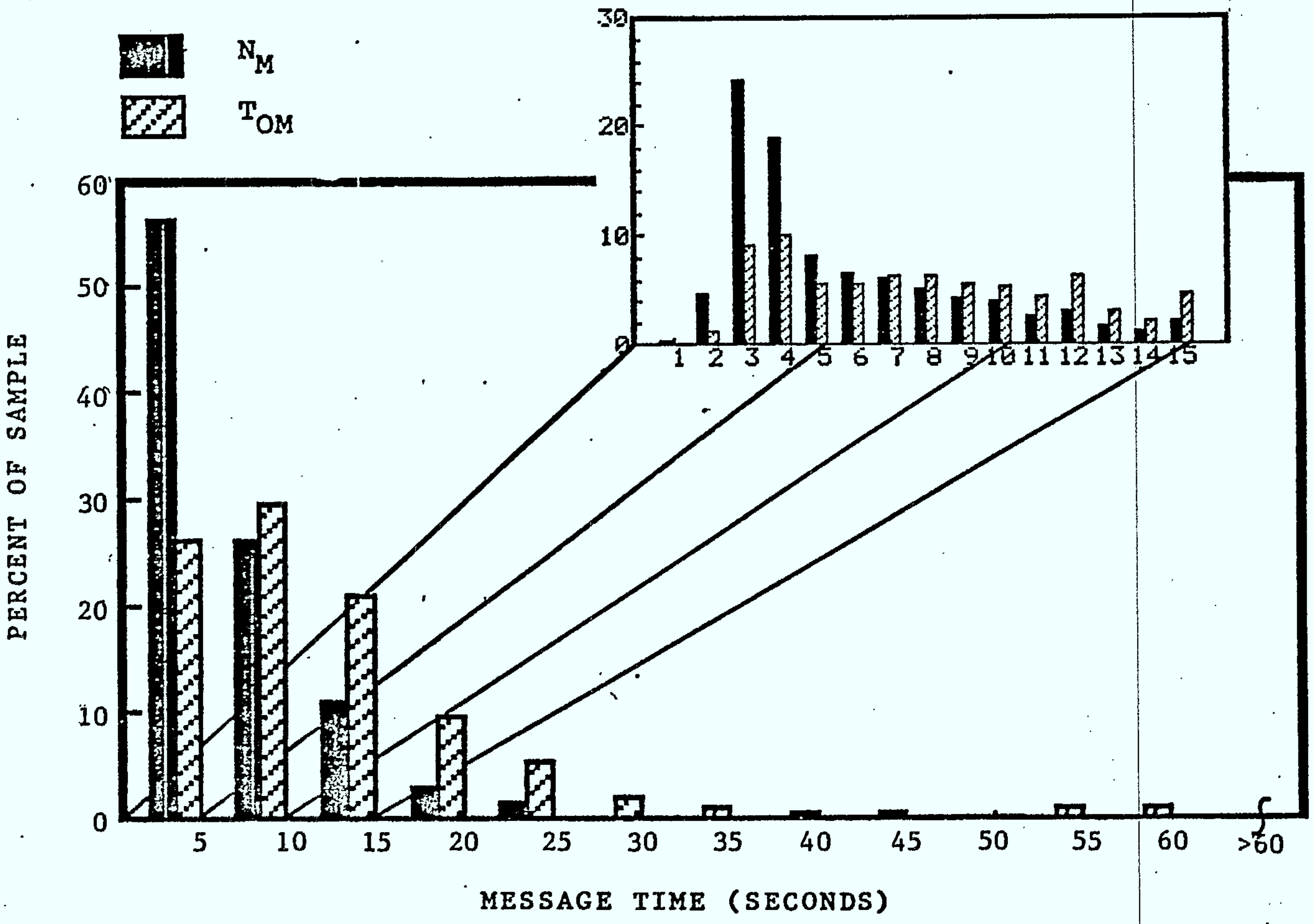


FIGURE 6-20 'BEFORE' MRDS - Message Type 3
Sample Distribution of Number of Messages ($N_M$) and Message Air-Time Occupancy ($T_{OM}$) Per Hour.

# 'AFTER' MRDS - 1982

RADIO CHANNELS 1 & 3 COMBINED

TYPE OF MESSAGE 3

Number of hours sampled (H) 42

Average number of patrol units ($F_P$) 28

$\overline{N}_M$ 29.6

$\overline{N}_M / \overline{F}_P$ 1.1

$\overline{T}_M$ 7.0 s

$\overline{T}_{OM}$ 206.3 s

$\overline{T}_{OM} / \overline{F}_P$ 7.4 s

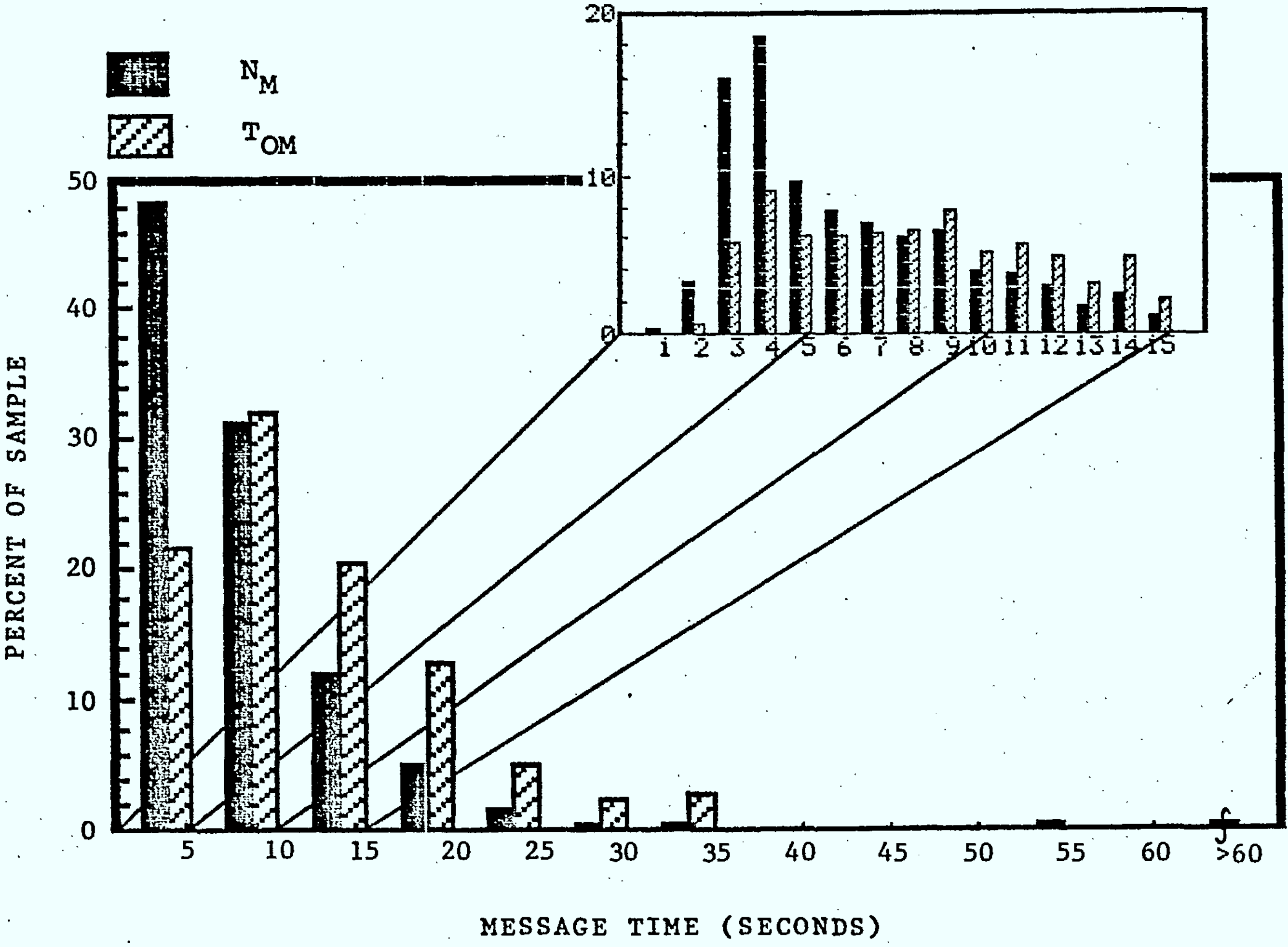


FIGURE 6- 21 'AFTER' MRDS - Message Type 3
Sample Distribution of Number of Messages ($N_M$) and Message Air-Time Occupancy ($T_{OM}$) Per Hour.

## 'BEFORE' MRDS - 1980

RADIO CHANNELS 1 & 3 COMBINED

TYPE OF MESSAGE 4

Number of hours sampled (H) 34

Average number of patrol units ($\overline{F}_P$) 17

$\overline{N}_M$ 25.0

$\overline{N}_M / \overline{F}_P$ 1.5

$\overline{T}_M$ 14.4 s

$\overline{T}_{OM}$ 358.2 s

$\overline{T}_{OM} / \overline{F}_P$ 21.1 s

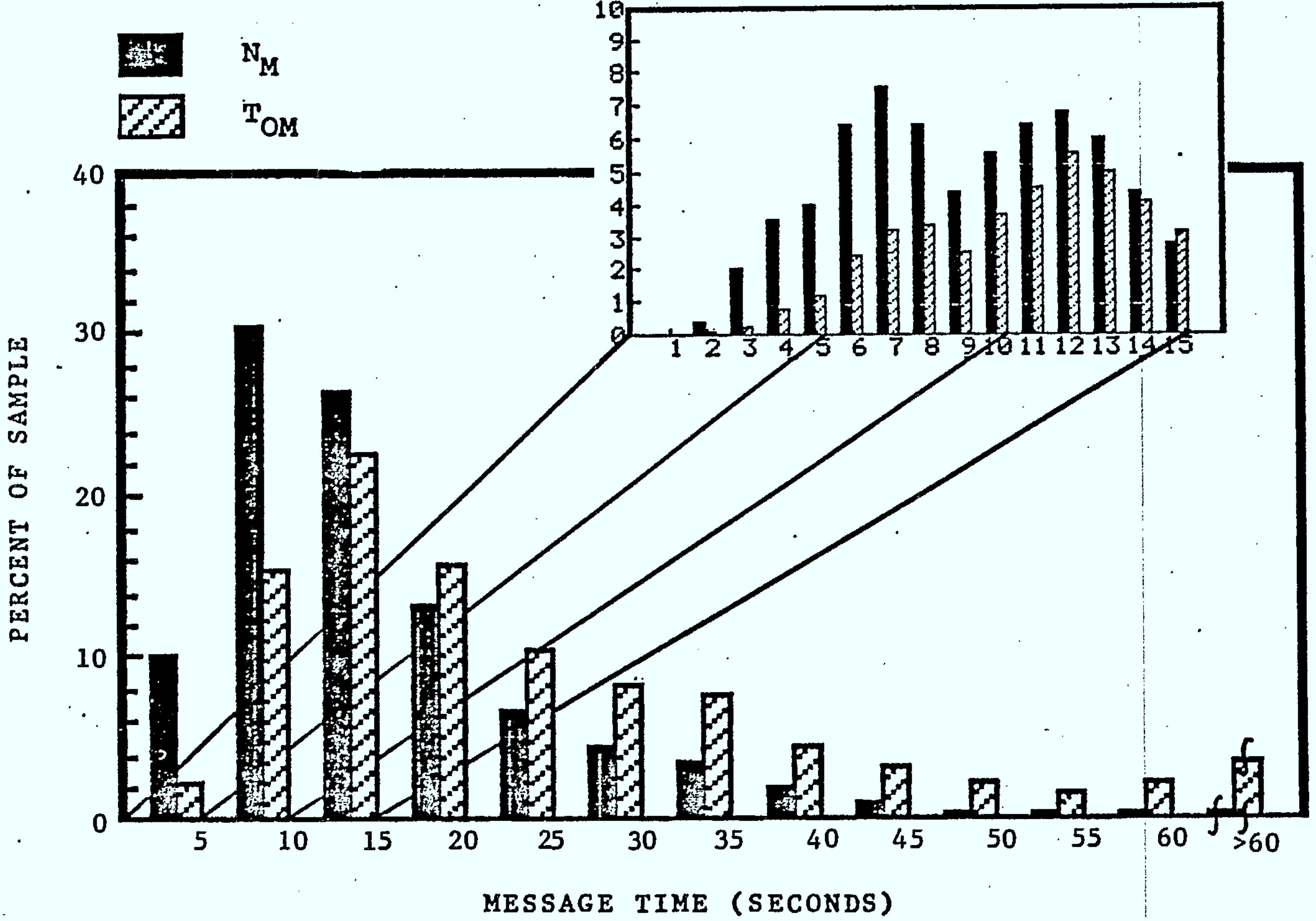


FIGURE 6-22 'BEFORE' MRDS - Message Type 4
Sample Distribution of Number of Messages ($N_M$) and
Message Air-Time Occupancy ($T_{OM}$) Per Hour.

## 'AFTER' MRDS - 1982

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE 4

Number of hours sampled (H) 42
Average number of patrol units ($F_P$) 28

$\overline{N}_M$ 25.8
$\overline{T}_M$ 14.1 s
$\overline{N}_M / \overline{F}_P$ 0.9
$\overline{T}_{OM}$ 363.2 s
$\overline{T}_{OM} / \overline{F}_P$ 13.0 s

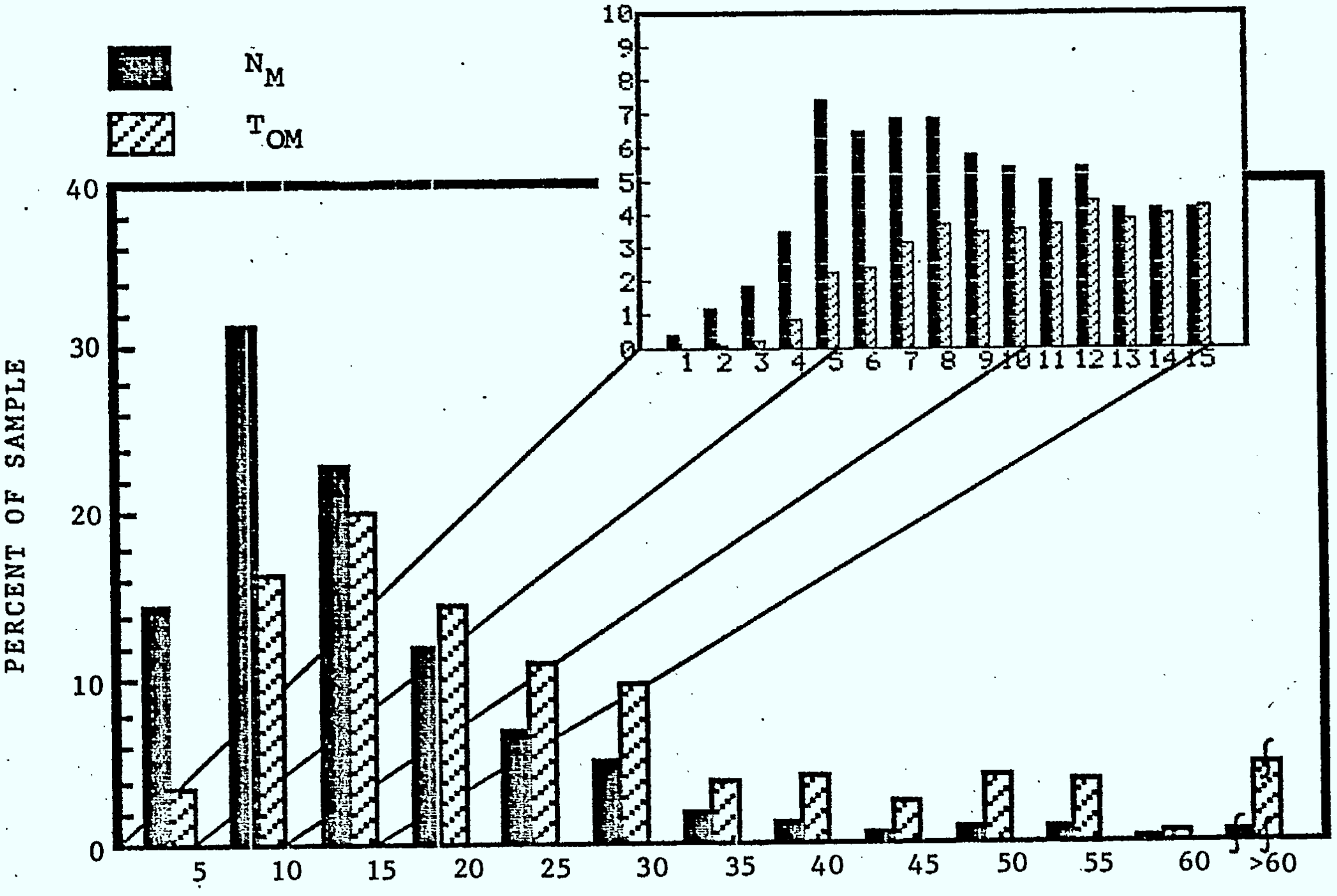


FIGURE 6- 23 'AFTER' MRDS - Message Type 4
Sample Distribution of Number of Messages ($N_M$) and Message Air-Time Occupancy ($T_{OM}$) Per Hour.

