REPORT 908-1

CHANNEL REQUIREMENTS FOR A DIGITAL SELECTIVE-CALLING SYSTEM

(Question 9/8)

(1982-1986)

1. Introduction

A digital selective-calling (DSC) system could ultimately replace manual watchkeeping on ships and give automatic alerting facilities for all the communications of interest to the ship such as morse telegraphy, radiotelex, radiotelephony etc. Two types of channel will be required: international and national.

- *International channels.* These are used in the direction shore to ship only when a coast station wishes to call a ship but does not know which frequencies are being monitored by the ship. It is considered that these calls will be relatively few. International channels are available to all coast stations.
- *National channels.* These are used when a ship wishes to contact any coast station or a coast station wishes to contact a ship of its own nationality or a ship which it contacts regularly. National channels are associated with particular coast stations. Although the calls can be in both directions current calling patterns suggest that mainly the direction is ship to shore but this could change with an improved service. Experience with the INMARSAT system may give some guidance here.

No national DSC channels are as yet allocated, and the presently allocated numbers of international DSC channels may not be sufficient to support a fully developed DSC system, and new channels will have to be allocated. It is, therefore, important to endeavour to make a provisional forecast for the initial development of the DSC system.

This Report considers the number of calling channels that may ultimately be required for calls other than distress and safety. This information is of value to assist in preparation for the World Administrative Radio Conference for the Mobile Services in 1987.

2. Use of scanning receivers

The use of a scanning receiver leads to a non-zero probability that a call intended for the receiving station is lost due to the decoder being engaged on another channel, usually referred to as the scanning loss. Scanning loss is a function of the number of channels scanned by a single receiver and the loading of the DSC channels, but, as follows from the definition, is independent of the number of calls intended for the receiving station. As a general rule the use of scanning receivers is not to be encouraged as the scanning loss increases channel loading and thus has a cumulative effect. Nevertheless, it must be recognized that the use of scanning receivers may be a necessity on many ships for economic reasons.

As a provisional value for a fully developed system, a single receiver should scan not more than six channels (see Annex I); thus the number of channels that a ship station should be expected to watch is of significant economic consequence. Two cases may be considered:

- minimum of about 6 frequencies, i.e. 1 national and 1 international channels in 3 bands. This would require cooperation of the ship's personnel to select the most appropriate bands at any given time and could increase the traffic load on the international channels due to the limited watch on national channels;
- minimum of about 15 frequencies, i.e. 2 national and 1 international channel in each of the bands 4, 6, 8, 12 and 16 MHz. This would give a more automatic service to the ship's personnel but would require more than one scanning receiver.

3. Assumptions for calculating MF channel requirements

Calculations were based on the following assumptions/data:

3.1 The MF traffic handled by Northern Europe coast stations represents the highest density of MF traffic in the world and meeting the channel requirements for this area will permit satisfaction of the MF requirements for other parts of the world.

3.2 The number of MF communications predicted to be handled in each hour of a typical 24-hour period in 1990 based on the combined traffic of Germany (Federal Republic of), Belgium, Denmark, Norway, the Netherlands, the United Kingdom, Sweden and 50% of the USSR traffic is given in Table I. These figures are assumed to represent the traffic referred to in § 3.1.

Note. – Only 20% of the predicted ship-to-shore radio teleprinter calls are included in Table I since it is assumed that most countries allow ships to use the selective calling system inherent in the radioteleprinter equipment (see Recommendations 476 and 625).

3.3 *Duration of a DSC call*

3.3.1 The duration of a DSC call from a ship station to a coast station is 5.8 s (assuming a 20-bit dot pattern (see Recommendation 493, Annex I, § 3.4.2).

3.3.2 The duration of a DSC call from a coast station to a ship station is 7.8 s (assumes a 2 s dot pattern).

3.4 A called station transmits an acknowledgement which lasts 5.8 s (assumes no dot pattern). A calling station will repeat a call in accordance with Recommendation 541, Annex II, until an acknowledgement is received.

3.5 The maximum permitted loading of a random access calling channel is 0.1 erlang (according to traffic theory the probability that two or more calls coincide and therefore fail, is 18%). Even for this relatively low channel loading, a second effect, i.e. congestion of a calling channel as a result of repeated unsuccessful calls cannot be neglected. Congestion can only be prevented by requiring a time delay before repeating the transmission of a call sequence. A higher channel loading would also adversely affect the use of scanning receivers (see Annex I and Recommendation 541, Annex II, § 2.1.8.1, 2.1.11 and 2.2.5).

