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PERFORMANCE OF THE HONEYWELL H-153 DATA MODEM OPERATING AT 144 KBIT/S ON VARIOUS GROUPBAND LOOPS

by B.M. Smith, N.Q. Duc and R.B. Coxhill

Transmission Branch

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Research Laboratories

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1. INTRODUCTION

During March-May 1979, a Honeywell Model H-153 groupbandwidth data modem, operating at 144 kbit/s was tested over various groupband loops terminating in the Research Laboratories in Clayton.

Because of the variability of some of the bearers and the limited availability of this modem from the manufacturer, the main emphasis in these tests was on the comparative performance with a TRT Sematrans V-36 data modem operating at 72 kbit/s and for which longer term transmission performance results are available [1]. The parameters recorded in these tests were the bit and block error rates and carrier losses (or failures).

In addition the performance of this modem was measured using the data test set developed by Transmission Systems Branch [2], and which gives the results directly in terms of the DDN proposed performance objectives.

This report summarizes the results of these measurements.

2. HONEYWELL MODEL H-153 DATA MODEM

This modem uses a 7-level class 4 partial-response (PR) single sideband amplitude modulated (SSBAM) line signal and is compatible with the CCITT requirements for operation on a groupband (V.36 Recommendation). It can operate at a variety of speeds from 112 to 168 kbit/s, but for these tests a speed of 144 kbit/s has been adopted. The modem also provides a 2 or 3 port multiplexing facility (eg. 2 x 72 kbit/s or 3 x 48 kbit/s ⇒ 144 kbit/s) but this option was not used in these tests.

The transmit level of the line signal was set to -6.0 dBm0 and the 11-stage scrambler was strapped in the non-self-synchronizing mode. The modem has an adaptive 66-tap linear transversal equalizer which minimizes the effects of linear distortion, especially the group delay distortion from the through-group filters and the through-supergroup filters (affecting groups 1 and 5). This equalizer also minimizes the effect of residual carrier and clock phase errors at the receiver.

The TRT Sematrans data modem used in the comparative tests operates at 72 kbit/s using a 3-level class 4 PR SSBAM line signal (V-36) but without adaptive equalization. The carrier phase error is adjusted manually to optimize the eyepattern.

If the received signals are perfectly equalized, the 3-level 72 kbit/s modem would be 7 dB less sensitive to noise than the 144 kbit/s modem and be able to tolerate a 21° phase hit in contrast to 7°. However in practice the advantage of the adaptive equalization in the higher speed modem could be expected to approximately offset the disadvantage of its increased number of levels.

3. TEST PROGRAMME

The comparative tests were conducted on groupband loops to Sydney (which includes an extra loop to Wagga Wagga), Canberra and Launceston from the Clayton Laboratories. Details of these loops are shown in Table 1.

The procedure adopted during the comparative tests was to interleave the operation of each modem (i.e. the Honeywell and the TRT Semetrans) about every 0.5 to 1 hour during the working day to ensure that the bearer variability is not a factor in the comparison. The data transmission performance was measured with a HP 1645A data test set with the block length set to 100,000 bits.

The H.P. test set was configured to count the number of carrier losses (or carrier failures) as detected by the data modems, rather than data dropouts (i.e. 16 consecutive clock periods without transitions). The bit error count is inhibited by carrier losses, clock slips (as detected by the test set) and data dropouts, but the test set has been modified to enable the block error count to continue during these three events.

With a block length of 100,000 bits and the two data modems operating at 144 and 72 kbit/s respectively, the block error rate can be used to give a reasonable estimate of the error performance in terms of Error-Free Seconds (EFS). This is then compared with the DDN proposed performance objective. At 144 kbit/s a block of 100,000 bits corresponds to 0.69 s and at 72 kbit/s this block has a duration of 1.39 s; hence using the block error rate to estimate the EFS percentage is expected to give an optimistic estimate for the 144 kbit/s rate and a pessimistic estimate for the 72 kbit/s rate.

The measurements, using the data test set based on the DDN Performance Objectives, were carried out on the loops to Adelaide and Perth. Details of these loops are shown in Table I. These measurements were made using only the Honeywell 144 kbit/s modem and are supplemented by results on the analogue performance of these bearers obtained by the Trunk Service Section, Engineering Department of the S.A. Administration.

