RECOMMENDATION ITU-R M.1081*

AUTOMATIC HF FACSIMILE AND DATA SYSTEM FOR MARITIME MOBILE USERS

(Question ITU-R 76/8)

(1994)

The ITU Radiocommunication Assembly,

considering

a) the increasing importance of non-voice telecommunication services, e.g. high-speed data transfer and facsimile services;

b) that not all maritime users have satellite installations to access the Public Switched Telephone Networks (PSTN) for voice or data communications;

c) that most maritime mobile users are equipped with MF/HF radio equipment to satisfy the requirements of the GMDSS;

d) that a high-speed data service over HF radio may be useful for updating Electronic Chart Display and Information Systems (ECDIS);

e) that most large vessels already use personal computers to run application software to manage ships' stores, staff, etc.;

f) that Article 60 of the Radio Regulations (RR) does not permit coast stations to emit identification or marking signals on idle radiotelephone working channels;

g) that system compatibility is necessary for international operation, and that commonality is desirable to ensure that system cost per mobile user is minimized;

h) that most ship stations are not able to simultaneously use their radio transmitter and receiver for duplex operation;

j) that the implementation of the GMDSS means that there will be fewer qualified radio officers with detailed knowledge of HF propagation operating the radio equipment;

k) that the digital selective-calling (DSC) system described in Recommendations ITU-R M.493 and ITU-R M.541 can be used for signalling over the radio path to enable common channels to be used for initial signalling purposes prior to transfer to a working channel;

l) that the data transfer rate that can be achieved over the radio path is significantly lower than that which can be achieved over the PSTN,

recommends

1. that the gateway which provides the interface at the coast station between the radio and PSTN paths includes store-and-forward facilities;

2. that the system characteristics and operational procedures for setting up calls and passing data messages, including facsimiles, between maritime mobile users and fixed users on the PSTN should be in accordance with Annex 1;

3. that the frequencies used for a radio contact between a maritime mobile user and the gateway should be automatically determined by a frequency prediction program;

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* The Director, Radiocommunication Bureau, is invited to bring this Recommendation to the attention of the Telecommunication Standardization Sector and the International Maritime Organization (IMO).

4. that calling channels should be used, employing digital selective-calling techniques based on the technical and operational characteristics in accordance with Recommendation ITU-R M.493, for establishing the initial contact between the mobile user and the gateway;

5. that the transfer of the data (including facsimile images) should be conducted on working channels employing data modems specifically designed to cope with HF propagation characteristics and capable of a user data rate, after error correction, on a typical HF telephony-bandwidth channel, of approximately 1 000 bit/s;

6. that the contents of the DSC messages used to establish the initial contact between the maritime mobile user and the gateway should be in accordance with Annex 2;

7. that the error correcting protocol and structure of the messages that are used to pass data between the maritime mobile user and the gateway over the working channel should be in accordance with Annex 3;

8. that the operation of the maritime mobile user's equipment should be simple and should not require detailed knowledge of HF radio propagation;

9. that the maritime mobile user's equipment should be capable of receiving data messages during unattended operation;

10. that fixed users on the PSTN should be able to use their normal data and facsimile equipment as used for communication with other users on the PSTN;

11. that data transmission over the working channel should have a very low residual error rate;

12. that the technical characteristics of the DSC and HF data modems should be in accordance with Annex 4;

13. that data compression techniques should be used on the data files transferred across the radio path to reduce the amount of data to be transferred;

14. that the mobile user's terminal should include an interface to a navigation system which provides on-line position information;

15. that the characteristics and procedures described in the annexes are equally applicable when the connection between the gateway and fixed users is via a Public Switched Data Network instead of via the PSTN.

ANNEX 1

System characteristics and operational procedures for setting up calls and passing data messages