3.6 It is assumed that primarily as a result of imperfect propagation, interfering signals, coincidence with other calls, etc., the transmission of two call or acknowledgement sequences is required for a successful call.

3.7 Ship-to-shore and shore-to-ship calls are made via common paired frequency channels.

3.8 Ship-to-shore and shore-to-ship acknowledgements are made using the same paired channels referred to in § 3.7.

3.9 One paired international channel is used in each of the 500 kHz and 2 MHz bands.

3.10 The traffic handling capacity in erlang for national DSC channels required for each hour is based on the following calculation:

3.10.1 *Shore-to-ship*

$$\text{Traffic handling capacity (erlangs)} = \frac{\begin{array}{c}\text{Number of calls per hour} \times \text{call duration} \\ 2 \text{ (see § 3.6)} \times 7.8 \text{ s (see § 3.3.2)}\end{array}}{3600 \text{ (s/h)}}$$

3.10.2 *Ship-to-shore*

$$\text{Traffic handling capacity (erlangs)} = \frac{\begin{array}{c}\text{Number of calls per hour} \times \text{call duration} \\ 2 \text{ (see § 3.6)} \times 5.8 \text{ s (see § 3.3.1)}\end{array}}{3600 \text{ (s/h)}}$$

TABLE 1 – *MF calls and DSC channels required (Northern Europe)*

(Based on traffic statistics from Germany (Federal Republic of), Belgium, Denmark, Norway, the Netherlands, the United Kingdom, Sweden, and the USSR (50%))

	Shore-to-ship						Ship-to-shore						Combined shore-to-ship plus ship-to-shore			
Time (UTC)	500 kHz Morse calls	2 MHz telephone calls	2 MHz teleprinter calls	2 MHz total calls	Total erlangs		500 kHz Morse calls	2 MHz telephone calls	2 MHz teleprinter × 20% calls	2 MHz total calls	Total erlangs		Total erlangs		Total DSC channels	
					500 kHz	2 MHz					500 kHz	2 MHz	500 kHz	2 MHz	500 kHz	2 MHz
00-01	4	6	4	10	0.02	0.04	31	27	3	30	0.10	0.10	0.12	0.14	2	2
01-02	5	3	3	6	0.02	0.03	11	17	3	20	0.04	0.06	0.06	0.09	1	1
02-03	3	9	1	10	0.01	0.04	7	12	2	14	0.02	0.05	0.03	0.09	1	1
03-04	4	6	7	13	0.02	0.06	5	14	2	16	0.02	0.05	0.04	0.11	1	2
04-05	6	8	2	10	0.03	0.04	14	16	2	18	0.05	0.06	0.08	0.10	1	1
05-06	8	7	3	10	0.03	0.04	21	34	4	38	0.07	0.12	0.10	0.14	1	2
06-07	13	12	7	19	0.06	0.08	32	54	5	59	0.10	0.19	0.16	0.27	2	3
07-08	17	9	5	14	0.07	0.06	41	105	6	111	0.13	0.36	0.20	0.42	2	5
08-09	21	33	13	46	0.09	0.20	40	148	6	154	0.13	0.50	0.22	0.70	3	7
09-10	28	37	14	51	0.12	0.22	37	146	5	151	0.12	0.49	0.24	0.71	3	8
10-11	21	44	19	63	0.09	0.27	34	137	4	141	0.11	0.45	0.20	0.72	2	8
11-12	18	36	11	47	0.08	0.20	37	117	2	119	0.12	0.38	0.20	0.40	2	4
12-13	17	22	13	35	0.07	0.15	33	117	3	120	0.11	0.39	0.18	0.33	2	4
13-14	20	32	14	46	0.09	0.20	33	119	3	122	0.11	0.39	0.20	0.40	2	4