4. RESULTS OF MEASUREMENTS

The results on a daily basis of the (interleaved) comparative measurements are shown in Appendix I, whilst Appendix II summarizes the overall performance of each loop. The results indicate that the two modems have a comparable performance except perhaps on the Melbourne-Sydney (Wagga Wagga) loop. It may be noted that this loop has 5 through-group filters instead of 3 in the other loops used in the comparative tests of the two modems.

The DDN long-term long-haul Error Performance Objective is 99.55% EFS which corresponds to 5×10^{-3} probability of an error-second. The results indicate that all the loops used for the comparative tests except Launceston, met this particular DDN Error Performance Objective over the test periods conducted.

The results of the measurements using the data test set based on the DDN Performance Objectives are shown in Appendix III. The low availability for the first week of the Adelaide loop tests and for the Perth loop tests is caused by loss of synchronism in the receive data. This is believed to be caused by loss of synchronism of the non-self-synchronizing descrambler in the data modem receiver and the resulting very high error rate until this situation is manually rectified. The data test set if it detects a very high error rate will go into a resynchronizing mode but this is fruitless if the data descrambler is out of synchronism. This lack of synchronism was caused in the first week of the Adelaide loop tests by mains power interference but this was subsequently rectified with a filter for the remaining tests. The loss of synchronism in the Perth loop tests is believed to be caused by severe transmission impairments.

The last column of Appendix III is the short-term error performance objective, based on the 99.1% EFS criteria; in Fig. 1 we have given results which indicate the sensitivity of the short-term error performance objective to differing values of this criterion.

Finally in Appendix IV, we have taken the analogue interruption data obtained by the South Australian Administration and have compared the total period of these interruptions with the total duration of error-second outages, i.e. events of 10 or more consecutive error-seconds, and the total period of the data modem carrier failures. For each carrier failure occurrence, there is a good correlation between the start of this failure and the analogue interruption; however the data modem appears to increase the length of short interruptions to a minimum of about 1.1 - 1.2 s. The main conclusion to be drawn from Appendix IV is that the dominant component of the unavailable time (as defined for the DDN) is due to frequent short interruptions and/or high noise activities, rather than long interruptions.

5. CONCLUSIONS

The Honeywell H-153 data modem has been tested on various groupband loops when operating at 144 kbit/s. These tests have been firstly on a comparative basis with a CCITT Rec. V-36 (72 kbit/s) data modem and also using a data set based on the DDN performance objectives.

The main conclusion to be drawn from these tests is that the adaptive equalization used in the H-153 data modem enables it to have a comparable performance with the simpler V-36 data modem when operating at the above rates.

Although it is not proposed to use this modem in the DDN, it has been of interest to compare its performance with that of the DDN performance objectives. The results show that on some loops (viz. Sydney, Canberra and Adelaide) performance comparable to that of the DDN objectives is achieved, whilst on the other loops (viz. Launceston and Perth), performance significantly poorer than the DDN objectives is obtained. Nevertheless, it is still considered that this modem could provide a workable data service on these routes.

6. ACKNOWLEDGEMENTS

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REFERENCES

1. N.Q. Duc, R.B. Coxhill and K.S. English "Loop Performance of Two 72 kbit/s Groupband Data Circuits : Melbourne-Adelaide and Melbourne-Perth", Transmission Systems Paper No. 18, July 1979.

2. N.Q. Duc and R.B. Coxhill, "A Microprocessor-Controlled Data Test Set : Facilities Aspects", Transmission Systems Branch Paper No. 16, March 1979.

Test Route Section	Bearer	SMG No	SG No	G No	Group Used from Clayton to Lonsdale
Melbourne - Adelaide (via Bordertown)	SV602	-	8	2	3
Adelaide - Perth	WS601	-	9	2	N/A
Melbourne - Canberra	2RT2	1	5	2	4
Melbourne - Launceston (via Flinders Island)	TV605	1	11	2	5
Melbourne - Sydney	VN608	3	9	2	2
(Melbourne - Wagga Wagga)	VN607	1	15	2	

TABLE I. Details of the Tested Groupband Circuits

SMG : Super mastergroup or 15-Supergroup Assembly
SG : Supergroup
G : Group

NOTE: Three through-group filters are used on the Adelaide, Canberra and Launceston loops while five filters are used on the Perth and Sydney loops.