## 'BEFORE' MRDS - 1980

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE 5

Number of hours sampled (H) 34
Average number of patrol units ($\overline{F}_P$) 17

$\overline{N}_M$ 11.2
$\overline{N}_M/\overline{F}_P$ 0.7

$\overline{T}_M$ 13.0 s
$\overline{T}_{OM}$ 138.8 s
$\overline{T}_{OM}/\overline{F}_P$ 8.2 s

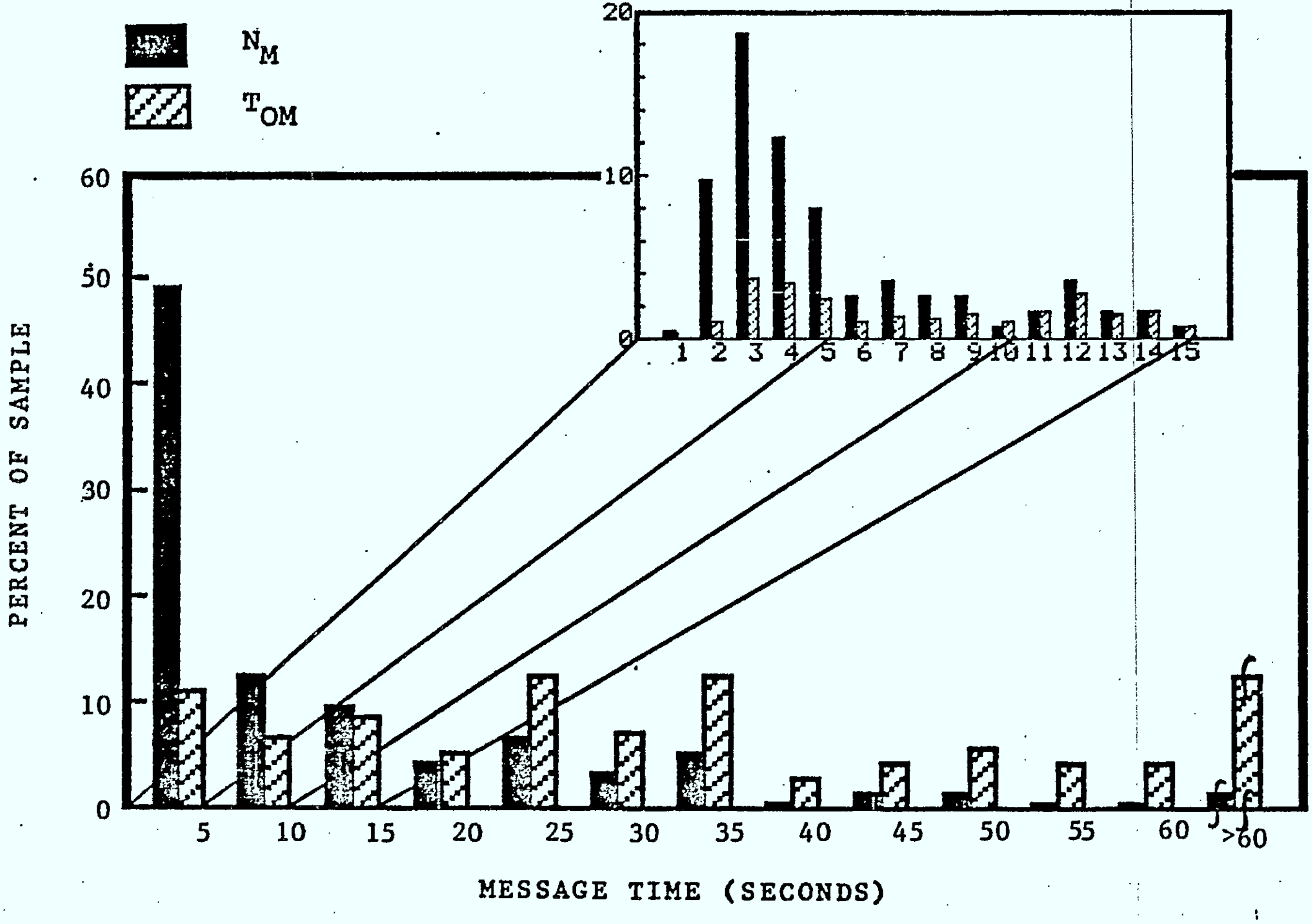


FIGURE 6-24 'BEFORE' MRDS - Message Type 5
Sample Distribution of Number of Messages ($N_M$) and Message Air-Time Occupancy ($T_{OM}$) Per Hour.

## 'AFTER' MRDS - 1982

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE 5

Number of hours sampled (H) 42
Average number of patrol units ($F_P$) 28

$\overline{N}_M$ 11.0
$\overline{N}_M / \overline{F}_P$ 0.4

$\overline{T}_M$ 12.9 s
$\overline{T}_{OM}$ 140.7 s
$\overline{T}_{OM} / \overline{F}_P$ 5.1 s

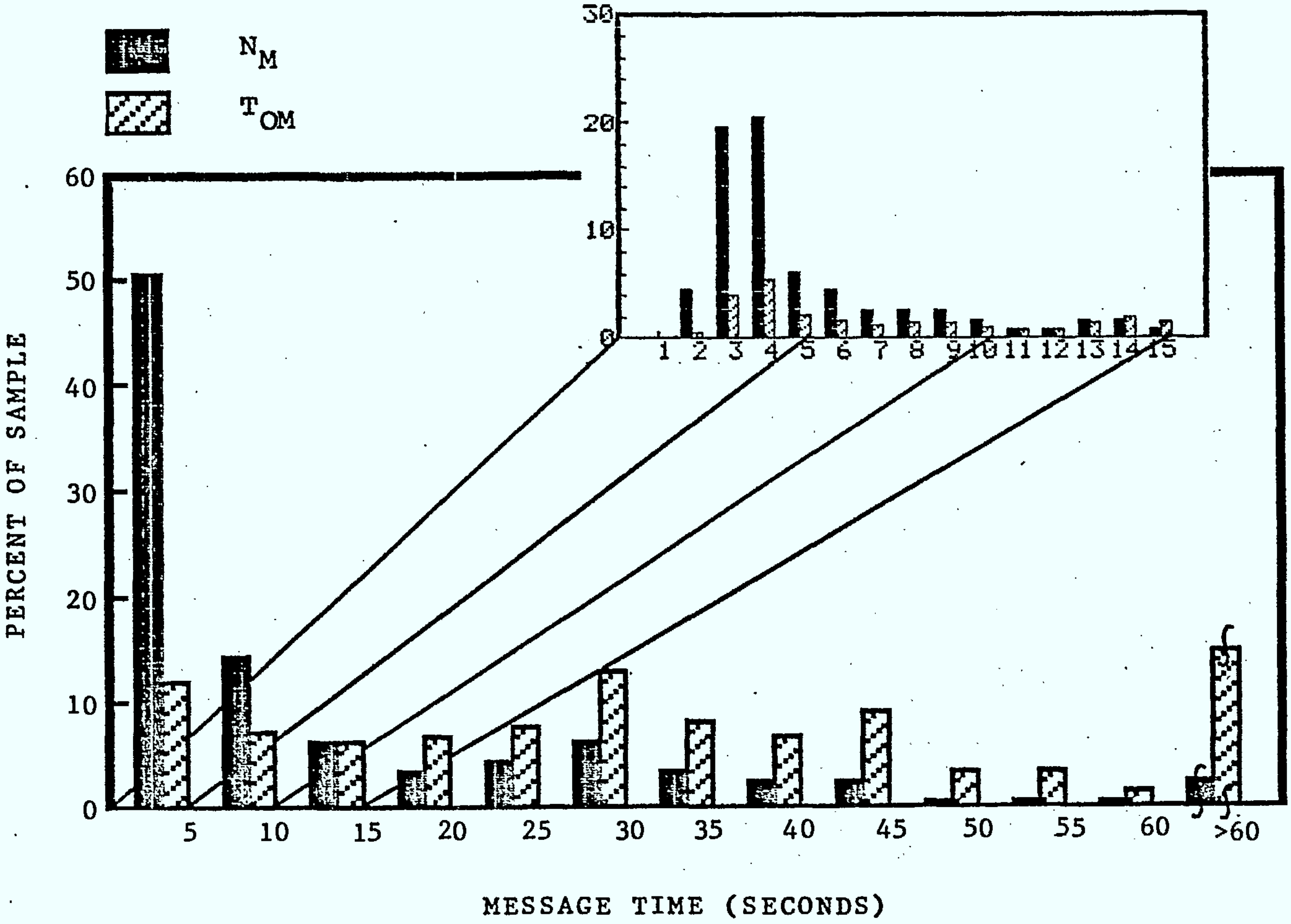


FIGURE 6-25 'AFTER' MRDS - Message Type 5
Sample Distribution of Number of Messages ($N_M$) and Message Air-Time Occupancy ($T_{OM}$) Per Hour.

## 'BEFORE' MRDS - 1980

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE 6

Number of hours sampled (H) 34
Average number of patrol units ($\overline{F}_P$) 17

$\overline{N}_M$ 21.4
$\overline{N}_M/\overline{F}_P$ 1.3

$\overline{T}_M$ 7.6 s
$\overline{T}_{OM}$ 164.0 s
$\overline{T}_{OM}/\overline{F}_P$ 9.7 s

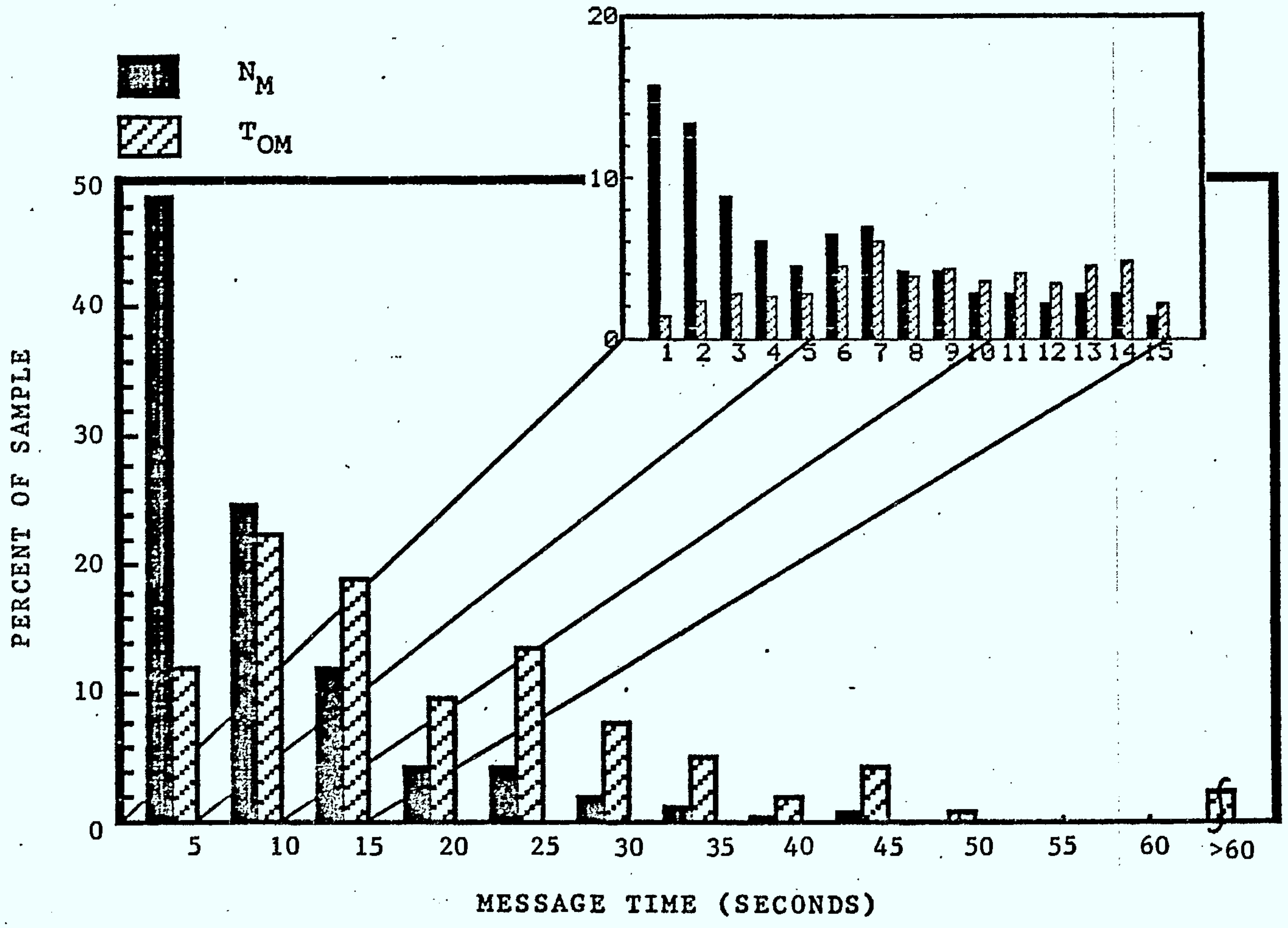


FIGURE 6-26 'BEFORE' MRDS - Message Type 6
Sample Distribution of Number of Messages ($N_M$) and Message Air-Time Occupancy ($T_{OM}$) Per Hour.