TABLE 1 *(continued)*

Time (UTC)	Shore-to-ship						Ship-to-shore						Combined shore-to-ship plus ship-to-shore			
	500 kHz Morse calls	2 MHz telephone calls	2 MHz teleprinter calls	2 MHz total calls	Total erlangs		500 kHz Morse calls	2 MHz telephone calls	2 MHz teleprinter × 20% calls	2 MHz total calls	Total erlangs		Total erlangs		Total DSC channels	
					500 kHz	2 MHz					500 kHz	2 MHz	500 kHz	2 MHz	500 kHz	2 MHz
14-15	17	33	7	40	0.07	0.17	36	94	3	97	0.12	0.31	0.19	0.36	2	4
15-16	13	28	14	42	0.06	0.18	25	105	4	109	0.08	0.35	0.14	0.32	2	4
16-17	17	23	16	39	0.07	0.17	26	91	3	94	0.08	0.30	0.15	0.47	2	5
17-18	18	20	6	26	0.08	0.11	27	119	2	121	0.09	0.39	0.17	0.50	2	5
18-19	15	27	11	38	0.07	0.16	34	122	2	124	0.11	0.40	0.18	0.56	2	6
19-20	12	24	8	32	0.05	0.14	25	107	2	109	0.08	0.35	0.13	0.49	2	5
20-21	18	24	9	33	0.08	0.14	25	102	3	105	0.08	0.34	0.16	0.48	2	5
21-22	8	19	8	27	0.03	0.12	31	82	2	84	0.10	0.27	0.13	0.39	2	4
22-23	9	16	3	19	0.04	0.08	25	50	1	51	0.08	0.16	0.12	0.24	2	3
23-24	7	7	1	8	0.03	0.03	22	37	1	38	0.07	0.12	0.10	0.15	1	2
Total	319	485	199	684	–	–	652	1972	73	2045	–	–	–	–	–	–

4. Calculation of the required number of MF calling channels

4.1 Based on the assumptions and data given in § 3, the calculations result in the number of national DSC calling channels for each hour given in Table I.

4.2 The maximum number of channels for any hour from Table I is:

3 channels in the 500 kHz band,
8 channels in the 2 MHz band.

4.3 During daylight hours, MF DSC channels used with Northern Europe coast stations have a limited interference range and can be re-used elsewhere in the world.

Although the interference range of MF channels may be greater during hours of darkness it is concluded that the reduced channel loading during such hours compensates for the increased interference range.

5. Assumptions for calculating HF channel requirements

Calculations were based on the assumptions contained in § 3.3 to 3.8 and 3.10.

5.1 Due to different propagation conditions affecting the various HF bands, the lower frequency bands offer a significant possibility of frequency re-use whereas the higher frequency bands, which in principle can be received world-wide, offer less of a possibility of frequency re-use. Sharing factors world-wide, offer less of a possibility of frequency re-use. Sharing factors indicated in Table II require further consideration particularly with regard to information which could be obtained from Report 911 and from Study Groups 1, 5 and 6 and may be changed at a later date.

TABLE II

Band (MHz)	4	6	8	12	16	22
World-wide sharing factors	2	2	2	1	1	1

5.2 HF traffic statistics valid for 1983 from 31 countries (see Note 1) together with predictions of traffic growth or reduction by the year 1990 are estimated to represent 70% of the world traffic in 1990. These traffic statistics indicate peak hour traffic as given in Table III (see Note 2).

Note 1. – Germany (Federal Republic of), Argentina, Australia, Belgium, Canada, Cape Verde, Chile, Cuba, Denmark, Egypt, Greece, Iran, Iraq, Jamaica, Japan, Kiribati, Malta, Mauritius, Mexico, Norway, New Zealand, Netherlands, Portugal, the United Kingdom, Senegal, Singapore, Sweden, Switzerland, Syria, the USSR, Uruguay.

Note 2. – Only 20% of the predicted ship-to-shore radioteleprinter calls are included since it is assumed that most countries allow ships to use the selective calling system inherent in the radioteleprinter equipment (see Recommendations 476 and 625).

TABLE III – *HF peak hour calls (0800-0900 UTC) and DSC channels required*

Shore-to-ship

Mode	Morse						Telephony						Teleprinter					
Frequency band (MHz)	4	6	8	12	16	22	4	6	8	12	16	22	4	6	8	12	16	22
Calls from 31 countries (1)	7	43	36	27	18	8	16	13	13	17	17	7	11	5	17	17	20	16
Total calls world-wide (2)	10	61	51	39	26	11	23	19	19	24	24	10	16	7	24	24	29	23
Total erlangs	0.04	0.26	0.22	0.17	0.11	0.05	0.10	0.08	0.08	0.10	0.10	0.04	0.07	0.03	0.10	0.10	0.13	0.10

Ship-to-shore

Mode	Morse						Telephony						Teleprinter					
Frequency band (MHz)	4	6	8	12	16	22	4	6	8	12	16	22	4	6	8	12	16	22
Calls to 31 countries (1)	8	27	91	65	64	21	49	12	73	66	74	31	4	2	7	7	13	6
Total calls worldwide (2)	11	39	130	93	91	30	70	17	104	94	106	44	6	3	10	10	19	9
Total erlangs	0.04	0.13	0.42	0.30	0.29	0.10	0.23	0.05	0.34	0.30	0.34	0.14	0.02	0.01	0.03	0.03	0.06	0.03