APPENDIX I

Comparative Error Performance of the Honeywell 144 kbit/s modem and the Sematrans 72 kbit/s modem on a Daily Basis.

LEGEND:

BER = Bit Error Rate
BKER = Block Error Rate (Block Length = 10^5 bits)
* = Overflown Bit Error Counter
† = Modem lost synchronization during this test period.

DATE	PARAMETER	MELBOURNE-CANBERRA LOOP (1000 km)		MELBOURNE-LAUNCESTON LOOP (1200 km)	
		HONEYWELL (144kbit/s)	SEMATRANS V-36 (72kbit/s)	HONEYWELL (144kbit/s)	SEMATRANS V-36 (72kbit/s)
23/3/79	Duration	3 hrs	4 hrs	4 hrs	3 hrs
	Bit errors	4	21	2042	933
	Block errors	3	6	592	220
	Carrier losses	0	0	0	0
	BER	$3x10^{-9}$	$2x10^{-8}$	$1x10^{-6}$	$1x10^{-6}$
	BKER	$2x10^{-4}$	$6x10^{-4}$	$3x10^{-2}$	$3x10^{-2}$
26/3/79	Duration	4 hrs	4 1/4 hrs	2 1/4 hrs	4 hrs
	Bit errors	14	47	3784	*
	Block errors	5	3	355	305
	Carrier losses	0	0	0	6
	BER	$7x10^{-9}$	$4x10^{-8}$	$3x10^{-6}$	*
	BKER	$2x10^{-4}$	$3x10^{-4}$	$3x10^{-2}$	$3x10^{-2}$
27/3/79	Duration	5 hrs	4 hrs	4 hrs	5 hrs
	Bit errors	1311	*	*	*
	Block errors	14	2	646	385
	Carrier losses	0	1	1	16
	BER	$5x10^{-7}$	*	*	*
	BKER	$5x10^{-4}$	$2x10^{-4}$	$3x10^{-2}$	$3x10^{-2}$
28/3/79	Duration	5 hrs	4 1/2 hrs	4 1/2 hrs	5 hrs
	Bit errors	66	*	3179	*
	Block errors	2	3	686	210
	Carrier losses	0	3	0	1
	BER	$3x10^{-8}$	*	$1x10^{-6}$	*
	BKER	$8x10^{-5}$	$3x10^{-4}$	$3x10^{-2}$	$2x10^{-2}$

APPENDIX I (cont)

DATE	PARAMETER	MELBOURNE-CANBERRA LOOP (1000 km)		MELBOURNE-LAUNCESTON LOOP (1200 km)	
		HONEYWELL (144kbit/s)	SEMATRANS V-36 (72kbit/s)	HONEYWELL (144kbit/s)	SEMATRANS V-36 (72kbit/s)
29/3/79	Duration	3 1/2 hrs	4 hrs	4 hrs	3 1/2 hrs
	Bit errors	548	3	*	*
	Block errors	32	1	1009	709
	Carrier losses	0	0	12	3
	BER	$3x10^{-7}$	$3x10^{-9}$	*	*
	BKER	$2x10^{-3}$	$1x10^{-4}$	$5x10^{-2}$	$8x10^{-2}$
30/3/79	Duration	3 1/2 hrs	3 3/4 hrs	3 3/4 hrs	3 1/2 hrs
	Bit errors	78214	0	*	*
	Block errors	8	0	617	297
	Carrier losses	1	0	99	9
	BER	$4x10^{-5}$	0	*	*
	BKER	$4x10^{-4}$	0	$3x10^{-2}$	$3x10^{-2}$
2/4/79	Duration	4 1/2 hrs	2 hrs	2 hrs	4 1/2 hrs
	Bit errors	0	0	*	1640
	Block errors	0	0	362	370
	Carrier losses	0	0	33	0
	BER	0	0	*	$1x10^{-6}$
	BKER	0	0	$3x10^{-2}$	$3x10^{-2}$
3/4/79	Duration	5 1/4 hrs	4 3/4 hrs	4 3/4 hrs	5 1/4 hrs
	Bit errors	30313	715	*	*
	Block errors	10	2	1298	507
	Carrier losses	1	1	31	8
	BER	$1x10^{-5}$	$6x10^{-7}$	*	*
	BKER	$4x10^{-4}$	$2x10^{-4}$	$5x10^{-2}$	$4x10^{-2}$