'AFTER' MRDS - 1982

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE 6

Number of hours sampled (H) 42
Average number of patrol units ($F_P$) 28

$\overline{N}_M$ 18.9
$\overline{N}_M/F_P$ 0.7

$\overline{T}_M$ 7.5 s
$\overline{T}_{OM}$ 140.6 s
$\overline{T}_{OM}/F_P$ 5.0 s

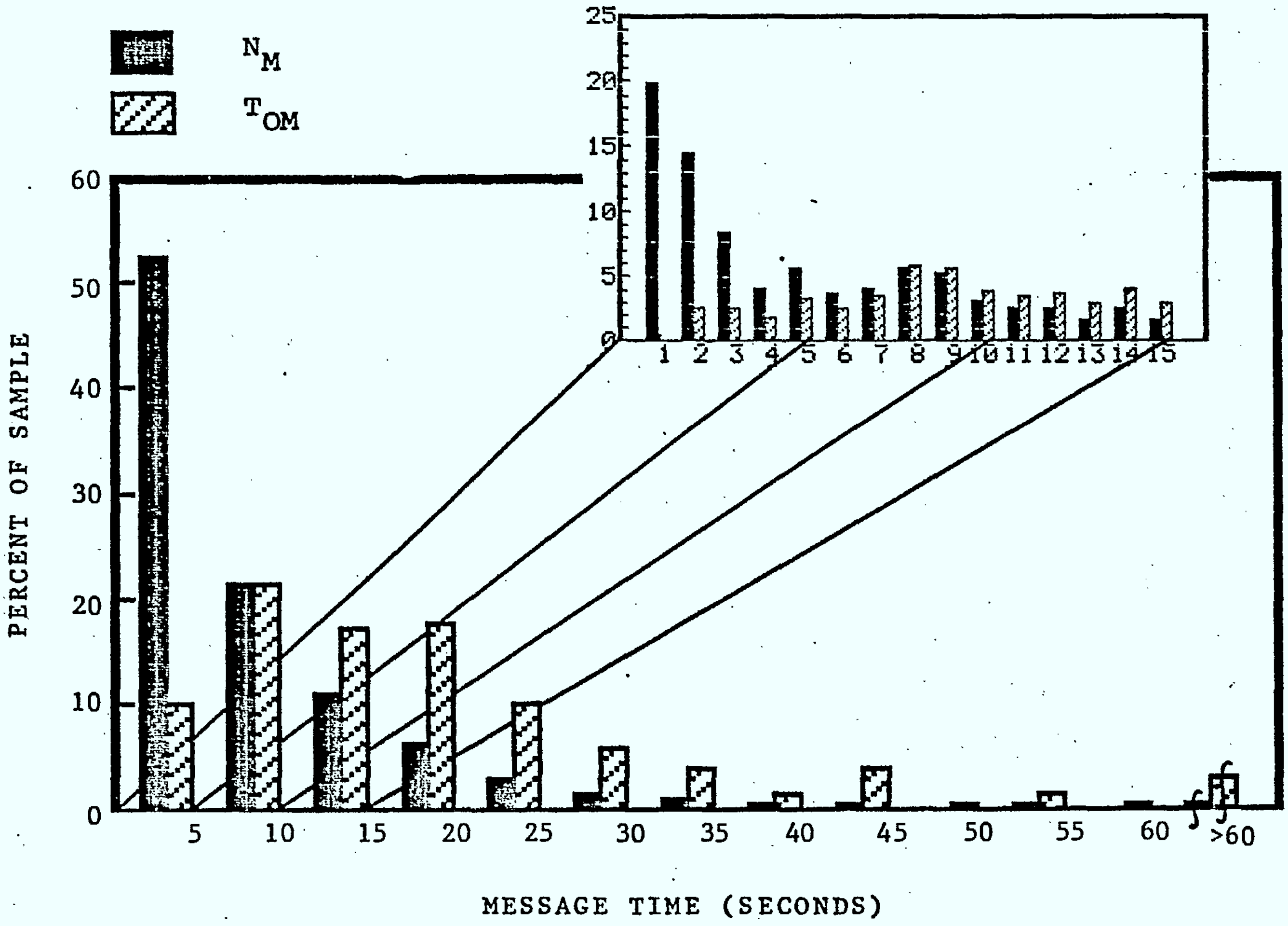


FIGURE 6-27 'AFTER' MRDS - Message Type 6
Sample Distribution of Number of Messages ($N_M$) and Message Air-Time Occupancy ($T_{OM}$) Per Hour.

# 'BEFORE' MRDS - 1980

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE ALL COMBINED

Number of hours sampled (H) 34
Average number of patrol units ($F_P$) 17

$\overline{N}_M$ 148.3
$\overline{N}_M/\overline{F}_P$ 8.7

$\overline{T}_T$ 7.1 s
$\overline{T}_{OT}$ 1048.8 s
$\overline{T}_{OT}/\overline{F}_P$ 61.7 s

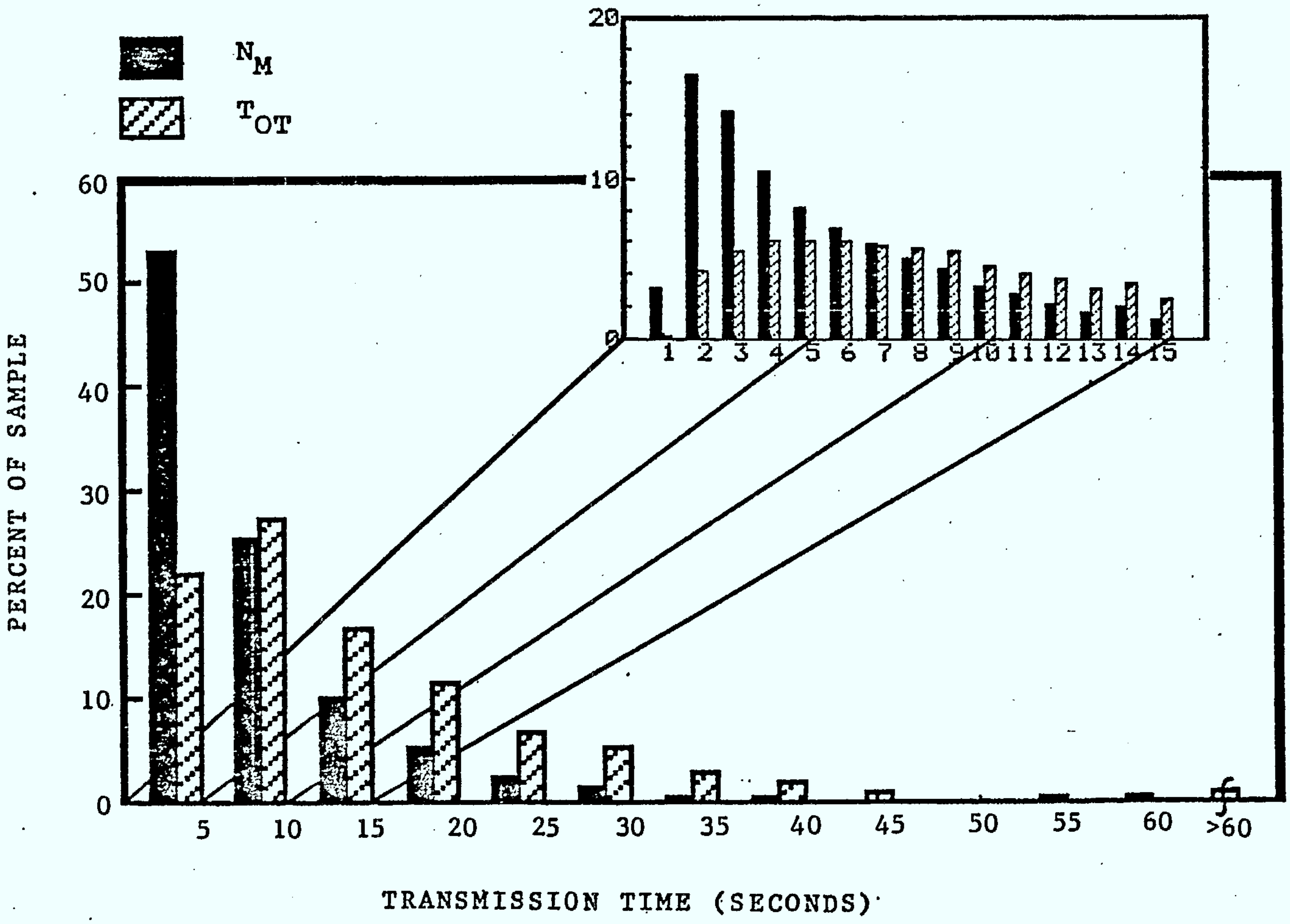


FIGURE 6-28 'BEFORE' MRDS - All Message Types Combined
Sample Distribution of Number of Messages ($N_M$) and Transmission Air-Time Occupancy ($T_{OT}$) Per Hour.

## 'AFTER' MRDS - 1982

RADIO CHANNELS _ 1 & 3 COMBINED_
TYPE OF MESSAGE _ _ ALL COMBINED_

Number of hours sampled (H) _ _ _ _ _ _ 42_ _ _ _
Average number of patrol units ($F_P$)_ _ 28_ _ _ _

$\overline{N}_M$ _ _ 158.1 _ _ _
$\overline{N}_M/\overline{F}_P$ _ 5.7 _ _

$\overline{T}_T$ _ _ 7.1 s _ _
$\overline{T}_{OT}$ _ 1116.2 s _ _
$\overline{T}_{OT}/\overline{F}_P$ 39.9 s _ _

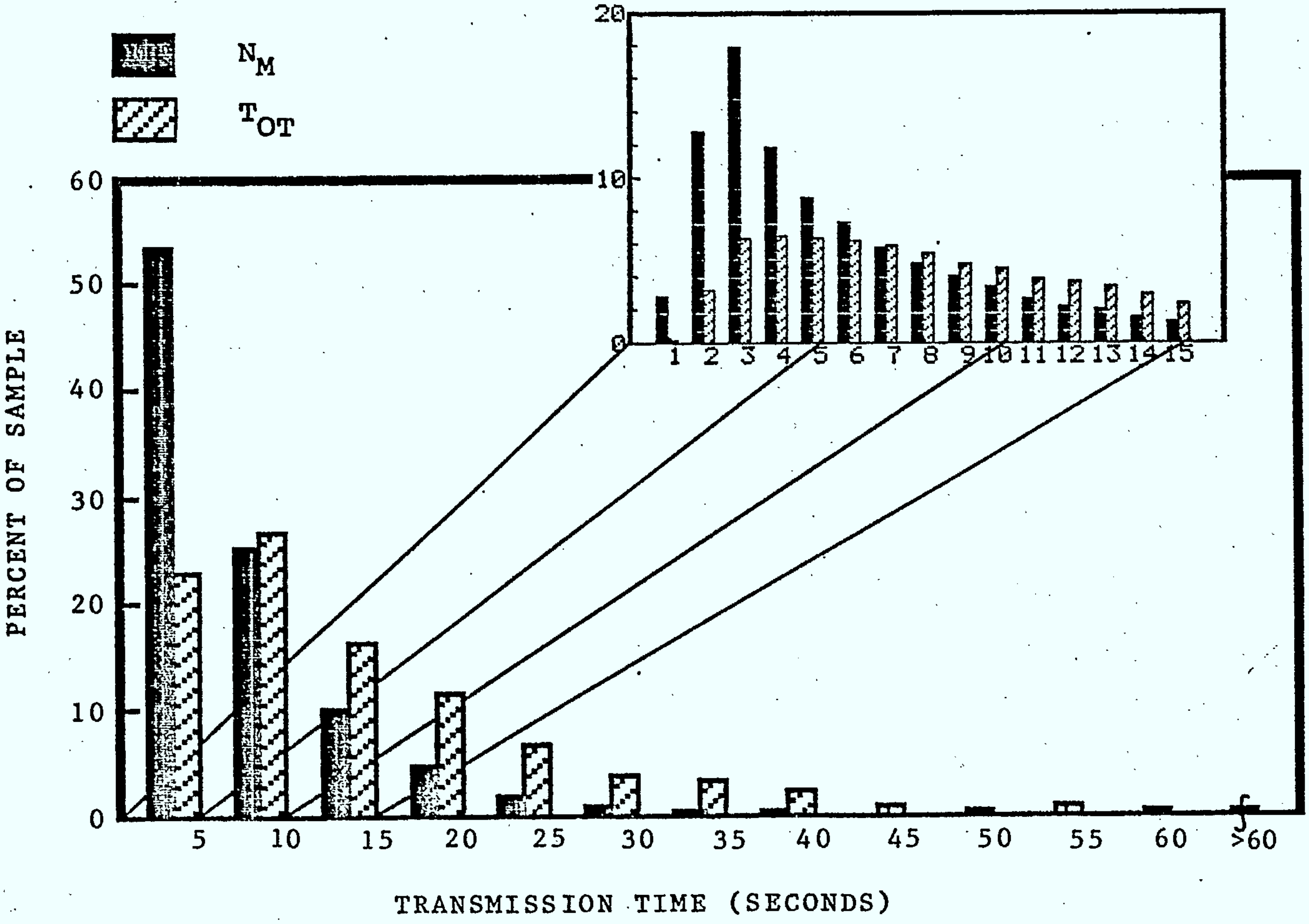


FIGURE 6-29 'AFTER' MRDS - All Message Types Combined
Sample Distribution of Number of Messages ($N_M$) and
Transmission Air-Time Occupancy ($T_{OT}$) Per Hour.

## 'BEFORE' MRDS - 1980

RADIO CHANNELS 1 & 3 COMBINED

TYPE OF MESSAGE 1

Number of hours sampled (H) 34

Average number of patrol units ($F_P$) 17

$\overline{N}_M$ 67.6

$\overline{N}_M/\overline{F}_P$ 4.0

$\overline{T}_T$ 7.9 s

$\overline{T}_{OT}$ 532.8 s

$\overline{T}_{OT}/\overline{F}_P$ 31.3 s

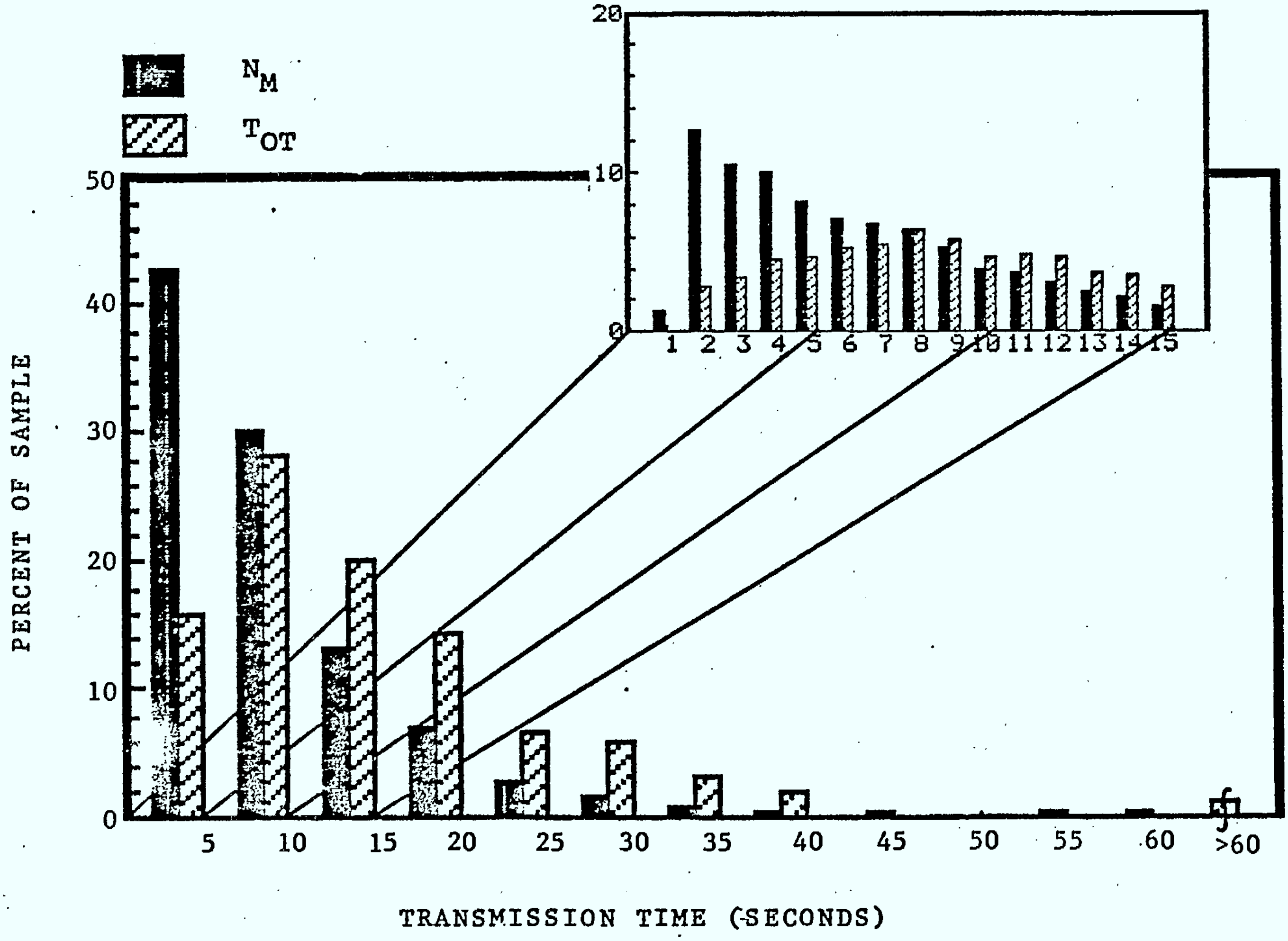


FIGURE 6-30 'BEFORE' MRDS - Message Type 1
Sample Distribution of Number of Messages ($N_M$) and Transmission Air-Time Occupancy ($T_{OT}$) Per Hour.