Combined shore-to-ship plus ship-to-shore (all modes)

Frequency band (MHz)	4	6	8	12	16	22	All
Total erlangs	0.50	0.56	1.19	1.00	1.03	0.46	4.74
Distribution over HF bands (%)	10	12	25	21	22	10	100
Distribution to cater for all sunspot conditions (3) (%)	10	19	33	26	22	10	120
Total erlangs for all sunspot conditions	0.50	0.90	1.56	1.23	1.03	0.46	5.68
Total DSC channels required (no sharing)	5	9	16	13	11	5	59
Total DSC channels required (using sharing factors (4))	3	5	8	13	11	5	45

(1) See § 5.2. Only 20% of ship-to-shore teleprinter calls are included.

(2) World-wide calls based on the calls from 31 countries representing 70% of world-wide total.

(3) See § 5.4.

(4) See § 5.2 and Table II.

5.3 The present distribution of traffic (sunspot maximum) over the various HF frequency bands is roughly as follows:

MHz	4	6	8	12	16	22
Percentage of traffic	10	12	25	21	22	10

The same distribution is assumed for the world-wide traffic.

During minimum sunspot activity, the distribution could be roughly as follows:

MHz	4	6	8	12	16	22
Percentage of traffic	10	19	33	26	12	0

The distribution of the number of calling channels should be sufficient for both situations. This yields the following distribution of traffic between each frequency band:

MHz	4	6	8	12	16	22
Percentage of traffic	10	19	33	26	22	10

5.4 Based on the assumptions and data given in § 6, the calculations result in the number of national DSC calling channels for each hour given in Table III.

5.5 The maximum number of channels for any hour from Table III is:

3 channels in the 4 MHz band
5 channels in the 6 MHz band
8 channels in the 8 MHz band
13 channels in the 12 MHz band
11 channels in the 16 MHz band
5 channels in the 22 MHz band

5.6 Based on statistics of traffic with ships which are not normally worked by a particular coast station, it has been calculated that approximately 13% of DSC calling will be on international channels (see § 1). Applying this percentage to the channels indicated in § 5.5 results in one international channel being required in each of the 4, 6, 8 and 22 MHz bands and two channels in each of the 12 and 16 MHz bands.

6. Other factors influencing the required number of calling channels

In the calculation of the number of national calling channels, it is assumed that at the coast station it is known which particular calling channels are being watched at a particular time by the ship to be called. It is also assumed that the position of the ship is known so that an operator is able to select both the optimum frequency band, the correct channel in the selected frequency band and the optimum time for sending the call.

In the calculation of the number of international calling channels this is assumed for at least a relatively large percentage of the cases. Lack of knowledge of the required information would increase the required number of call attempts and consequently would result in a correspondingly higher number of calling channels.

The problem of obtaining the information on the channels watched by a ship, can be solved by grouping them, e.g. according to the alphabet or the ship's identification. Such an arrangement would, however, not guarantee an even distribution of calling traffic over the calling channels.

A similar problem may arise in the allocation of national calling channels to coast stations. Since the number of coast stations is too large to allow the use of exclusive calling channels, shared use must be made of a limited number of common calling channels.

The allocation of national calling channels should be such that calling traffic would be evenly distributed over these channels. Imperfect distribution of traffic from coast stations and ships over the calling channels would create relatively busy calling channels and relatively empty calling channels. Adverse effects due to such an imperfection could be prevented by lowering the average loading of calling channels, i.e. by increasing the total number of calling channels.

7. Possible means of reducing the number of calling channels

7.1 *Introducing "slotting"*

"Slotted random access" is similar to the normal random access so far considered except that calls can only be transmitted in fixed time slots. This concept would reduce the loss due to call overlap from 18% to 9% and at the same time would have a positive effect on channel stability. However, the possible increase in channel loading would be less than the factor of two indicated from the call overlap. Further study is required on the implementation aspects, the reduction in channel requirements and the effect on the use of scanning receivers.

7.2 *Listening to a channel before transmitting*

This would reduce the probability of call overlap, but more study is required to assess the possible reduction factor for MF and HF transmissions. On VHF, however, equipment could easily perform automatic listening to determine the presence of on-going DSC calls and the loss reduction factor may be determined within reasonable limits. The case where such listening is accomplished prior to making calls other than distress and safety-related calls, is described in § 8 and shows that the use of this technique results in a minimum effect from other calls on the distress call loss probability when all calls are made on one channel.