DATE	PARAMETER	MELBOURNE-CANBERRA LOOP (1000 km)		MELBOURNE-SYDNEY MELBOURNE-WAGGA WAGGA LOOP (2600 km)	
		HONEYWELL (144kbit/s)	SEMATRANS V-36 (72kbit/s)	HONEYWELL (144kbit/s)	SEMATRANS V-36 (72kbit/s)
20.4.79	Duration	4 hrs	4 1/2 hrs	4 1/2 hrs	4 hrs
	Bit errors	†	707	99	61
	Block errors	†	2	14	8
	Carrier losses	†	0	0	1
	BER	†	6×10^{-7}	4×10^{-8}	6×10^{-8}
	BKER	†	2×10^{-4}	6×10^{-4}	8×10^{-4}
23.4.79	Duration	3 3/4 hrs	3 hrs	2 1/4 hrs	3 3/4 hrs
	Bit errors	14	967	15	0
	Block errors	1	1	6	0
	Carrier losses	0	1	0	0
	BER	7×10^{-9}	1×10^{-6}	1×10^{-8}	0
	BKER	5×10^{-5}	1×10^{-4}	5×10^{-4}	0
24.4.79	Duration	4 3/4 hrs	4 1/4 hrs	4 1/4 hrs	4 3/4 hrs
	Bit errors	408	2879	*	*
	Block errors	2	6	44	7
	Carrier losses	0	4	5	1
	BER	2×10^{-7}	3×10^{-6}	*	*
	BKER	8×10^{-5}	5×10^{-4}	2×10^{-3}	7×10^{-4}
26.4.79	Duration	5 1/2 hrs	3 3/4 hrs	3 3/4 hrs	5 1/2 hrs
	Bit errors	55	1904	27	3
	Block errors	1	2	14	1
	Carrier losses	0	2	0	0
	BER	2×10^{-8}	2×10^{-6}	1×10^{-8}	3×10^{-9}
	BKER	3×10^{-5}	2×10^{-4}	7×10^{-4}	1×10^{-4}
27.4.79	Duration	5 1/4 hrs	3 hrs	3 hrs	5 1/4 hrs
	Bit errors	2816	175	*	24
	Block errors	37	3	56	5
	Carrier losses	1	0	8	0
	BER	1×10^{-6}	2×10^{-7}	*	2×10^{-8}
	BKER	1×10^{-3}	3×10^{-4}	4×10^{-3}	5×10^{-4}
30.4.79	Duration	4 3/4 hrs	4 3/4 hrs	4 3/4 hrs	4 3/4 hrs
	Bit errors	0	707	499	66
	Block errors	0	3	129	10
	Carrier losses	0	1	0	0
	BER	0	7×10^{-7}	2×10^{-7}	6×10^{-8}
	BKER	0	3×10^{-4}	5×10^{-3}	1×10^{-3}

DATE	PARAMETER	MELBOURNE-CANBERRA LOOP (1000 km)		MELBOURNE-SYDNEY MELBOURNE-WAGGA WAGGA LOOP (2600 km)	
		HONEYWELL (144kbit/s)	SEMATRANS V-36 (72kbit/s)	HONEYWELL (144kbit/s)	SEMATRANS V-36 (72kbit/s)
1.5.79	Duration	5 hrs	4 1/4 hrs	4 1/4 hrs	5 hrs
	Bit errors	445	3	82	12
	Block errors	3	1	40	3
	Carrier losses	0	0	0	0
	BER	2×10^{-7}	3×10^{-9}	4×10^{-8}	9×10^{-9}
	BKER	1×10^{-4}	9×10^{-5}	2×10^{-3}	2×10^{-4}
2.5.79	Duration	4 hrs	5 1/4 hrs	5 1/4 hrs	4 hrs
	Bit errors	3	3767	†	1597
	Block errors	2	6	†	9
	Carrier losses	0	4	†	1
	BER	1×10^{-9}	3×10^{-6}	†	1×10^{-6}
	BKER	8×10^{-5}	4×10^{-4}	†	1×10^{-4}
3.5.79	Duration	4 1/4 hrs	5 hrs	5 hrs	4 1/4 hrs
	Bit errors	0	0	993	*
	Block errors	0	0	96	55
	Carrier losses	0	0	0	32
	BER	0	0	4×10^{-7}	*
	BKER	0	0	4×10^{-3}	5×10^{-3}

APPENDIX II

Summary of the Comparative Error Performance of the Honeywell 144 kbit/s Modem and the Sematrans 72 kbit/s modem.