## 'AFTER' MRDS - 1982

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE 1

Number of hours sampled (H) 42
Average number of patrol units ($F_P$) 28

$\overline{N}_M$ 71.9
$\overline{N}_M/\overline{F}_P$ 2.6
$\overline{T}_T$ 8.2 s
$\overline{T}_{OT}$ 588.4 s
$\overline{T}_{OT}/\overline{F}_P$ 21.0 s

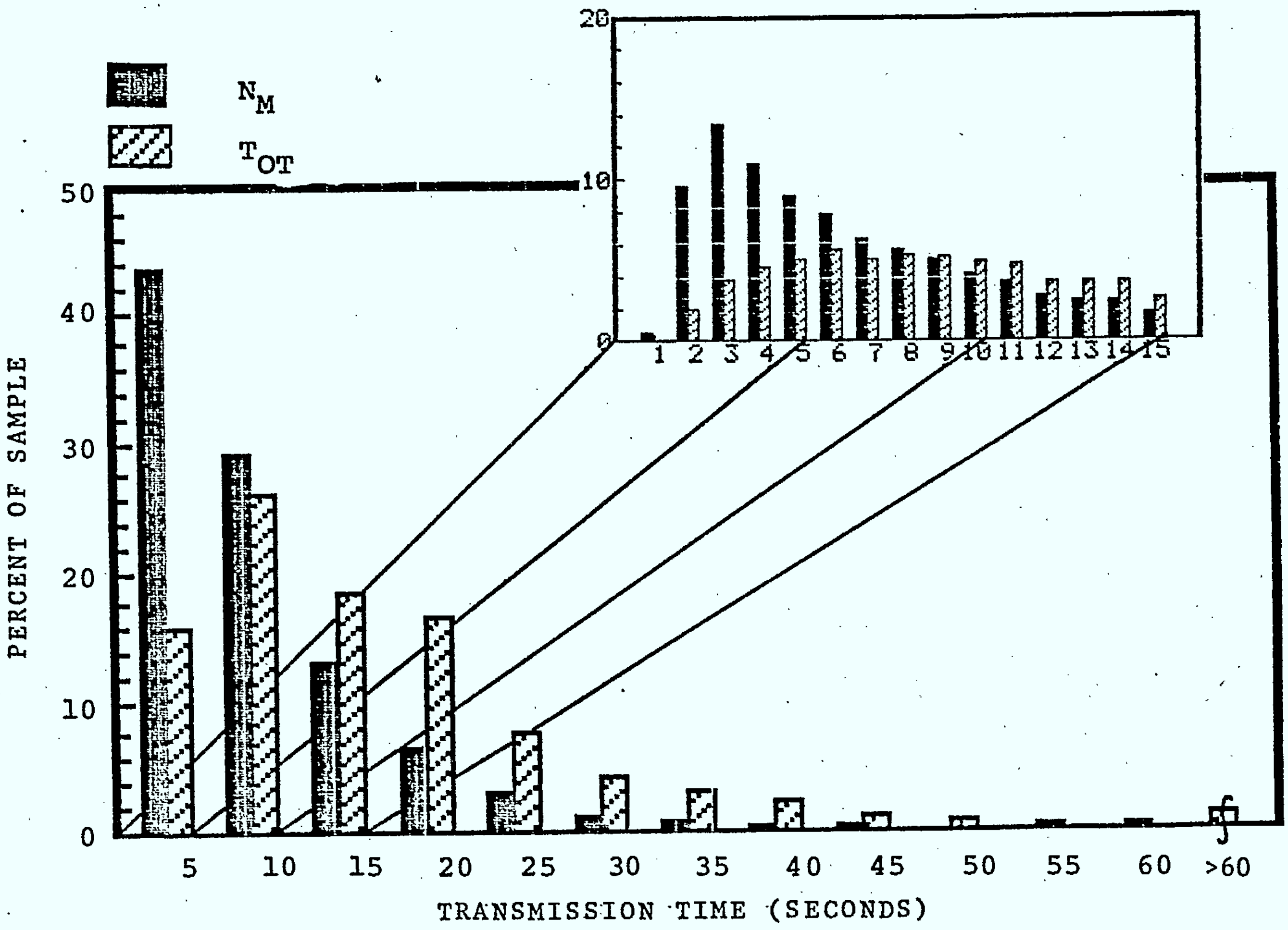


FIGURE 6-31 'AFTER' MRDS - Message Type 1
Sample Distribution of Number of Messages ($N_M$) and Transmission Air-Time Occupancy ($T_{OT}$) Per Hour.

## 'BEFORE' MRDS - 1980

RADIO CHANNELS 1 & 3 COMBINED

TYPE OF MESSAGE 2

Number of hours sampled (H) 34

Average number of patrol units ($F_P$) 17

$\overline{N}_M$ 0.5

$\overline{N}_M / \overline{F}_P$ 0.03

$\overline{T}_T$ 4.2 s

$\overline{T}_{OT}$ 2.1 s

$\overline{T}_{OT} / \overline{F}_P$ 0.1 s

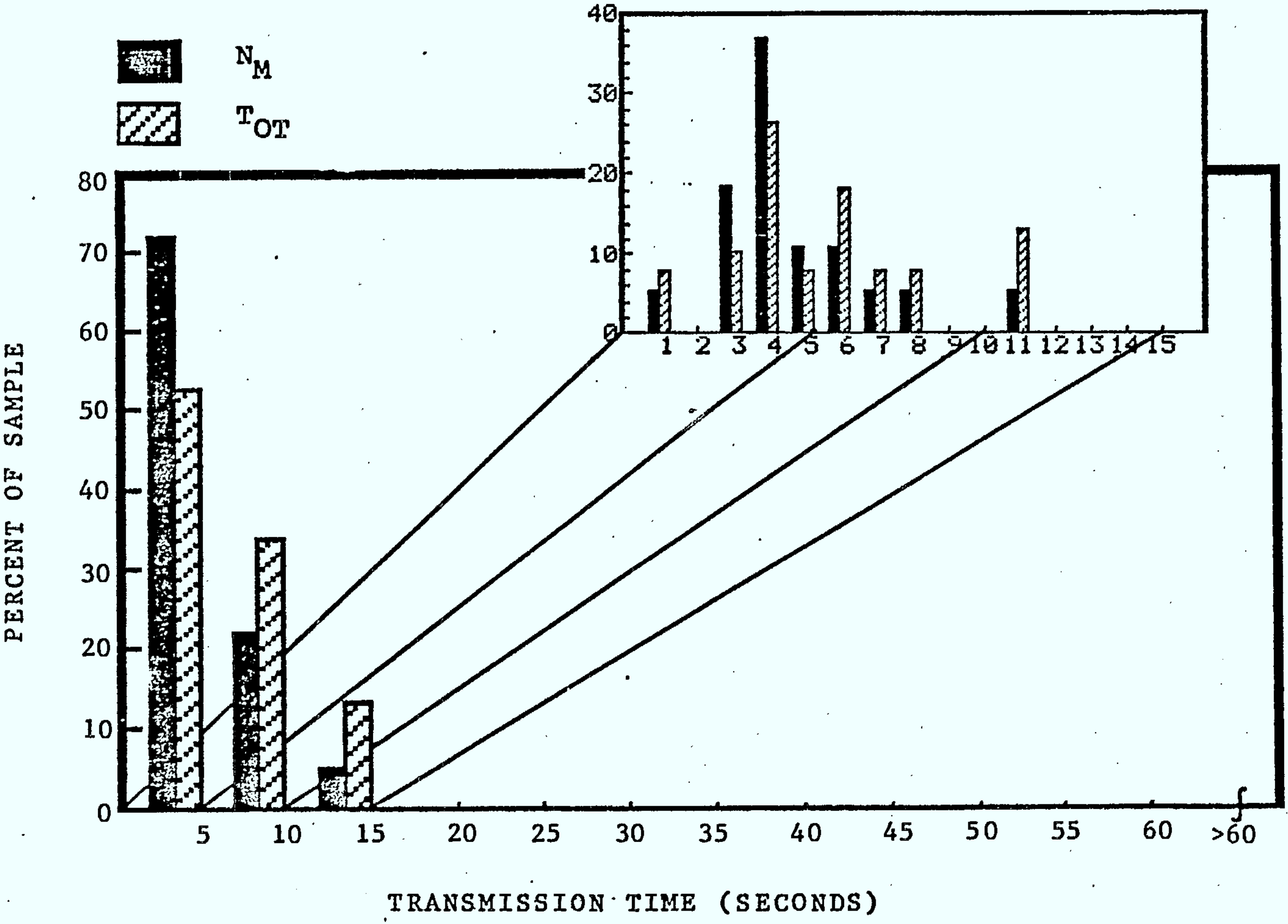


FIGURE 6-32 'BEFORE' MRDS - Message Type 2
Sample Distribution of Number of Messages ($N_M$) and Transmission Air-Time Occupancy ($T_{OT}$) Per Hour.

## 'AFTER' MRDS - 1982

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE 2

Number of hours sampled (H) 42
Average number of patrol units ($F_P$) 28

$\overline{N}_M$ 0.9
$\overline{N}_M/\overline{F}_P$ 0.03

$\overline{T}_T$ 5.1 s
$\overline{T}_{OT}$ 4.6 s
$\overline{T}_{OT}/\overline{F}_P$ 0.2 s

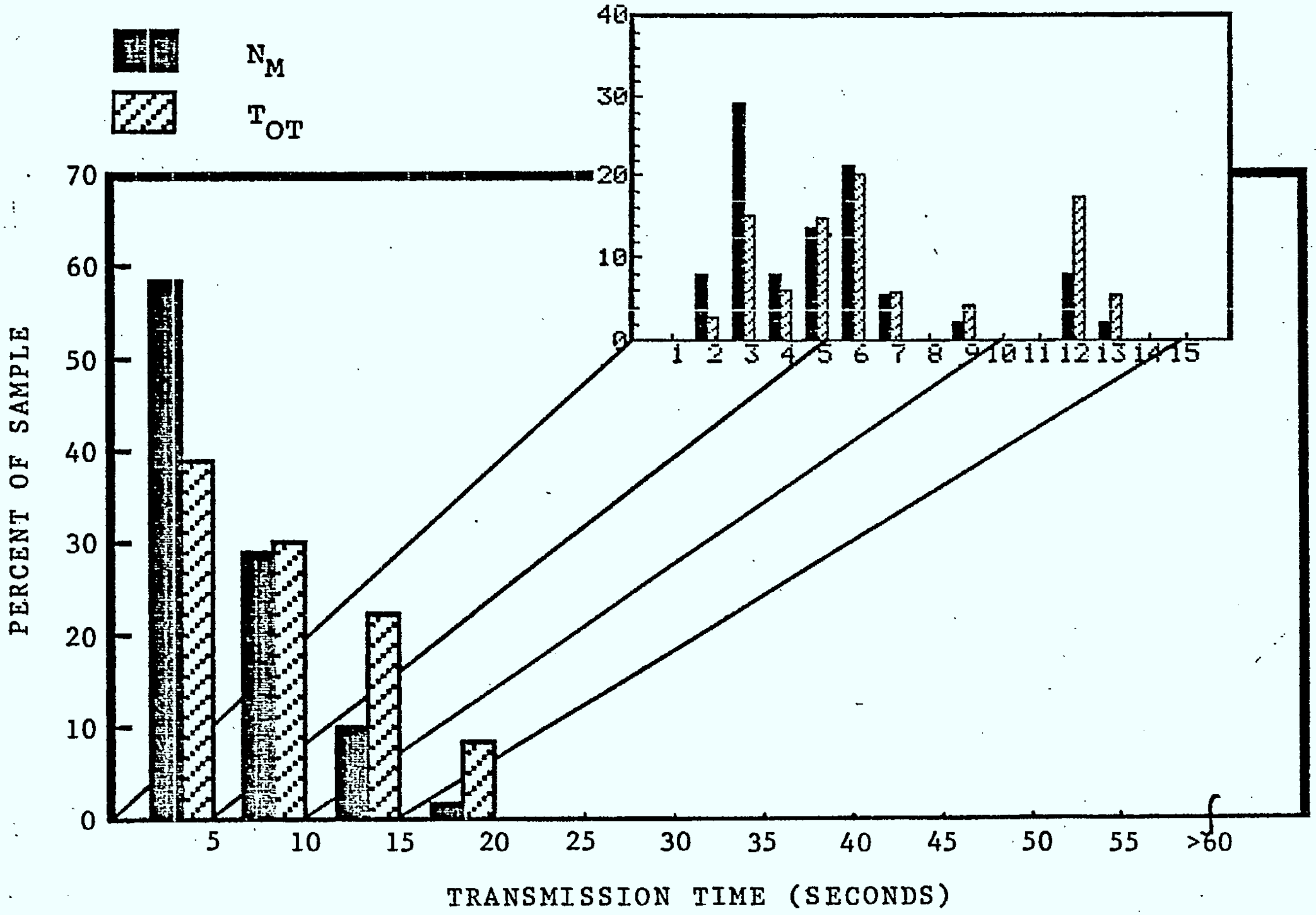


FIGURE 6-33 'AFTER' MRDS - Message Type 2
Sample Distribution of Number of Messages ($N_M$) and Transmission Air-Time Occupancy ($T_{OT}$) Per Hour.