7.3 *Coordinating the transmissions of coast stations*

This would permit a higher loading of calling channels without causing congestion.

For instance, to give coverage of a region served by several countries, e.g. the North Sea, calls from the administrations having interests in the region could be sent through one station which was common for the countries. Alternatively, the calls could be sent through each country's coast stations and means taken to correlate its transmission times with those of other countries serving the area.

Where it is required to cover an area larger than the service area of one station, additional service areas would be required, either operating on the same frequency in a coordinated manner, or on a separate frequency.

This approach would have most impact on the number of international calling channels but the higher loading could limit the use of scanning receivers aboard the ship (see Annex I).

Coast stations could also control the shore-to-ship calls in such a manner that the peak to average traffic ratio approached unity. Such a procedure is more easily applied to radiotelegraph calls than radiotelephone but could be applied in varying degrees to each type of service.

7.4 *Coordinating the transmissions of ship stations*

In many stations it is presently common practice to establish schedules for certain vessels to contact coast stations when their operational requirements permit such a method of contacting. This scheduling procedure should particularly lend itself to the type of reliable contacting provided by DSC. It is expected that once vessels find that contacting a desired station can be accomplished in a very reliable manner the peaking will be reduced and a large number of calls will be placed in "off-hours".

Additionally, it may be possible to provide monetary incentives to ship stations to contact the station in other than peak hours. If the charge for calls placed during the peak hours is high, it can be assumed that some vessels will call during periods when the charge is reduced. This will reduce the ratio of peak/average calls/hour to be handled at the coast station.

8. Calculation of the required number of VHF calling channels

8.1 *Maximum possible signalling intensity at VHF*

The maximum signalling intensity would occur in densely populated waters such as around Denmark, where more than 30 000 recreational boats from Germany (Federal Republic of), Sweden and Denmark are equipped with VHF. At some places, a DSC call from a ship may be received by a number of coast stations, but channel assignment schemes will preclude interference on public correspondence channels except under severe ducting conditions. Thus the maximum number of working channels within the possible range from the calling ship is 28, according to Appendix 18 of the Radio Regulations.

Two DSC sequences (call plus acknowledgement) will be used to set up a commercial communication on a working channel, but a DSC call may not always result in a commercial communication set-up due to abnormal propagation or congestion.

Statistics from Germany (Federal Republic of) and Denmark show that a working channel has a maximum capacity of 0.8 erlang, and that the average duration of a commercial communication is 5 min. The introduction of automatic call-set-up from ship-to-shore may shorten the call-set-up time, but experience from automatic land-mobile systems has shown that the average call duration tends to be longer when a system is automated.

The maximum number of commercial communications per hour from the coast stations which simultaneously may receive the same DSC call will therefore be:

$$\frac{28 \times 0.8 \times 60}{5} = 269 \text{ calls/h}$$

which will require:

$$2 \times 269 = 538 \text{ DSC sequences/h}$$

As mentioned above, this corresponds to the rather hypothetical situation where one coast station would receive all the DSC calls necessary for establishing communications on the total number of public correspondence channels allocated in the Radio Regulations, Appendix 18.

In addition to calls for commercial correspondence, the calling channel may to some extent be used for calls for "navigational communications", i.e. using the inter-ship, port operations and ship movement channels of Appendix 18.

If absolute worst-case conditions are assumed, the calling channel must additionally cater for communications on the total number of navigational channels of Appendix 18, which is 27 (excluding channels 70 and 16), i.e.

$$27 \times 0.8 \times 2 \times 60/5 = 518 \text{ calls/h}$$

The length of the DSC sequence for commercial and navigational calls is 640 bits including a 20 bit dot-pattern, i.e. 0.533 s, and the total load on the channel would then be:

$$538 + 518 = 1056 \text{ calls/h}$$

or:

$$1056 \times 0.533/3600 = 0.156 \text{ erlang.}$$

If the stations are accessing the system randomly, the probability that a new call is generated while another is in progress, is:

$$p_1 = 1 - \exp(-0.156) = 0.144$$

The probability that a call is mutilated by another call is therefore:

$$p_2 = 1 - \exp(-2 \times 0.156) = 0.268$$

However, as the system requires disciplined calling by prescribing listening-in on the channel before transmission and randomly distributed delays after the ceasing of the occupying carrier, the probability of mutilation will be lower, because not every call in progress is necessarily heard by all possible interferers. The ship-to-ship communication range is usually considerably less than the range between ship and coast station.

It is a possibility that two ships within the same coast station coverage area are out of range of each other, and may therefore be accessing the coast station randomly. One may assume that a particular ship will only be able to hear approximately 30% of the other ships in the area, and thus the coast station may have interference from 70% of the total ship station signalling.