LEGEND:

BER = Bit Error Rate
BKER = Block Error Rate (Block Length = 10^5 bits)
* = Overflown Bit Error Counter
† = Test periods during which modem lost synchronization are excluded.

PARAMETER	MELBOURNE-CANBERRA LOOP (1000 km) 23/3/79-3/4/79		MELBOURNE-LAUNCESTON LOOP (1200 km) 23/3/79-3/4/79	
	HONEYWELL (144kbit/s)	SEMATRANS V-36 (72kbit/s)	HONEYWELL (144kbit/s)	SEMATRANS V-36 (72kbit/s)
Duration	33 3/4 hrs	31 1/4 hrs	29 1/4 hrs	33 3/4 hrs
Bit errors	110470	*	*	*
Block errors	74	17	5565	3003
Carrier losses	2	5	176	43
BER	$6x10^{-6}$	*	*	*
BKER	$4x10^{-4}$	$2x10^{-4}$	$4x10^{-2}$	$3x10^{-2}$

PARAMETER	MELBOURNE-CANBERRA LOOP (1000 km) 20/4/79-3/5/79		MELBOURNE-SYDNEY MELBOURNE-WAGGA WAGGA LOOP (2600 km) 20/4/79-3/5/79	
	HONEYWELL (144kbit/s)	SEMATRANS V-36 (72kbit/s)	HONEYWELL (144kbit/s)	SEMATRANS V-36 (72kbit/s)
Duration	37 1/4 hrs†	37 3/4 hrs	31 3/4 hrs†	41 1/4 hrs
Bit errors	3741	11109	*	*
Block errors	46	24	399	98
Carrier losses	1	12	13	35
BER	$2x10^{-7}$	$1x10^{-6}$	*	*
BKER	$2x10^{-4}$	$2x10^{-4}$	$2x10^{-3}$	$6x10^{-4}$

APPENDIX III

Results of measurements based on DDN Performance Objectives of the Honeywell 144 kbit/s data Modem

Loop	Weekly Period	% Valid Time	% Availability	% Error-Free Seconds in Available Time	% of 15-minute intervals that have at least 99.1 EFS*
Melb-Adel. (1500km looped)	5/4/79-11/4/79	69.79	99.00	98.17	70.78
	12/4/79-18/4/79	100.00	99.94	99.41	81.54
Melb-Perth (6800km looped)	19/4/79-25/4/79	49.40	99.26	93.70	11.14
	26/4/79-2/5/79	77.38	94.97	92.96	3.65

* This criterion is applied only to the available time in a given 15-minute interval and also the contribution of each interval that meets this criterion to the final result is weighted by the ratio of (available time/15 minute).

Note: DDN Availability Objectives : 99.98% (for long-haul segment)
Long-term (1 year) Percentage EFS : 99.55% (for long-haul segment)

APPENDIX IV

Comparison of unavailability-related results with analogue interruption data from S.A.

(a) Melbourne-Adelaide (Looped) 5.4.79 - 18.4.79

DATE	DURATION (sec)				
	ERROR-SECOND OUTAGES	CARRIER FAILURES	CARRIER FAILURES (≥10 sec)	ANALOGUE INTERRUPTIONS (SA Record)	REMARKS
Apr 5	10	1.10	0	0.02	
6	395	5.62	0	0.29	
7	3767	0	0	0	
8	0	1.13	0	0.04	
9	31	21.98	0	24.26	Note 1
10	0	0.04	0	0.05	
11	0	2.24	0	11.07	Notes 2 & 3
Apr 12	0	0	0	0	
13	28	0	0	0	
14	231	2.45	0	0.09	
15	94	3.33	0	0.13	
16	0	0	0	0	
17	0	0	0	0	
18	0	0	0	0	
TOTAL	4556	37.89	0	35.95	

Notes:

1. Fading in Victorian section
2. Equalizer fault at One Tree Hill (Vic)
3. Data test period contains invalid intervals

APPENDIX IV (cont)