## 'BEFORE' MRDS - 1980

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE 3

Number of hours sampled (H) 34
Average number of patrol units ($F_P$) 17

$\overline{N}_M$ 22.6 $\overline{T}_T$ 3.6 s
$\overline{N}_M/\overline{F}_P$ 1.3 $\overline{T}_{OT}$ 80.7 s
$\overline{T}_{OT}/\overline{F}_P$ 4.8 s

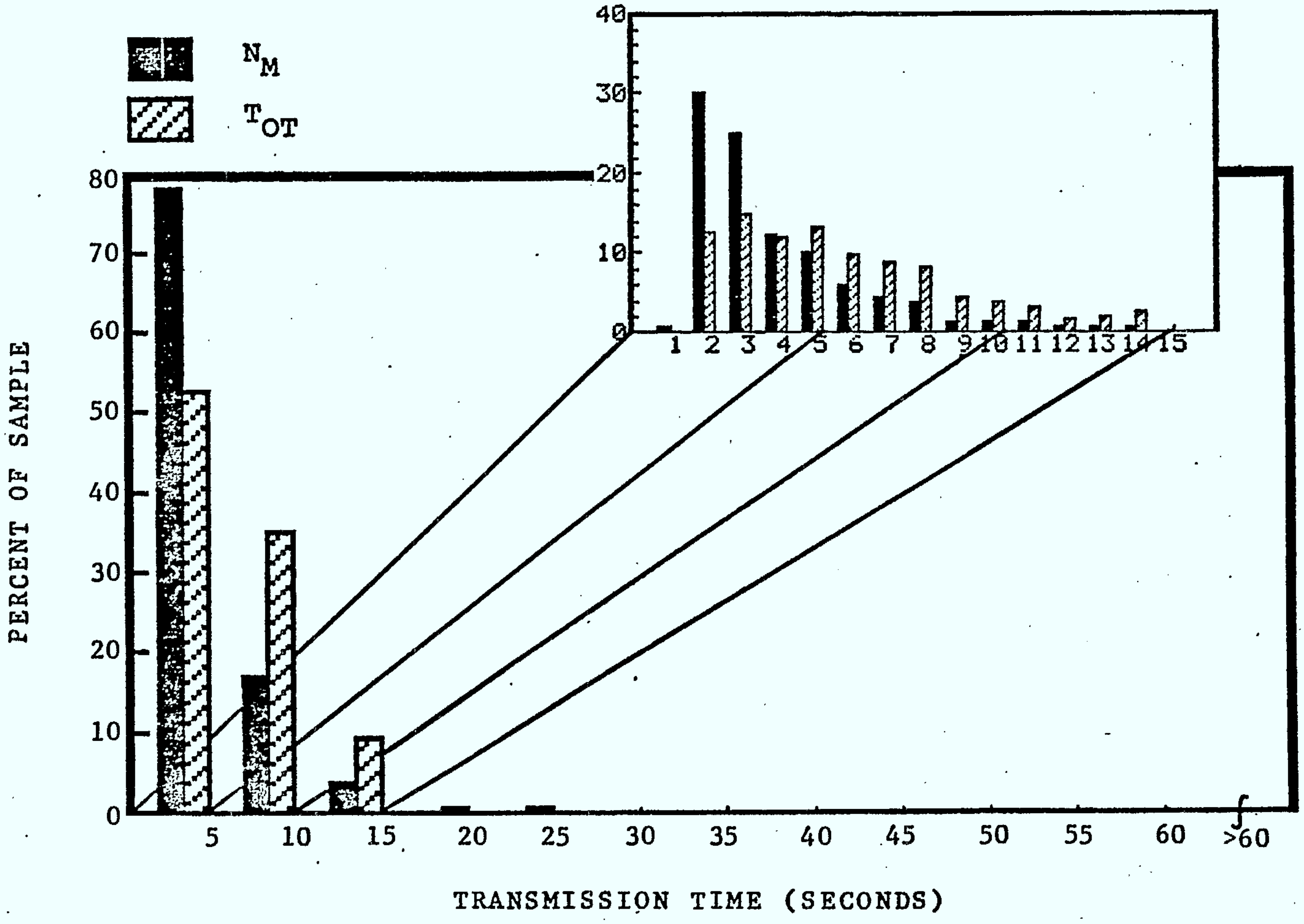


FIGURE 6- 34 'BEFORE' MRDS - Message Type 3
Sample Distribution of Number of Messages ($N_M$) and Transmission Air-Time Occupancy ($T_{OT}$) Per Hour.

# 'AFTER' MRDS - 1982

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE 3

Number of hours sampled (H) 42
Average number of patrol units ($F_P$) 28

$\overline{N}_M$ 29.6
$\overline{N}_M / \overline{F}_P$ 1.1
$\overline{T}_T$ 4.2 s
$\overline{T}_{OT}$ 123.0 s
$\overline{T}_{OT} / \overline{F}_P$ 4.4 s

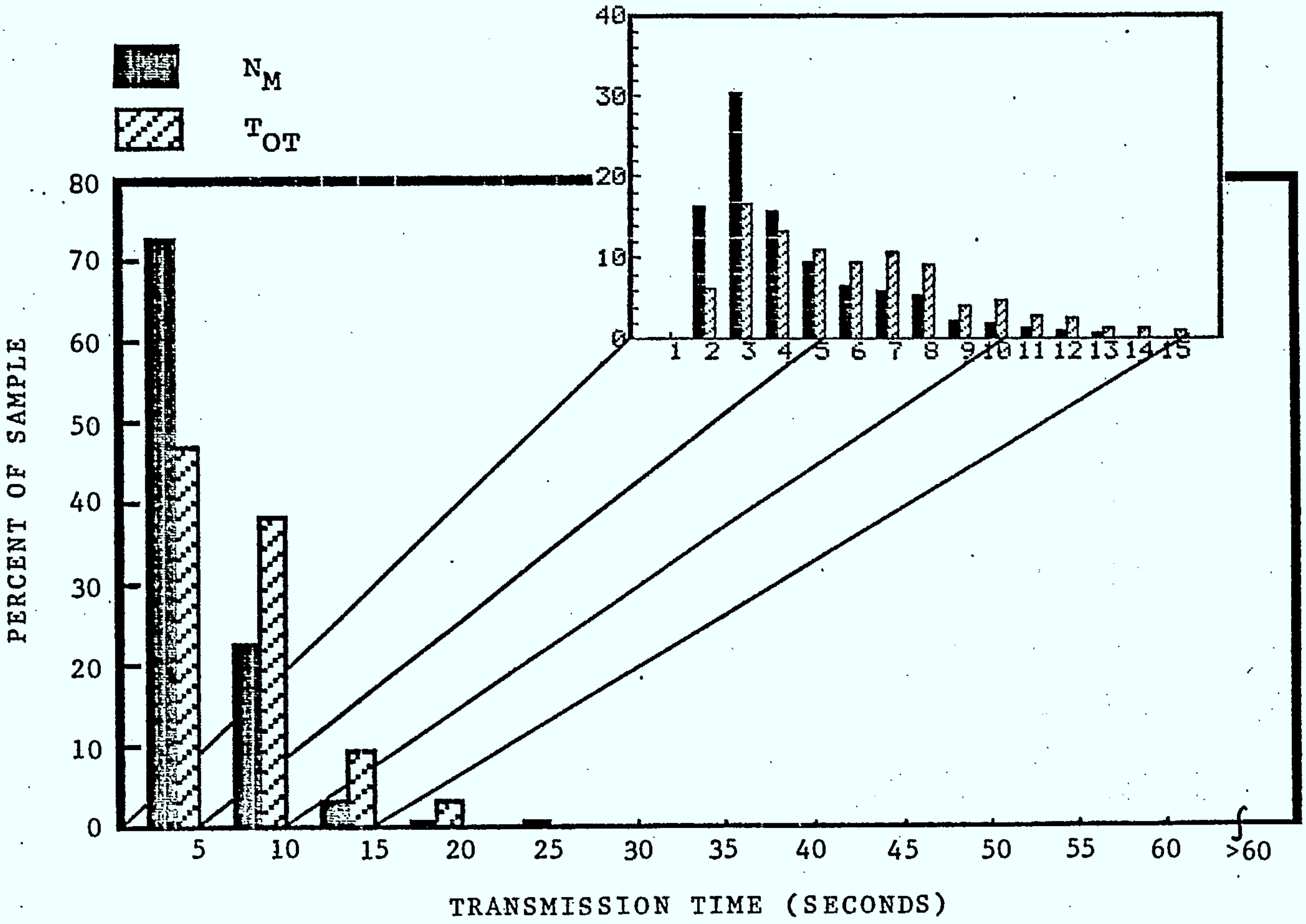


FIGURE 6-35 'AFTER' MRDS - Message Type 3
Sample Distribution of Number of Messages ($N_M$) and Transmission Air-Time Occupancy ($T_{OT}$) Per Hour.

# 'BEFORE' MRDS - 1980

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE 4

Number of hours sampled (H) 34
Average number of patrol units ($F_P$) 17

$\overline{N}_M$ 25.0
$\overline{N}_M / \overline{F}_P$ 1.5

$\overline{T}_T$ 8.9 s
$\overline{T}_{OT}$ 223.4 s
$\overline{T}_{OT} / \overline{F}_P$ 13.1 s

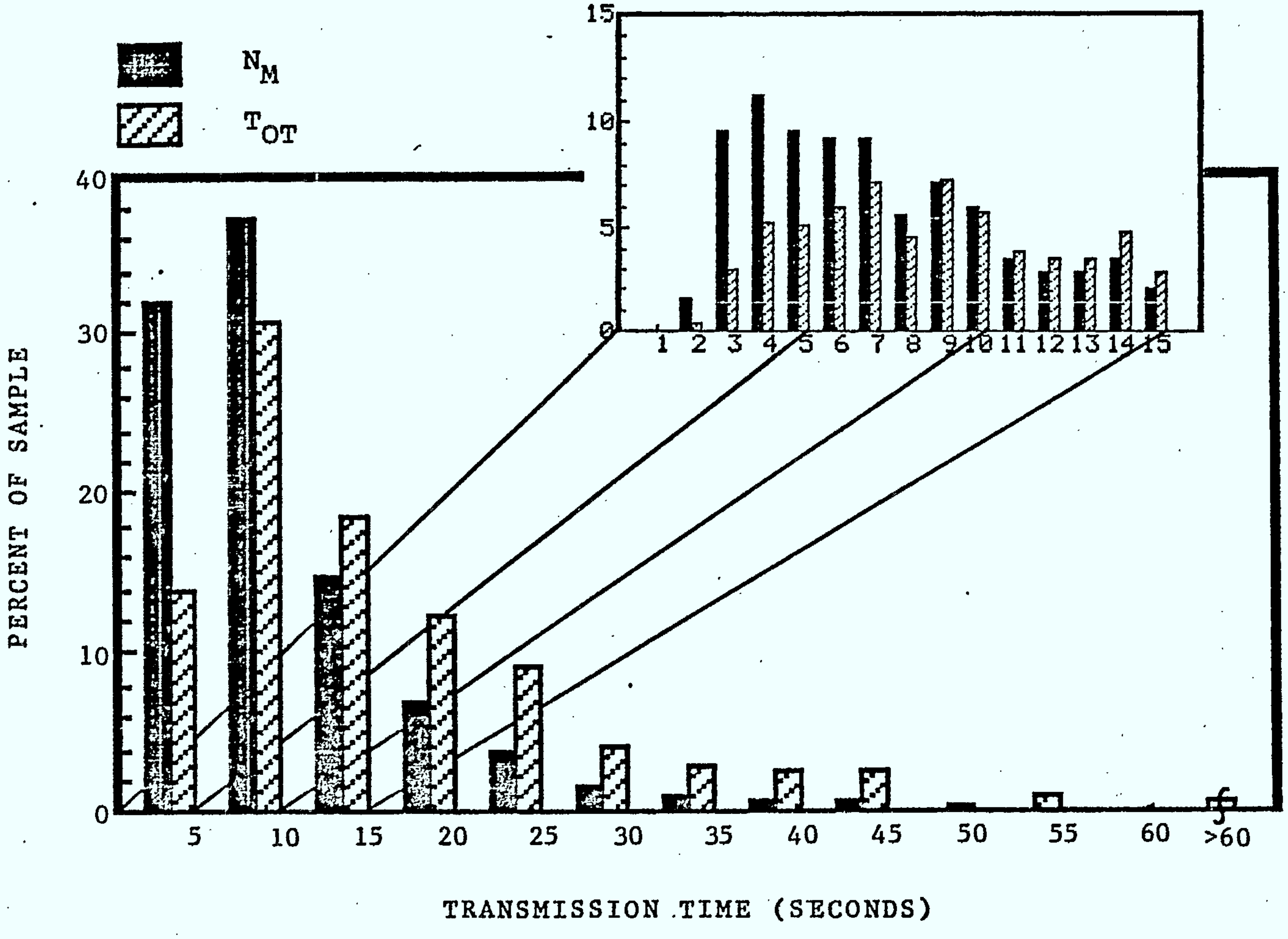


FIGURE 6-36 'BEFORE' MRDS - Message Type 4
Sample Distribution of Number of Messages ($N_M$) and Transmission Air-Time Occupancy ($T_{OT}$) Per Hour.

## 'AFTER' MRDS - 1982

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE 4

Number of hours sampled (H) 42
Average number of patrol units ($F_P$) 28

$\overline{N}_M$ 25.8
$\overline{N}_M / \overline{F}_P$ 0.9
$\overline{T}_T$ 8.9 s
$\overline{T}_{OT}$ 229.1 s
$\overline{T}_{OT} / \overline{F}_P$ 8.2 s

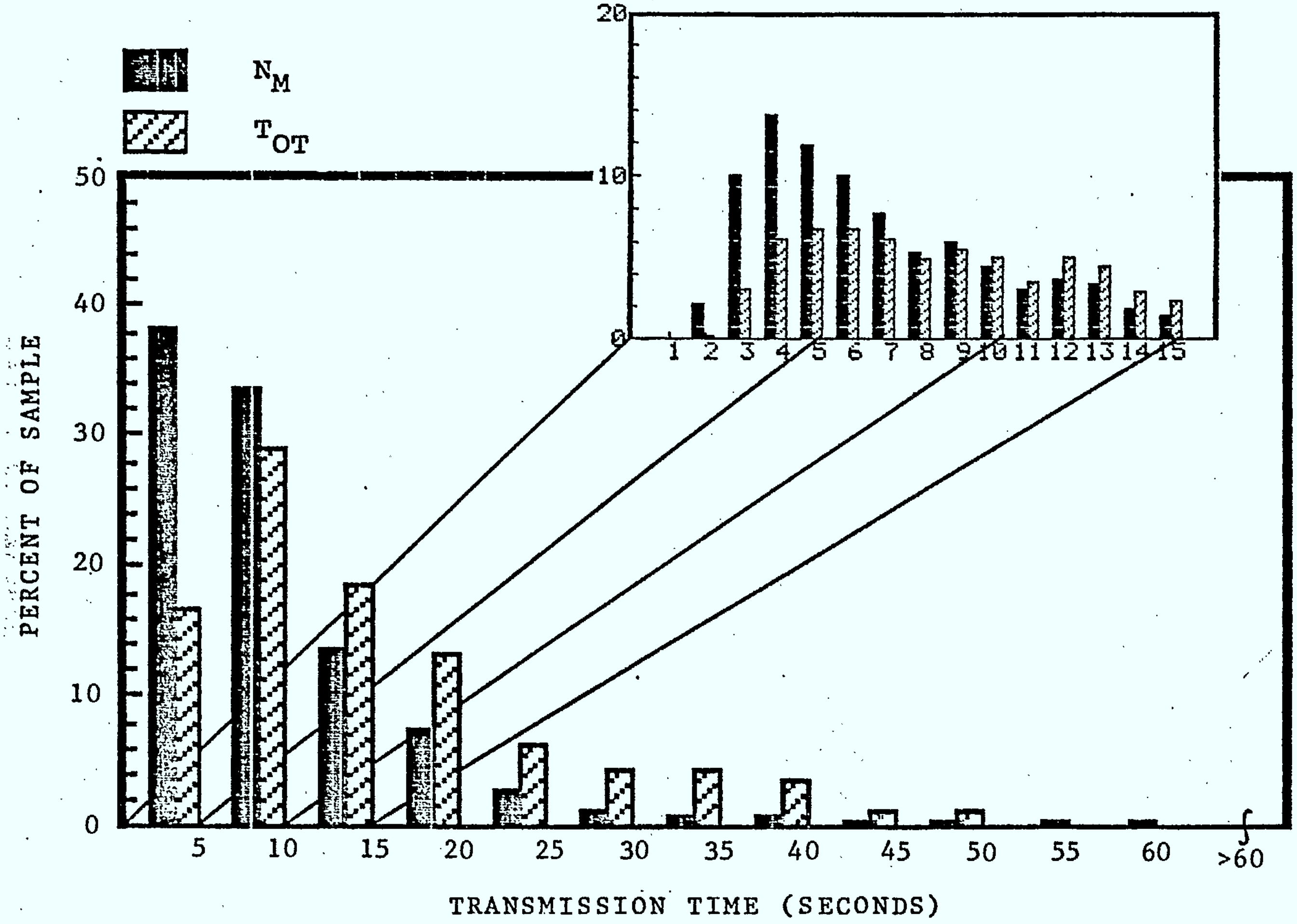


FIGURE 6-37 'AFTER' MRDS - Message Type 4
Sample Distribution of Number of Messages ($N_M$) and Transmission Air-Time Occupancy ($T_{OT}$) Per Hour.