Every ship station will be able to hear all coast station calls (50% of the total number of commercial calls), 30% of the ship station commercial calls (15% of the total number of commercial calls) and 30% of the navigational calls (30% of the total number of navigational calls).

The total number of «hearable» calls at the ship would then be:

$$269 + 81 + 155 = 505 \text{ calls/h,}$$

and the total number of "unheard" calls would be:

$$1056 - 505 = 551 \text{ calls/h.}$$

The probability that a commercial call will be lost due to a call that is heard at the coast station but not at the ship station is therefore:

$$p_3 = 1 - \exp(-2 \times 551 \times 0.533/3600) = 0.15$$

This value can be regarded to be acceptable.

The calculations above are based on the condition that all coast station public correspondence channels and all navigational channels in the Radio Regulations are in maximum use within the coverage area of one coast station, and that all calls are set up using DSC.

In practice, the maximum number of Appendix 18 channels used by stations within range of each other will be less than the total of 28 public correspondence plus 27 "navigational" channels. Therefore a margin is available to cope with conditions of extraordinary ducting or call congestion.

8.2 *Common channel for DSC distress and ordinary calls*

A distress call may be mutilated by another call. If no other distress call is in progress, then the probability that a commercial or navigational call is in progress at any time and thus possibly mutilating the distress call, is:

$$p_4 = 1 - \exp(-1056 \times 0.533/3600) = 0.14$$

If a distress call is in progress it will not be heard by the ships originating the 551 "unheard" calls/hour, and the probability that such a ship will start a commercial or navigational call during the first distress call, and therefore possibly mutilating it, is:

$$p_5 = 1 - \exp(-551 \times 0.45/3600) = 0.067$$

(the duration of a distress call being 0.45 s including a 20-bit dot pattern).

The combined probability that a distress call may be mutilated is then when a commercial or navigational call is in progress, OR when it is started while a distress call is in progress by a ship outside the hearing range of the ship transmitting the distress call, AND consequentially this commercial or navigational call is NOT already in progress, i.e.:

$$p_6 = p_4 + p_5 \times (1 - p_4) = 0.20$$

The second distress call in a distress call attempt may start before all calls in progress, when the call attempt started, have ended. The possibility that the second distress call may be mutilated is somewhat less than p_6, depending on the relative time between the calls. When the third, fourth and fifth distress call starts it may only be mutilated by ships unable to hear it, i.e. p_5 applies. The probability that the whole distress call attempt is mutilated by other calls than distress calls is therefore less than:

$$p_7 = (p_6)^2 \times (p_5)^3 = 0.000012 = 1/83300$$

If only distress calls are present on the DSC channel, the probability that a distress call attempt will be mutilated due to a collision with another distress call attempt on the basis of two per hour is:

$$p_8 = 1 - \exp(-2 \times 0.45/3600) = 0.00025$$

For 10 distress attempts within an hour we obtain $p_8 = 0.00125$.

The mutilation probability of two distress call attempts because of the maximum possible commercial and navigational calls on the same channel is thus:

$$p_9 = p_8 + p_7 (1 - p_8) = 0.00026$$

It may therefore be concluded that when using a single channel for both distress calls and ordinary calls, the effect of the maximum possible ordinary traffic density is an insignificant increase in the risk that one distress call attempt may mutilate another one.

8.3 *Use of a dedicated calling channel for distress calls*

If a dedicated channel is used for distress calls, a 200-bit dot pattern must be added to all DSC calls (both distress and ordinary calls) to allow the use of a scanning receiver on board ship which needs to receive both types of calls. This 200-bit dot pattern will increase the length of all calls, and therefore increase the probability of loss for both types of calls.

8.3.1 *Distress calls*

A single distress call will be increased in length to 0.60 s. Therefore the probability that a distress call attempt will be mutilated due to a collision with another distress call attempt is:

$$p_{10} = 1 - \exp(-2 \times 0.60/3600) = 0.00033$$

A further factor to be taken into account is the scanning loss which would increase p_{10} still further.

Comparing p_{10} with p_9, it can be seen that the use of a dedicated channel for distress calls increases the probability of a loss of a distress call by at least 27%.

8.3.2 *Commercial and navigational calls*

A commercial or navigational DSC call will be increased in length to 0.683 s, resulting in a possibility of a loss of a commercial call due to a collision with another commercial call of:

$$p_{11} = 1 - \exp(-2 \times 551 \times 0.683/3600) = 0.19$$

Comparing with p_3, this results in an increase of probability of the loss of a commercial call of approximately 27%.