(b) Melbourne-Perth (Looped) 19.4.79 - 2.5.79

DATE	DURATION (sec)				REMARKS
	ERROR-SECOND OUTAGES	CARRIER FAILURES	CARRIER FAILURES (≥10 sec)	ANALOGUE INTERRUPTIONS (SA Record)	
Apr 19	0	5.95	0	11.69	Note 1
20	1881	27.83	0	26.60	Note 2
21	57	1.25	0	3.54	Note 1
22	59	1.08	0	0.12	
23	0	6.03	0	5.92	
24	208	14.12	0	3.98	
25	-	-	-	-	Note 3
Apr 26	890	4.74	0	0.59	
27	239	62.84	58.03	1.20	Note 4
28	281	0	0	1.94	Note 1
29	7793	2.08	0	0.12	
30	12485	30.62	0	5.63	
May 1	363	6.43	0	0.06	
2	1487	24.51	0	7.16	
TOTAL	25743	187.48	58.03	68.55	

Notes:

1. Data test period contains invalid intervals
2. Interruption and noise activities in Adelaide-Perth section and fault in Victorian section.
3. Invalid data test period.
4. Unavailability of data circuit suspected to occur in Russell-Lonsdale-Clayton section (Vic).

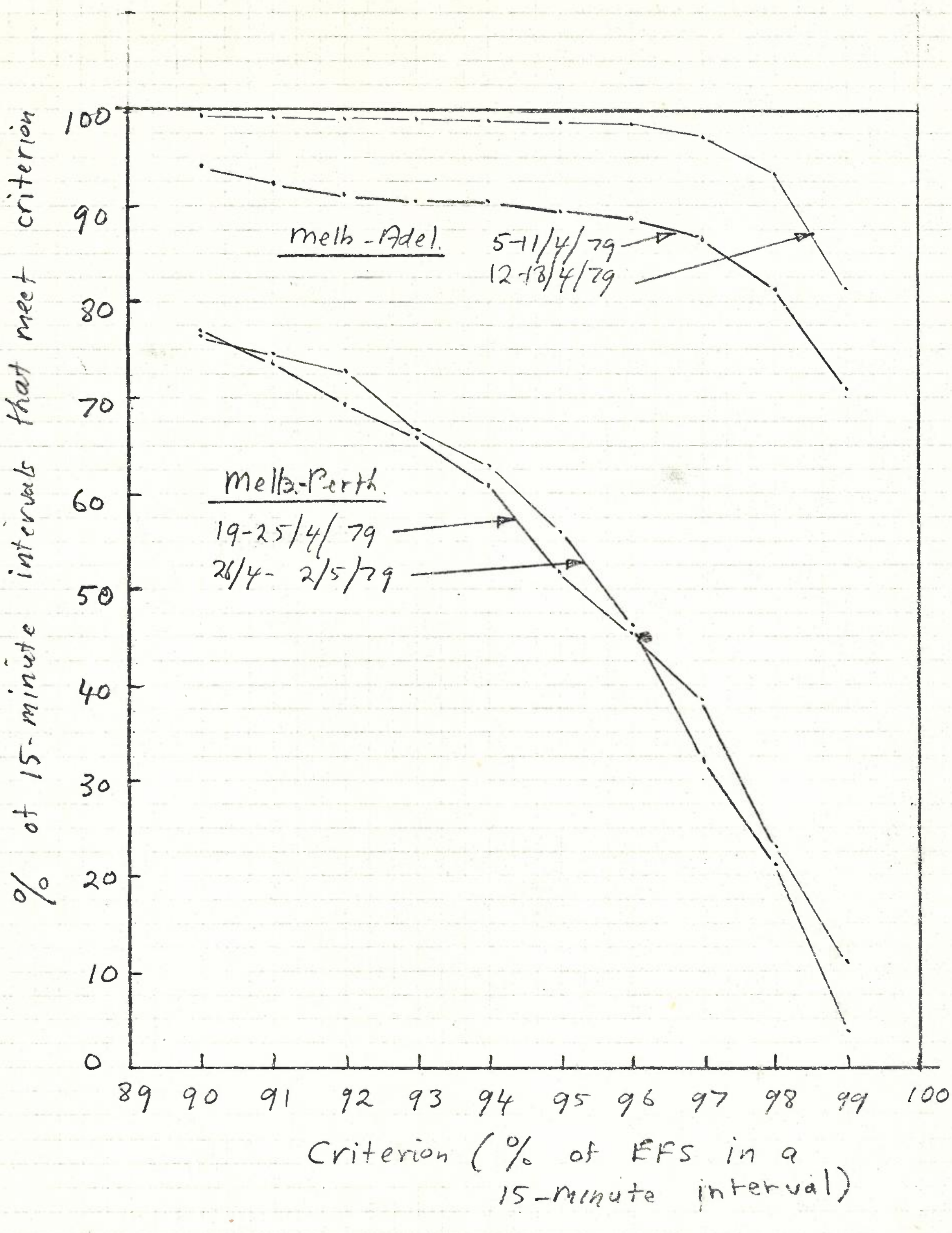

Fig. 1 The Sensitivity of the Short-Term Error Performance Objective to the Percentage Error-Free Second (EFS) Criterion.

```
 ELBOURNE-PERTH(LOOPED) HONEYWELL MODEM 144KBIT/S
DISTRIBUTION OF BIT ERROR COUNTS PER ERROR SECOND FOR THE PERIOD 19/ 4/79 - 25/ 4/79

              +---------+---------+---------+---------+---------+---------+---------+---------+-----
      1-2     .*******************************************
      3-4     .********
      5-8     .******
     9-16     .**************************
    17-32     .*******
    33-64     .****
   65-128     .***
  129-256     .*
  257-512     .
 513-1024     .***
1025-2048     .
2049-4096     .
4097-8192     .
8193-16384    .
16385-        .
              +---------+---------+---------+---------+---------+---------+---------+---------+-----
              0%       10%       20%       30%       40%       50%       60%       70%       80%

                  TOTAL NO. OF ERROR SECONDS =  20905
              TOTAL NO. OF AVAILABLE SECONDS = 296595
                  TOTAL NO. OF VALID SECONDS = 298800