## 'BEFORE' MRDS - 1980

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE 5

Number of hours sampled (H) 34
Average number of patrol units ($F_P$) 17

$\overline{N}_M$ 11.2
$\overline{T}_T$ 8.8 s
$\overline{N}_M / \overline{F}_P$ 0.7
$\overline{T}_{OT}$ 120.3 s
$\overline{T}_{OT} / \overline{F}_P$ 7.1 s

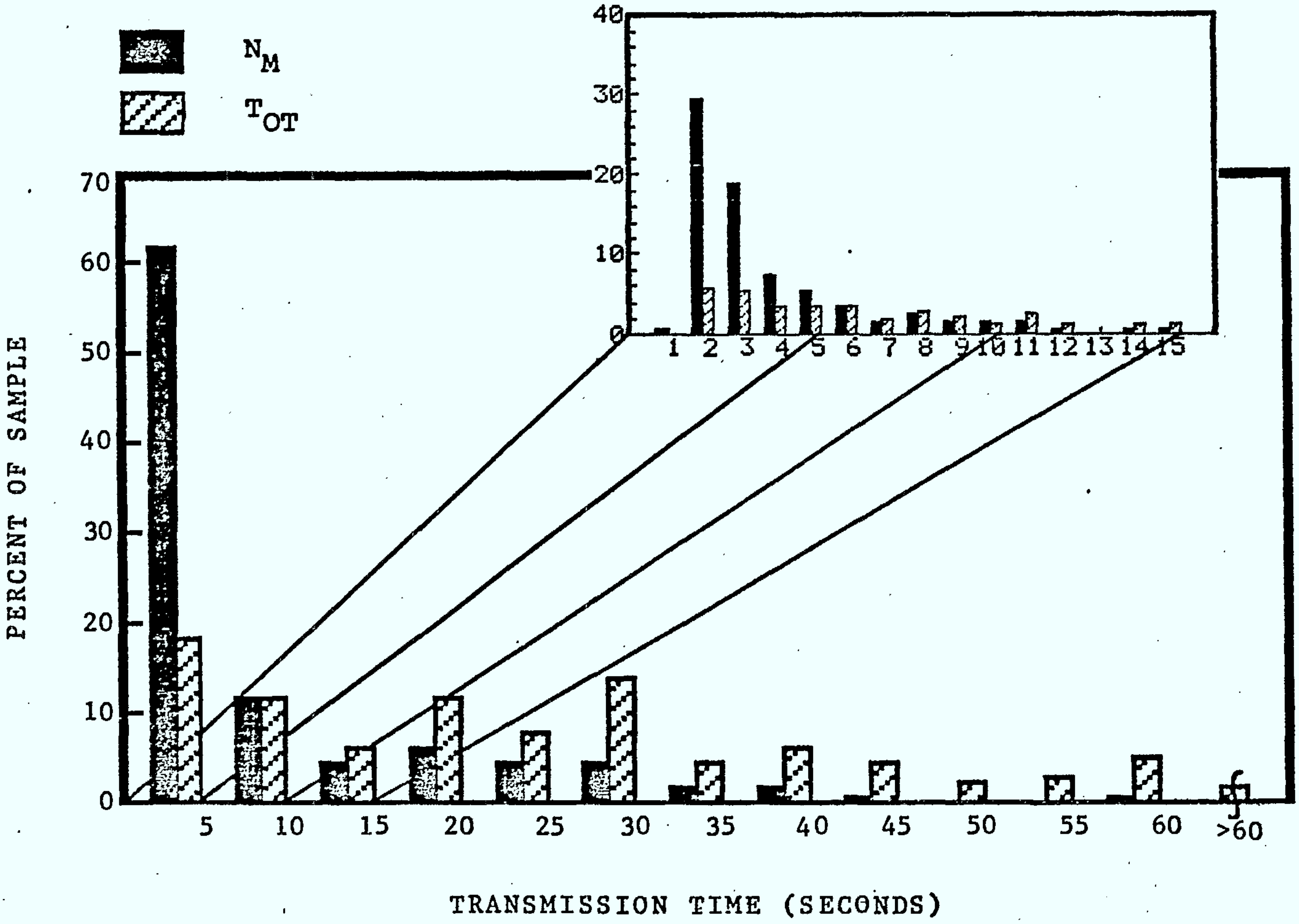


FIGURE 6-38 'BEFORE' MRDS - Message Type 5
Sample Distribution of Number of Messages ($N_M$) and Transmission Air-Time Occupancy ($T_{OT}$) Per Hour.

# 'AFTER' MRDS - 1982

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE 5

Number of hours sampled (H) 42
Average number of patrol units ($F_P$) 28

$\overline{N}_M$ 11.0
$\overline{T}_T$ 8.4 s
$\overline{N}_M/\overline{F}_P$ 0.4
$\overline{T}_{OT}$ 92.8 s
$\overline{T}_{OT}/\overline{F}_P$ 3.3 s

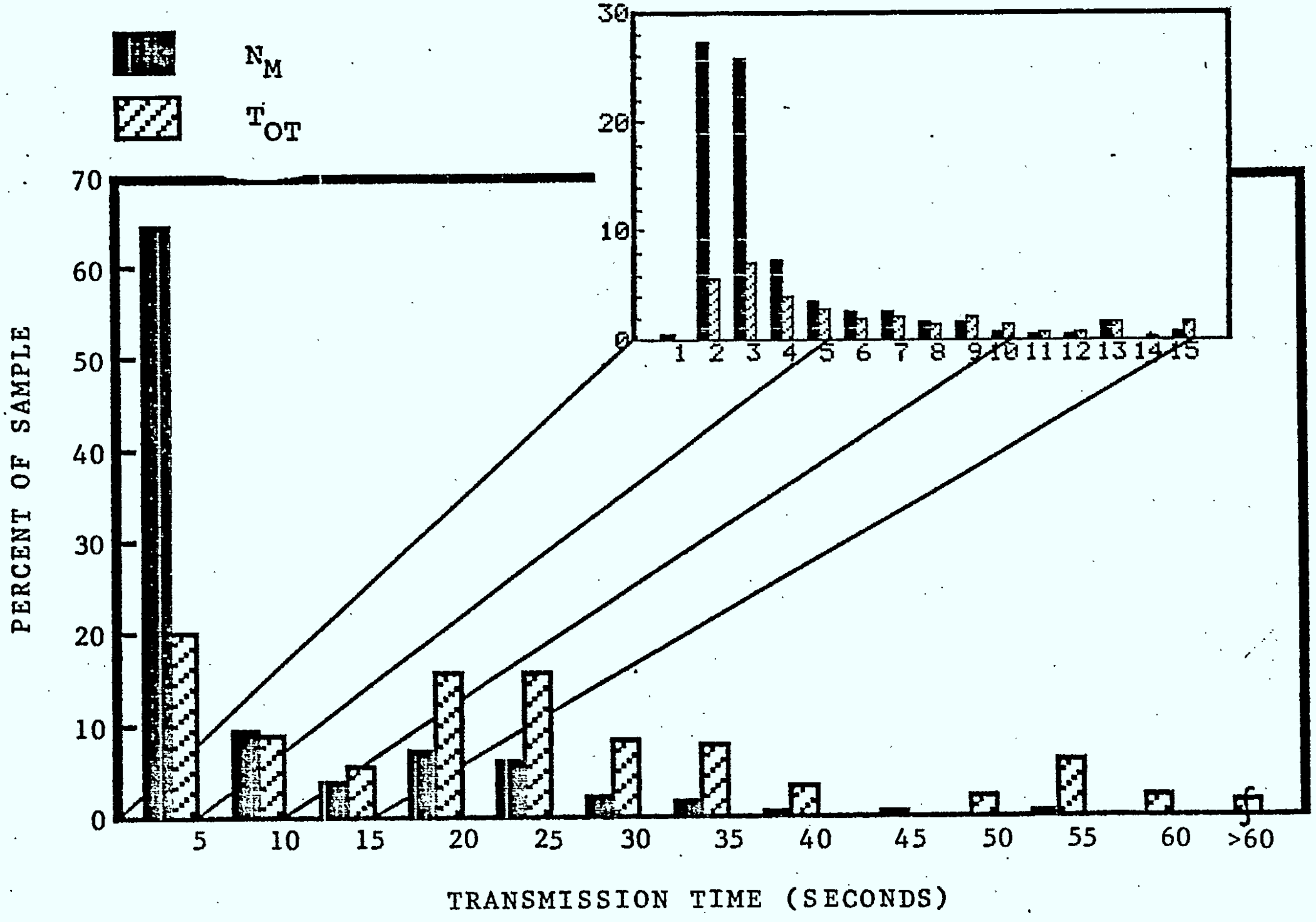


FIGURE 6-39 'AFTER' MRDS - Message Type 5
Sample Distribution of Number of Messages ($N_M$) and Transmission Air-Time Occupancy ($T_{OT}$) Per Hour.

## 'BEFORE' MRDS - 1980

RADIO CHANNELS 1 & 3 COMBINED
TYPE OF MESSAGE 6

Number of hours sampled (H) 34
Average number of patrol units ($F_P$) 17

$\overline{N}_M$ 21.4
$\overline{N}_M / \overline{F}_P$ 1.3

$\overline{T}_T$ 4.2 s
$\overline{T}_{OT}$ 89.5 s
$\overline{T}_{OT} / \overline{F}_P$ 5.3 s

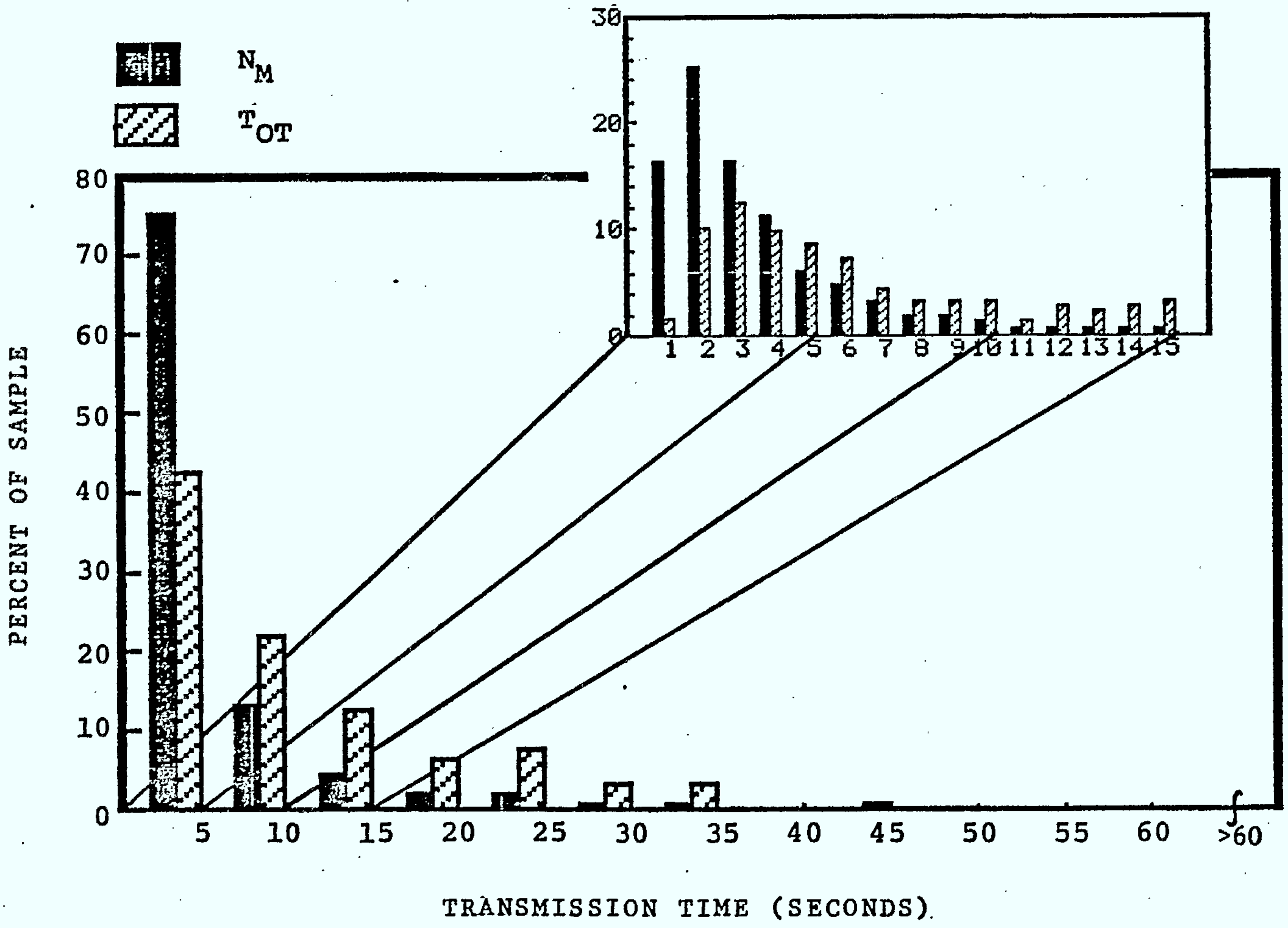


FIGURE 6-40 'BEFORE' MRDS - Message Type 6
Sample Distribution of Number of Messages ($N_M$) and Transmission Air-Time Occupancy ($T_{OT}$) Per Hour.

## 'AFTER' MRDS - 1982

RADIO CHANNELS 1 & 3 COMBINED

TYPE OF MESSAGE 6

Number of hours sampled (H) 42

Average number of patrol units ($F_P$) 28

$\overline{N}_M$ 18.9

$\overline{T}_T$ 4.1 s

$\overline{N}_M/\overline{F}_P$ 0.7

$\overline{T}_{OT}$ 78.3 s

$\overline{T}_{OT}/\overline{F}_P$ 2.8 s

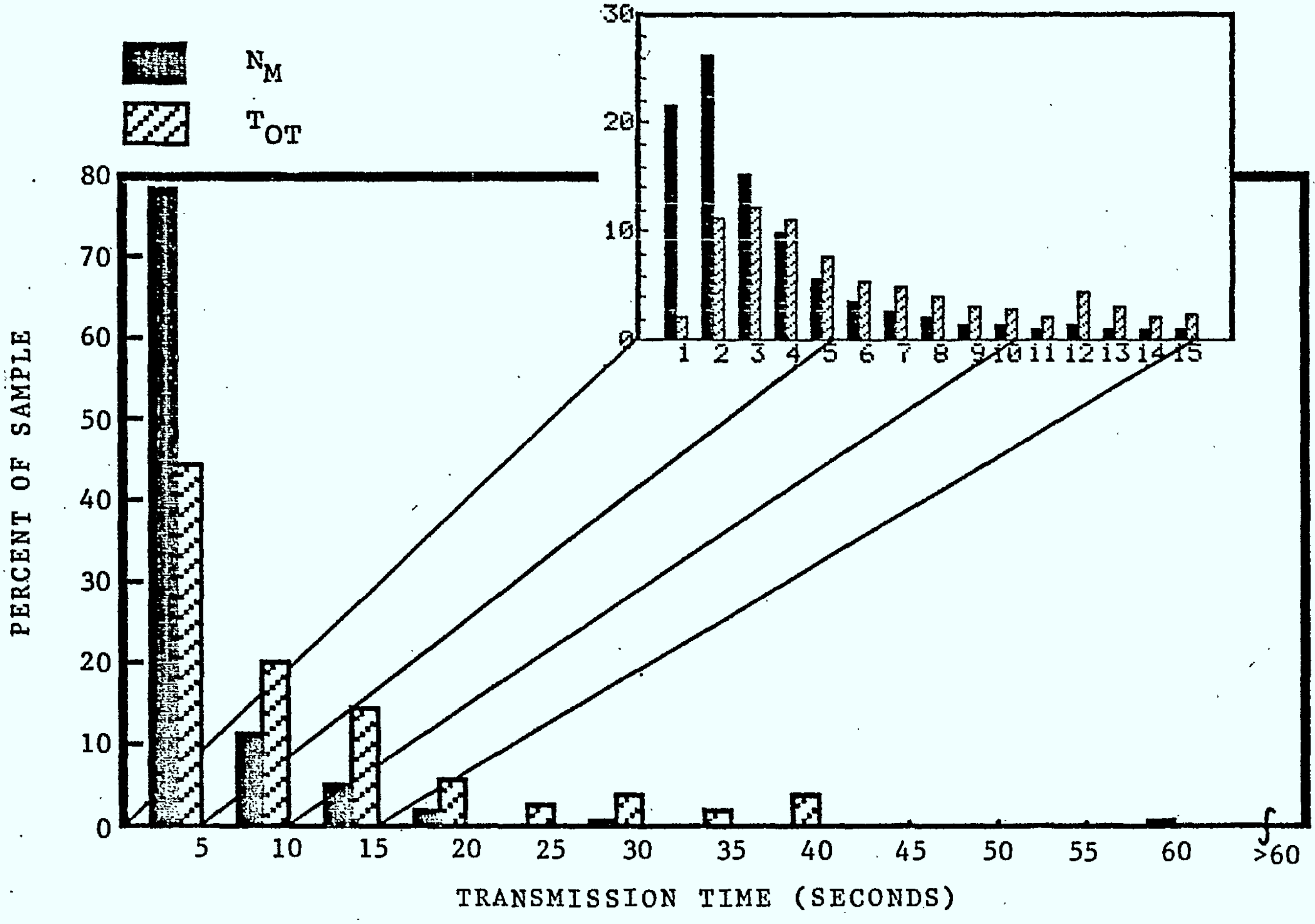


FIGURE 6-41 'AFTER' MRDS - Message Type 6

Sample Distribution of Number of Messages ($N_M$) and Transmission Air-Time Occupancy ($T_{OT}$) Per Hour.