8.4 *Conclusion*

The probability of losing a single distress call attempt or a commercial call is higher when using separate calling channels, and would require a substantially higher complexity of both the shipborne and coast-station equipment. A common channel for both commercial calls and distress calls would also automatically ensure that all VHF users, including the fishing and recreational fleets, will watch the distress channel, and furthermore the system would be more reliable since system faults would be recognized earlier when a channel is in regular use, thus improving safety at sea.

It is therefore recommended that all DSC calling should be made on a single frequency VHF channel.

Note. – The WARC MOB-83 allocated channel 70 exclusively for distress and safety (see the Radio Regulations No. 2993B Mob-83). It is recommended that administrations reconsider this decision at the WARC MOB-87.

9. Summary

Estimates for the number of DSC channels ultimately required have been calculated as:

- 45 for national calling in the HF bands;
- 8 for international calling in the HF bands;
- 8 for national calling in the 2 MHz band;
- 1 for international calling in the 2 MHz band;
- 3 for national calling in the 500 kHz band;
- 1 for international calling in the 500 kHz band;
- 1 for all calling in the VHF band.

The estimates assume fully random calling and assume that a ship is monitoring a number of channels – around 6 to 15 as a minimum. Consideration is given to non-random calling to reduce the number of channels but more work is required before any conclusions can be drawn.

Since it is expected that DSC will reduce the ratio of peak to average calls per hour currently experienced by coast stations, and that this has not been taken into account, the attention of administrations is particularly directed to § 7 of this Report. Contributions concerning the degree that these means will reduce the number of calling channels are requested.

ANNEX I

FAILURE OF CALLS DUE TO SCANNING AT MF/HF

1. Assumptions

Calculations were based on the following assumptions:

- the scanner only halts at a calling channel if the "dot pattern" (see § 2) is recognized;
- in all other cases the scanner immediately moves on (so no time is required for recognizing another situation);
- a time, t (see § 2) is required, on an average, to recognize that a call is destined for a different station; after that the scanner immediately moves on.

2. Format of the call

Figure 1 contains the information relevant for the calculation:

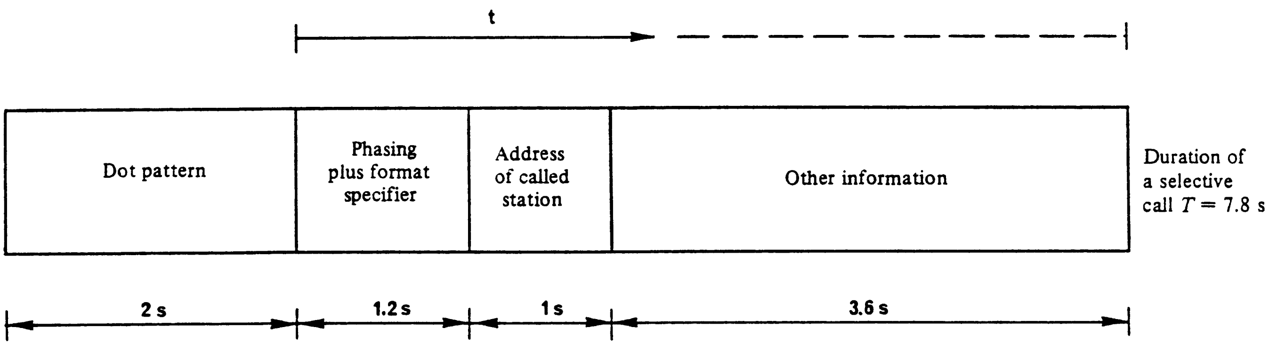

FIGURE 1

Three options for t are considered:

- $t = 1.5$ s
  when the signal processing of the receiver disregards the RX character positions if no bit error is found in the DX position;
- $t = 2.0$ s
  if the signal processing of the receiver requires both the RX and the DX position of each character to be decoded;
- $t = 5.8$ s
  if the signal processing of the receiver requires the complete message to be decoded.