```

MELBOURNE-PERTH(LOOPED) HONEYWELL MODEM 144KBIT/S
DISTRIBUTION OF BIT ERROR COUNTS PER ERROR SECOND FOR THE PERIOD 26/ 4/79 - 2/ 5/79

```
               +---------+---------+---------+---------+---------+---------+---------+---------+----
      1-2      .***********************************
      3-4      .**********
      5-8      .*********
     9-16      .*********
    17-32      .*******
    33-64      .*****
   65-128      .****
  129-256      .****
  257-512      .***
 513-1024      .*******
1025-2048      .*
2049-4096      .
4097-8192      .
8193-16384     .
16385-         .******
               +---------+---------+---------+---------+---------+---------+---------+---------+----
               0%        10%       20%       30%       40%       50%       60%       70%       80%
```

TOTAL NO. OF ERROR SECONDS = 58369
TOTAL NO. OF AVAILABLE SECONDS = 444456
TOTAL NO. OF VALID SECONDS = 468000

```
MELBOURNE-ADELAIDE(LOOPED) HONEYWELL MODEM 144KBIT/S
DISTRIBUTION OF BIT ERROR COUNTS PER ERROR SECOND FOR THE PERIOD  5/ 4/79 - 11/ 4/79

               +---------+---------+---------+---------+---------+---------+---------+---------+------
     1-2       .*************
     3-4       .********
     5-8       .************
     9-16      .******************************************************
    17-32      .**********
    33-64      .**
    65-128     .
   129-256     .
   257-512     .
   513-1024    .
  1025-2048    .
  2049-4096    .
  4097-8192    .
  8193-16384   .
 16385-        .
               +---------+---------+---------+---------+---------+---------+---------+---------+------
               0%        10%       20%       30%       40%       50%       60%       70%       80%

                              TOTAL NO. OF ERROR SECONDS =  11844
                         TOTAL NO.  OF AVAILABLE SECONDS = 417897
                              TOTAL NO. OF VALID SECONDS = 422100
```