## 'AFTER' MRDS - 1982

RADIO CHANNELS _ _ _ DATA _ _ _ _
TYPE OF MESSAGE _ ALL COMBINED _ _

Number of hours sampled (H) _ _ _ _ 21 _ _
Average number of MRDS terminals in the field ($F_M$) _ _ 40.7 _
Average number of MRDS terminals originating ($F_O$) _ _ 29.0 _

$\overline{N}_M$ _ _ _ 235.2 _ _
$\overline{N}_M/\overline{F}_M$ _ _ 5.8 _ _

$\overline{T}_M$ _ _ _ 0.3 s _
$\overline{T}_{OM}$ _ _ _ 79.2 s _
$\overline{T}_{OM}/\overline{F}_M$ _ 2.0 s _

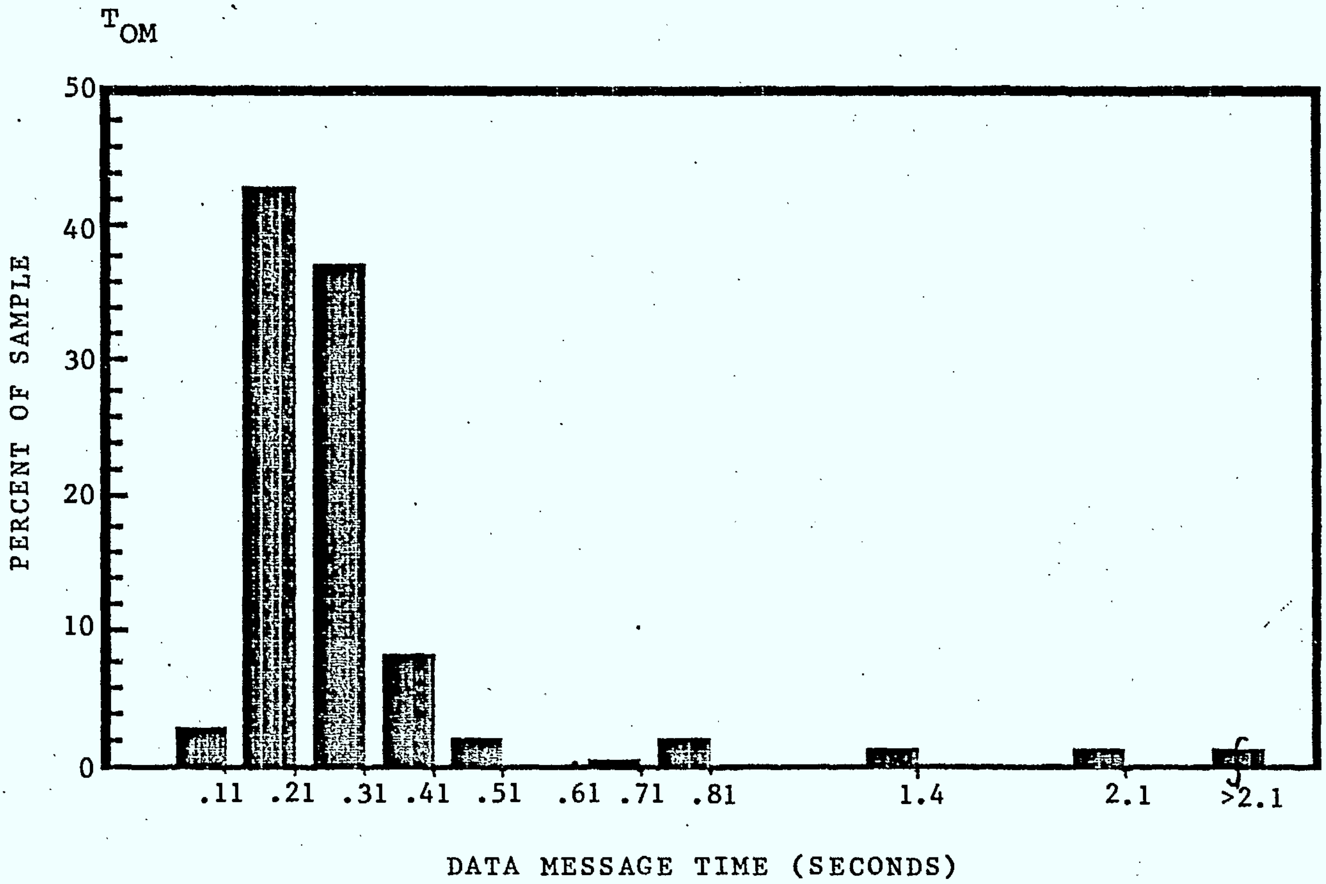


FIGURE 6-42 'AFTER' MRDS - All Data Message Types Combined
Sample Distribution of Message Air-Time Occupancy ($T_{OM}$)
Per Hour.

# 'AFTER' MRDS - 1982

RADIO CHANNELS __ DATA ______

TYPE OF MESSAGE ___ 3 ______

Number of hours sampled (H) ____ 21 __

Average number of MRDS terminals in the field ($F_M$) __ 40.7 _

Average number of MRDS terminals originating ($F_O$) __ 29.0 _

$\overline{N}_M$ ____ 15.6 __

$\overline{N}_M / \overline{F}_M$ _ 0.4 __

$\overline{T}_M$ ____ 0.2 s _

$\overline{T}_{OM}$ ____ 3.3 s _

$\overline{T}_{OM} / \overline{F}_M$ _ 0.1 s _

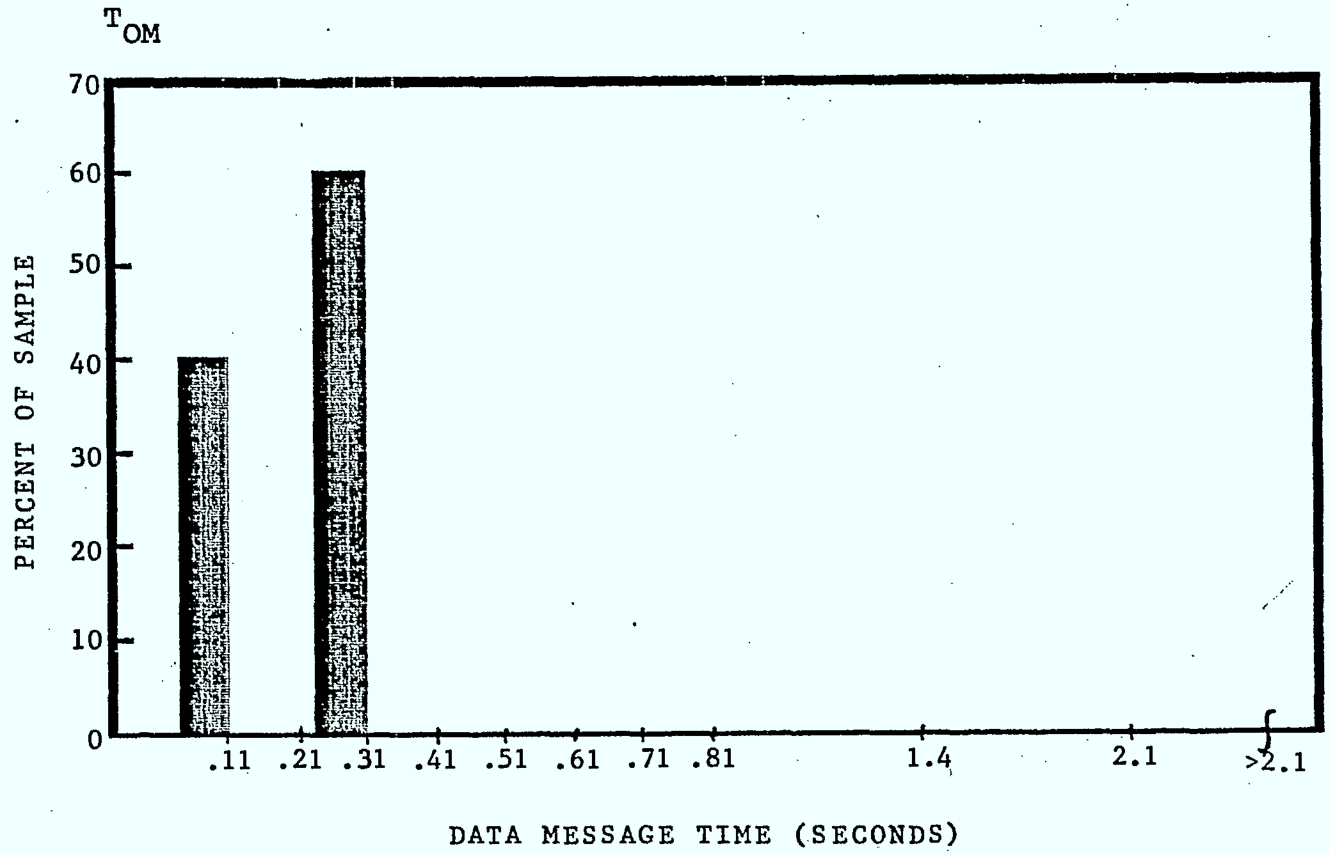


FIGURE 6-43 'AFTER' MRDS - Data Message Type 3 Sample Distribution of Message Air-Time Occupancy ($T_{OM}$) Per Hour.

# 'AFTER' MRDS - 1982

RADIO CHANNELS _ _ DATA _ _ _ _ _
TYPE OF MESSAGE _ _ _ 4 _ _ _ _ _

Number of hours sampled (H) _ _ _ _21 _ _
Average number of MRDS terminals in the field ($F_M$) _ _40.7 _
Average number of MRDS terminals originating ($F_O$) _ _29.0 _

$\overline{N}_M$ _ _ _ 90.7 _ _

$\overline{N}_M / \overline{F}_M$ _ _2.3 _ _

$\overline{T}_M$ _ _ _ 0.2 s _

$\overline{T}_{OM}$ _ _ _18.2 s _

$\overline{T}_{OM} / \overline{F}_M$ _ 0.4 s _

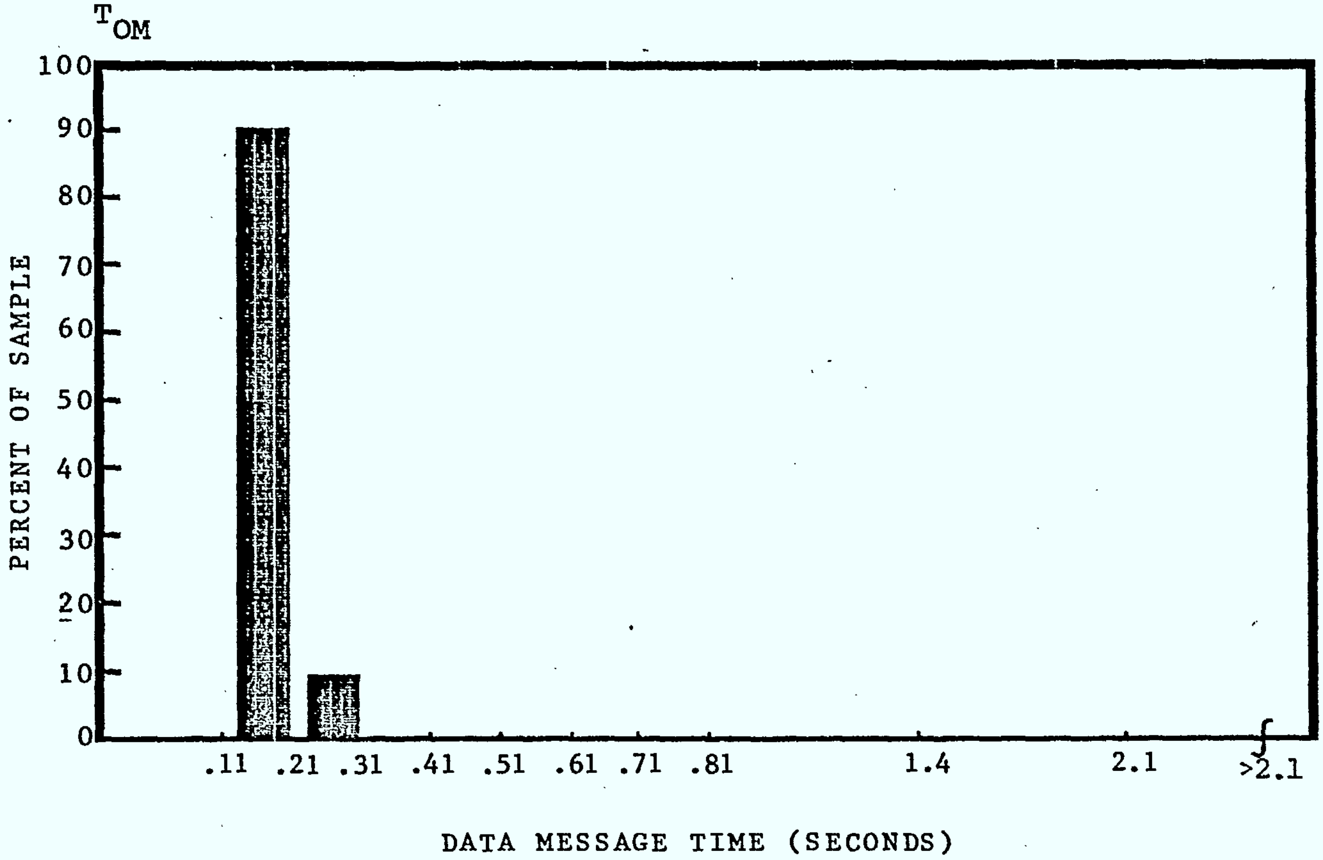


FIGURE 6-44 'AFTER' MRDS - Data Message Type 4
Sample Distribution of Message Air-Time Occupancy ($T_{OM}$) Per Hour.