3. Result of the calculation

The probability that a call for station A fails, due to scanning is equal to the sum of 2 sub-probabilities:

- p_1 the probability that the scanner is busy decoding calls (on other channels) for other stations while the "dot pattern" is being transmitted;
- p_2 the probability that the scanner is busy decoding calls (on other channels) for station A while the "dot pattern" is being transmitted.

$$p_1 = 1 - e^{-(n-1)\lambda t}$$

$$\approx (n-1)\lambda t \qquad \text{(neglecting second order effects)}$$

$$p_2 = 1 - e^{-(n-1)5.8\lambda a}$$

$$\approx (n-1)5.8\lambda a \qquad \text{(neglecting second order effects);}$$

in which:

- n : the number of channels which is scanned by the scanner;
- λ : the average calling frequency; if the average load of a calling channel is 0.1 erlang, $\lambda T = 0.1$, so that $\lambda = 1/78$;
- a : the percentage of calls for station A;
- t : see § 2.

For ships, a can be considered to be 0; for coast stations monitoring international HF channels it is assumed that $a = 3.5\%$.

The result of the calculations are given in Tables IVa, IVb and IVc below.

TABLE IVa – *Percentage of calls lost as a result of scanning for t = 1.5 s*

λ \ n	3	4	5	6	7	8	9	10	11	12	13	14	
λ = 1/78 (0.1 erlang)	4.3	6.4	8.4	10.5	12.4	14.4	16.3	18.2	Impermissibly high				Coast station $a = 3.5\%$
	3.8	5.6	7.4	9.2	10.9	12.6	14.3	15.9					Ships
λ = 1/117 (0.067 erlang)	2.9	4.3	5.7	7.1	8.4	9.8	11.1	12.5	13.8	15.0	16.3	17.6	Coast station $a = 3.5\%$
	2.5	3.8	5.0	6.2	7.4	8.6	9.8	10.9	12.0	13.2	14.3	15.4	Ships
λ = 1/156 (0.05 erlang)	2.2	3.2	4.3	5.3	6.4	7.4	8.4	9.4	10.4	11.4	12.4	13.4	Coast station $a = 3.5\%$
	1.9	2.8	3.8	4.7	5.6	6.5	7.4	8.3	9.2	10.0	10.9	11.7	Ships

TABLE IVb – *Percentage of calls lost as a result of scanning for t = 2.0 s*

λ \ n	3	4	5	6	7	8	9	10	11	12	13	14	
λ = 1/78 (0.1 erlang)	5.5	8.2	10.8	13.3	15.8	18.2	Impermissibly high						Coast station $a = 3.5\%$
	5.0	7.4	9.7	12.0	14.3	16.4	18.5						Ships
λ = 1/117 (0.067 erlang)	3.7	5.5	7.3	9.1	10.8	12.5	14.2	15.8	17.4				Coast station $a = 3.5\%$
	3.4	5.0	6.6	8.2	9.8	11.3	12.8	14.3	15.7	17.1	18.6		Ships
λ = 1/156 (0.05 erlang)	2.8	4.2	5.5	6.8	8.2	9.5	10.8	12.0	13.3	14.6	15.8	17.0	Coast station $a = 3.5\%$
	2.5	3.8	5.0	6.2	7.4	8.6	9.7	10.9	12.0	13.1	14.2	15.3	Ships

TABLE IVc – *Percentage of calls lost as a result of scanning for t = 5.8 s*

λ \ n	3	4	5	6	7	
λ = 1/78 (0.1 erlang)	13.8	20.0	Impermissibly high			Coast stations and ships
λ = 1/117 (0.067 erlang)	9.4	13.8	18.0			
λ = 1/156 (0.05 erlang)	7.2	10.5	13.8	16.9		

4. Conclusions

It follows from the tables above that in the case of ships' receivers for acceptable loss (< 15%):

– nine channels could be scanned for 0.1 erlang channel loading and a message holding time of 1.5 s;

– seven channels could be scanned for 0.1 erlang channel loading and a message holding time of 2 s.

The number of channels that may be scanned varies approximately in inverse proportion to the channel loading.

It also follows from Table IVc that scanning is of limited use when the complete message has to be decoded before scanning can be resumed.

REPORT 1028

3 kHz DUPLEX SEPARATION FOR DSC CHANNELS IN THE BAND 435-526.5 kHz

(Question 53/8)

(1986)

1. Introduction

1.1 The Regional Administrative Radio Conference for the Maritime Mobile Service and the Aeronautical Radionavigation Service in certain parts of the MF band in Region 1 (Geneva, 1985) adopted Recommendation No. 6 which invites the CCIR:

"**1.** To study the technical problems that may arise from the 3 kHz duplex separation in the digital selective calling channels in the band 435-526.5 kHz.

2. To review the appropriate CCIR Recommendations."

1.2 This Report considers the probable characteristics of digital selective calling (DSC) receivers for interference rejection, the ratio of transmitted powers likely to be experienced in practice and the effect that they are likely to have if 3 kHz channel spacing is used.