→ Y12/3/31 July 79

MELBOURNE-ADELAIDE(LOOPED) HONEYWELL MODEM 144KBIT/S

DISTRIBUTION OF BIT ERROR COUNTS PER ERROR SECOND FOR THE PERIOD 12/ 4/79 - 18/ 4/79

```
              +---------+---------+---------+---------+---------+---------+---------+---------+-------
       1-2    .*****************************
       3-4    .*********
       5-8    .*******
      9-16    .******************************
     17-32    .*******
     33-64    .****
    65-128    .***
   129-256    .**
   257-512    .**
  513-1024    .*******
 1025-2048    .*
 2049-4096    .*
 4097-8192    .
8193-16384    .
16385-        .
              +---------+---------+---------+---------+---------+---------+---------+---------+-------
              0%       10%       20%       30%       40%       50%       60%       70%       80%
```

TOTAL NO. OF ERROR SECONDS = 3936

TOTAL NO. OF AVAILABLE SECONDS = 604447

TOTAL NO. OF VALID SECONDS = 604800

```
 MELBOURNE-ADELAIDE(LOOPED) HONEYWELL MODEM 144KBIT/S
DISTRIBUTION OF ERROR FREE SECOND RUNS FOR PERIOD 12/ 4/79 - 18/ 4/79

              +---------+---------+---------+---------+---------+---------+---------+---------+-----.
      1-2     .**********
      3-4     .*****
      5-8     .******
     9-16     .*********
    17-32     .***********
    33-64     .*************
   65-128     .*************
  129-256     .************
  257-512     .********
 513-1024     .*******
1025-2048     .*******
2045-4096     .
4097-8192     .
8193-16384    .
16385-32768   .
32769-65536   .
              +---------+---------+---------+---------+---------+---------+---------+---------+-----.
              0%       10%       20%       30%       40%       50%       60%       70%       80%


                              TOTAL NO. OF E.F.S.R. =  3668
```

MELBOURNE-ADELAIDE(LOOPED) HONEYWELL MODEM 144KBIT/S
DISTRIBUTION OF ERROR FREE SECOND RUNS FOR PERIOD 5/ 4/79 - 11/ 4/79

```
             +---------+---------+---------+---------+---------+---------+---------+---------+----
        1-2  .*********************
        3-4  .************
        5-8  .**************
       9-16  .***************
      17-32  .***********
      33-64  .*********
     65-128  .******
    129-256  .****
    257-512  .***
   513-1024  .**
  1025-2048  .**
  2045-4096  .
  4097-8192  .
 8193-16384  .
16385-32768  .
32769-65536  .
             +---------+---------+---------+---------+---------+---------+---------+---------+----
             0%       10%       20%       30%       40%       50%       60%       70%       80%
```

TOTAL NO. OF E.F.S.R. = 6854

```
MELBOURNE-PERTH(LOOPED) HONEYWELL MODEM 144KBIT/S
DISTRIBUTION OF ERROR FREE SECOND RUNS FOR PERIOD 26/ 4/79 -  2/ 5/79

               +---------+---------+---------+---------+---------+---------+---------+---------+-----
         1-2   .*********************************
         3-4   .*************
         5-8   .**************
        9-16   .*************
       17-32   .************
       33-64   .*********
      65-128   .****
     129-256   .**
     257-512   .
    513-1024   .
   1025-2048   .
   2049-4096   .
   4097-8192   .
  8193-16384   .
 16385-32768   .
 32769-65536   .
               +---------+---------+---------+---------+---------+---------+---------+---------+-----
               0%       10%       20%       30%       40%       50%       60%       70%       80%

                                         TOTAL NO. OF E.F.S.R. = 23508
```

MELBOURNE-PERTH(LOOPED) HONEYWELL MODEM 144KBIT/S
DISTRIBUTION OF ERROR FREE SECOND RUNS FOR PERIOD 19/ 4/79 - 25/ 4/79

```
                +---------+---------+---------+---------+---------+---------+---------+---------+------
        1-2     .************************
        3-4     .**************
        5-8     .******************
       9-16     .*****************
      17-32     .*************
      33-64     .*********
     65-128     .****
    129-256     .**
    257-512     .
   513-1024     .
  1025-2048     .
  2045-4096     .
  4097-8192     .
 8193-16384     .
16385-32768     .
32769-65536     .
                +---------+---------+---------+---------+---------+---------+---------+---------+------
                0%       10%       20%       30%       40%       50%       60%       70%       80%
```

TOTAL NO. OF E.F.S.R. = 15025