## 'AFTER' MRDS - 1982

RADIO CHANNELS _ _ _ DATA _ _ _ _

TYPE OF MESSAGE _ _ _ _ 5 _ _ _ _

Number of hours sampled (H) _ _ _ _ 21 _ _

Average number of MRDS terminals in the field ($F_M$) _ _ 40.7 _

Average number of MRDS terminals originating ($F_O$) _ _ 29.0 _

$\overline{N}_M$ _ _ _ 75.0 _ _

$\overline{N}_M/\overline{F}_M$ _ _ 1.8 _ _

$\overline{T}_M$ _ _ _ 0.5 s _

$\overline{T}_{OM}$ _ _ _ 40.7 s _

$\overline{T}_{OM}/\overline{F}_M$ _ 1.0 s _

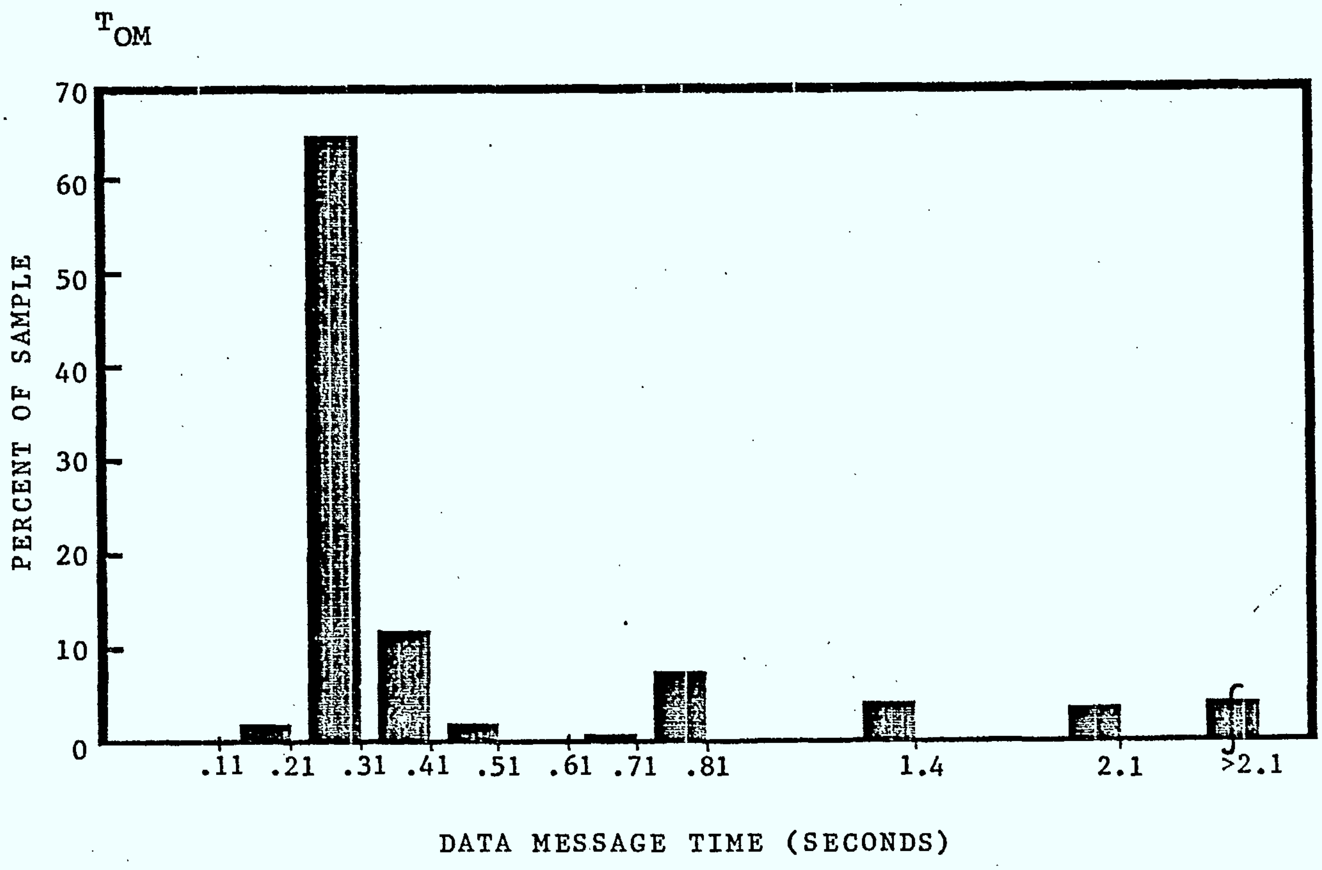


FIGURE 6-45 'AFTER' MRDS - Data Message Type 5
Sample Distribution of Message Air-Time Occupancy ($T_{OM}$) Per Hour.

## 'AFTER' MRDS - 1982

RADIO CHANNELS ____ DATA ____

TYPE OF MESSAGE ____ 6 ____

Number of hours sampled (H) ____ 21 __

Average number of MRDS terminals in the field ($F_M$) __ 40.7 __

Average number of MRDS terminals originating ($F_O$) __ 29.0 __

$\overline{N}_M$ ___ 37.4 __

$\overline{N}_M/\overline{F}_M$ __ 0.9 __

$\overline{T}_M$ ___ 0.3 s __

$\overline{T}_{OM}$ ___ 10.6 s __

$\overline{T}_{OM}/\overline{F}_M$ __ 0.3 s __

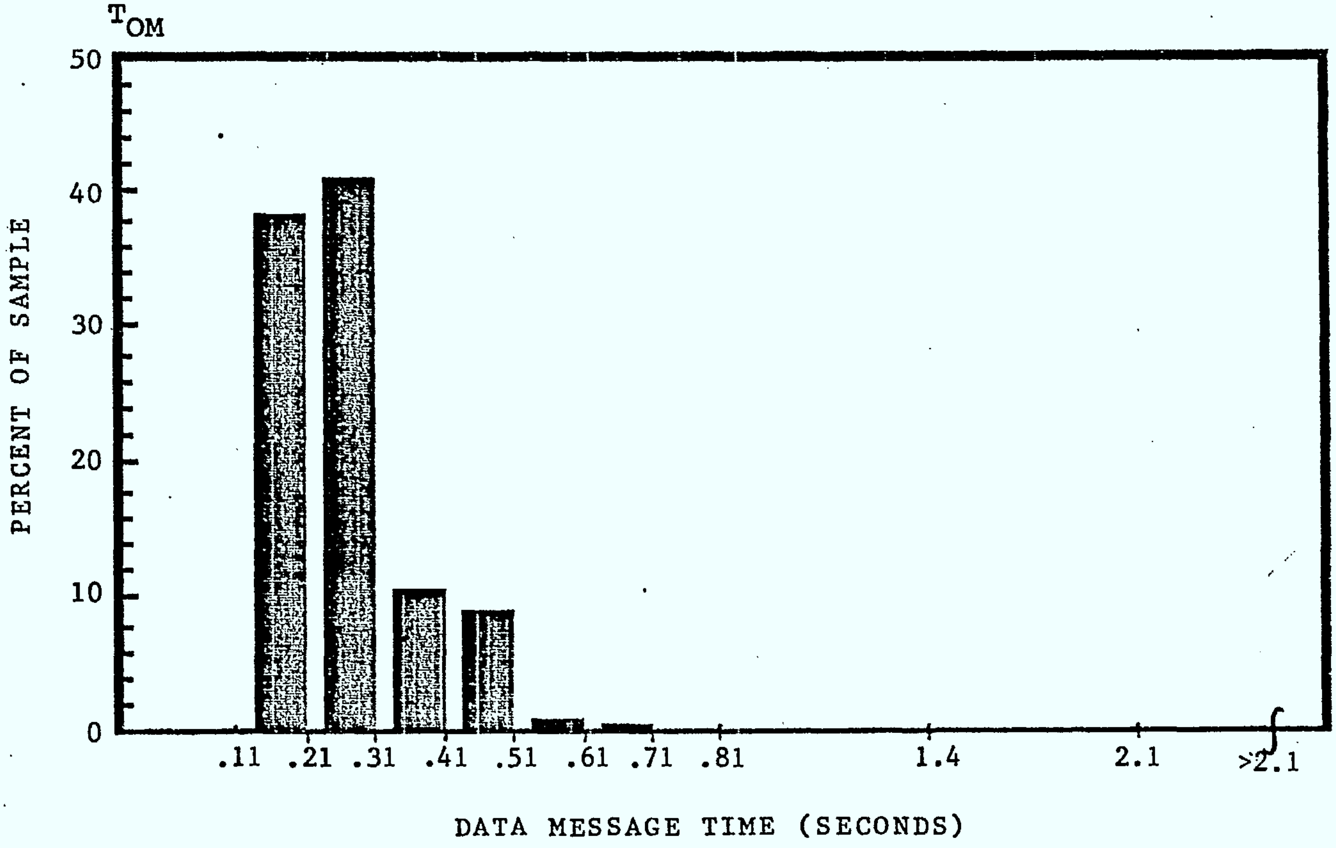


FIGURE 6-46 'AFTER' MRDS - Data Message Type 6
Sample Distribution of Message Air-Time Occupancy ($T_{OM}$) Per Hour.

# 'AFTER' MRDS - 1982

RADIO CHANNELS _ _ _ DATA _ _ _ _
TYPE OF MESSAGE _ _ _ ERROR _ _ _

Number of hours sampled (H) _ _ _ _ 21 _ _
Average number of MRDS terminals in the field ($F_M$) _ _ 40.7 _
Average number of MRDS terminals originating ($F_O$) _ _ 29.0 _

$\overline{N}_M$ _ _ _ _ 16.5 _ _
$\overline{N}_M / \overline{F}_M$ _ _ 0.4 _ _

$\overline{T}_M$ _ _ _ _ 0.4 s _
$\overline{T}_{OM}$ _ _ _ _ 6.3 s _
$\overline{T}_{OM} / \overline{F}_M$ _ 0.2 s _

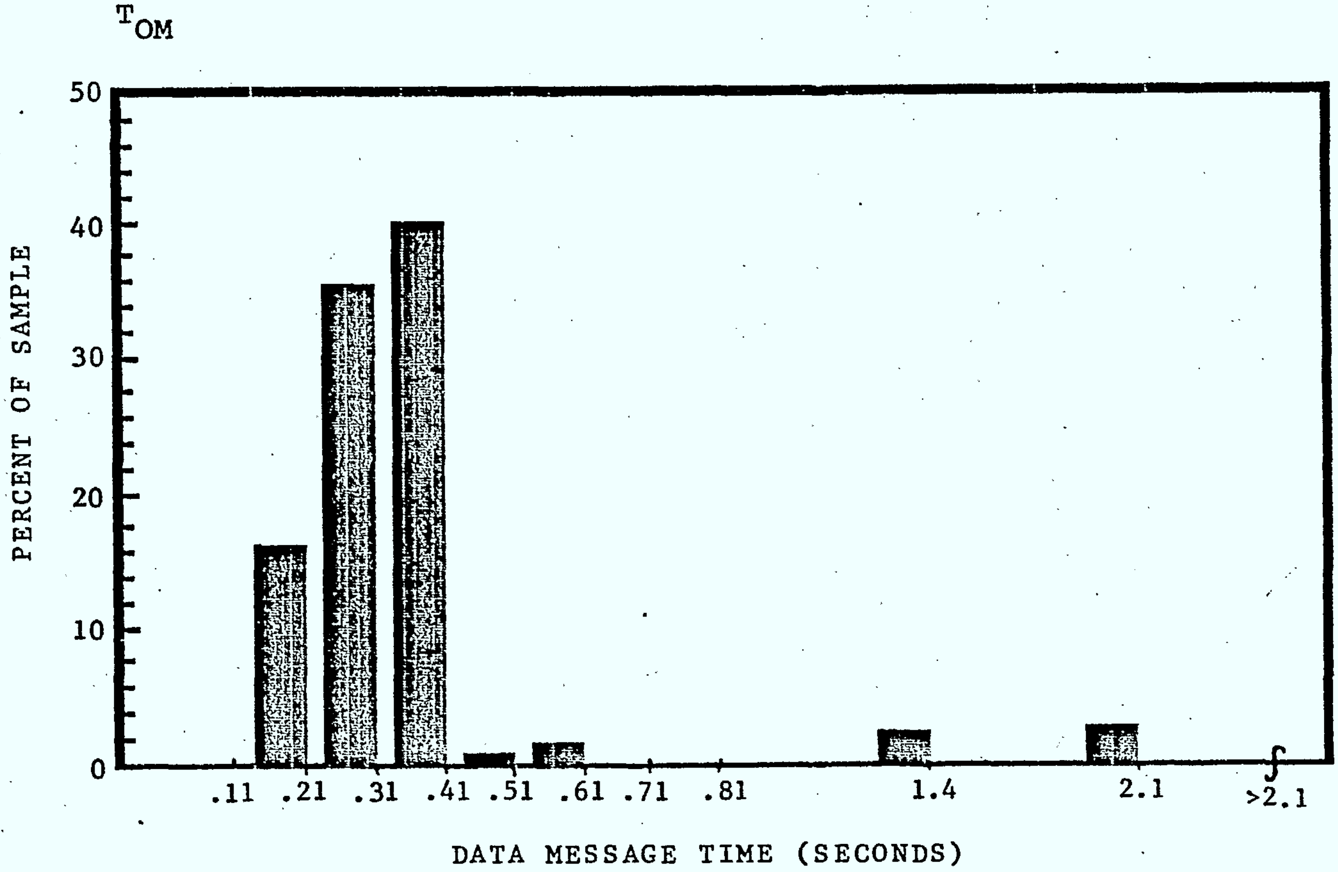


FIGURE 6-47 'AFTER' MRDS - Data Message Type 'Error'
Sample Distribution of Message Air-Time Occupancy ($T_{OM}$)
Per Hour.

# MRDS TRAFFIC AND SPECTRUM USE STUDY

## APPENDIX H

## TO

## REPORT R-276-001

## DEFINITION OF SYMBOLS

# MRDS TRAFFIC AND SPECTRUM USE STUDY

## Definitions of Symbols

## H1. SINGLE MESSAGE STRUCTURE

### 1.1 Time

| | |
|---|---|
| $D$ | a single transmission originated by the dispatcher in seconds |
| $U$ | a single transmission originated by a patrol unit in seconds |
| $G$ | an idle time gap between successive transmissions in seconds |
| $T_D = \Sigma D$ | aggregated dispatcher transmission time in seconds |
| $T_U = \Sigma U$ | aggregated unit transmission time in seconds |
| $T_G = \Sigma G$ | aggregated idle radio channel gap time in seconds |
| $T_T = T_D + T_U$ | total time for transmissions in one message (referred to as "message time" during the MRDS program but now discontinued so as not to confuse it with $T_M$) |
| $T_M = T_T + T_G$ | total message time in seconds |
| $T_{CM}$ | measured message time by clocking the complete message from beginning to end with a stopwatch in seconds |
| $T_M = T_M - T_{CM}$ | operator error in clocking D's, U's and G's in seconds |

### 1.2 Content

| | |
|---|---|
| $N_D$ | number of dispatcher transmissions |
| $N_U$ | number of unit transmissions |
| $N_G$ | number of idle time gaps |
| $N_T = N_D + N_U$ | number of transmissions |

## H2. HOURLY VALUES

### 2.1 Single Hour

| | |
|---|---|
| $N_M$ | number of messages |
| $\overline{N}_D$ | average number of dispatcher transmissions per message |
| $\overline{N}_U$ | average number of unit transmissions per message |
| $\overline{N}_G$ | average number of idle gaps per message |
| $\overline{N}_T$ | average number of transmission per message |
| $\overline{T}_D$ | average dispatcher transmission time per message |
| $\overline{T}_U$ | average unit transmission time per message |
| $\overline{T}_G$ | average idle gap time per message |
| $\overline{T}_T$ | average total transmission time per message |
| $\overline{T}_{CM}$ | average clocked message time |
| $T_{OT} = \Sigma T_T$ | total channel occupancy time by transmissions during one hour |
| $T_{OM} = \Sigma T_M$ | total channel occupancy time by messages during one hour |
| $T_{CU}$ | total time when the transmitter and receiver are keyed on during one hour - referred to as "channel use" (from Vancouver Police Records) |
| $P_P$ | number of patrol units |
| $P_M$ | number of MRDS terminals in the field |
| $P_O$ | number of MRDS terminals which have originated messages |

### 2.2 Over the Hours Sampled

| | |
|---|---|
| $\overline{T}_{OT}$ | average value per hour of total transmission time |
| $\overline{T}_{OM}$ | average value per hour of total message time |
| $\overline{T}_{CU}$ | average channel use per hour |
| $\overline{N}_M$ | average number of messages per hour |

Other symbols relating to time and content of the hours sampled are used interchangeably with those in 2.1 above. However where this is the case it is specifically indicated that the hourly averages are over the hours sampled.

LOPIANOWSKI, N. M.
--Traffic and spectrum use study
of Vancouver police department
mobile radio data system.