1. General

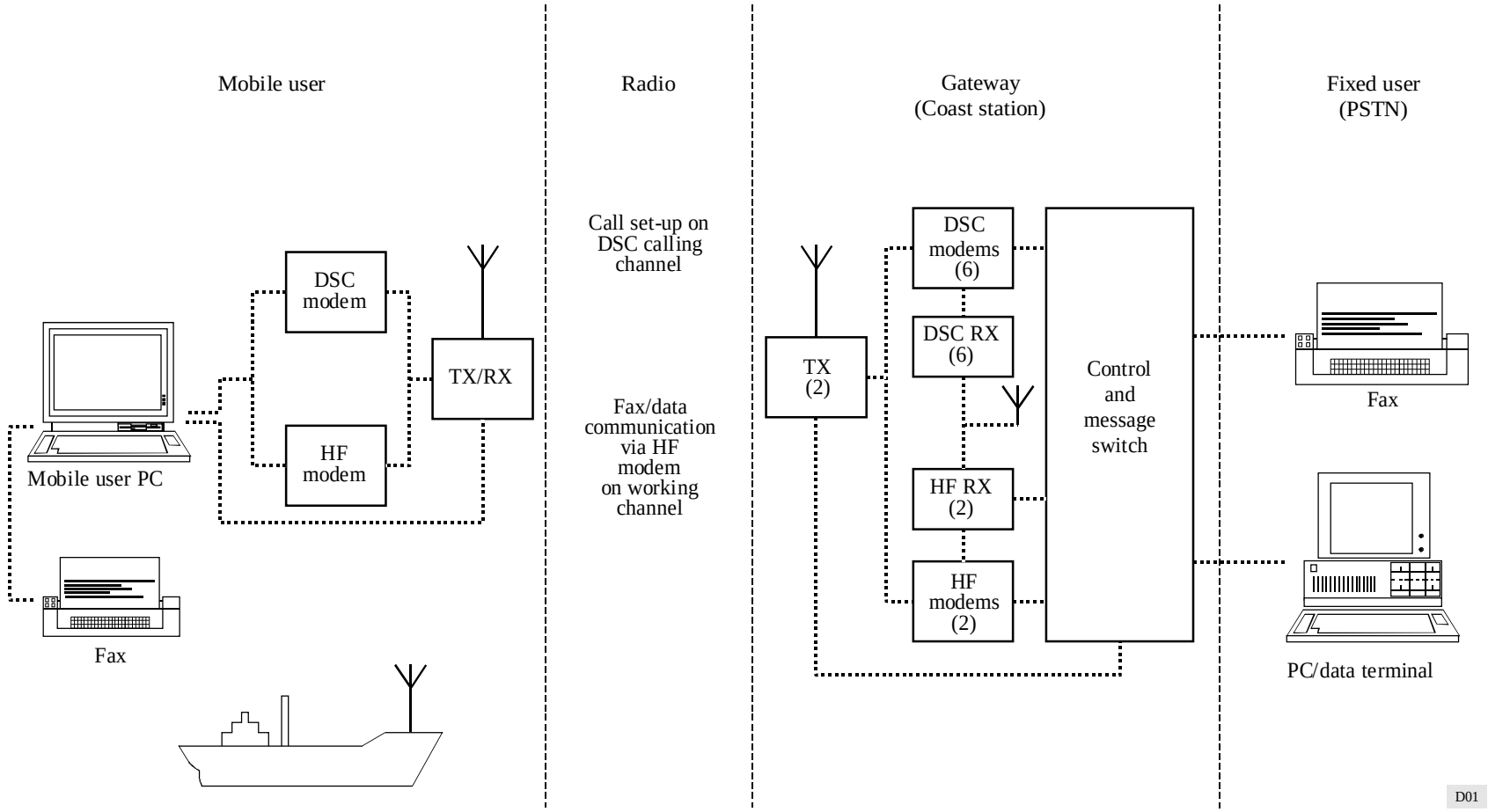
1.1 A typical configuration of a complete communication system is shown in Fig. 1.

1.2 The gateway, through which all messages pass, is basically a store-and-forward message switch which provides an interface between the radio and PSTN message paths. The gateway communicates with maritime mobile users over the radio path and with fixed users over the PSTN.

1.3 To facilitate automatic calling of the mobile and to enable billing, all mobile and fixed users wishing to send messages should be registered on a database in the gateway. Mobile users should be identified by their name and unique nine-digit Maritime Mobile Service Identity (MMSI). Fixed users should be identified by their name and a ten-digit Personal Identification Number (PIN). The gateway checks the user's MMSI or PIN number before allowing them to send messages into the gateway. The gateway's database also maintains an up-to-date record of mobile users' positions (see § 2.1 and 3.2 below).

FIGURE 1

Automatic HF facsimile and data system (typical configuration)



1.4 The call set-up over the radio path between the gateway and maritime mobile user terminal uses standard digital selective-calling techniques on the DSC calling channels allocated for public correspondence in the maritime mobile HF bands in a similar way to that for automatic MF/HF radiotelephony according to Recommendation ITU-R M. 1082. The gateway and mobile stations therefore need only to monitor a small number of DSC calling channels instead of all working channels when waiting for an incoming call.

1.5 The frequency band to be used to make the initial contact between the maritime mobile user and the gateway is determined by a frequency prediction program which makes use of the date, time, positions of the mobile user and gateway, solar activity indices, propagation data and radio noise data to determine the best, if any, of the frequency bands available.

1.6 Following the exchange of a DSC call and acknowledgement on the calling channel, both the mobile and the gateway establish contact on a working channel. This contact, and all further communication on the working channel, uses HF data modems designed in accordance with Annex 4.

1.7 The contents of the DSC messages during calling and acknowledgement sequences by the mobile user and the gateway are described in Annex 2.

1.8 The messages passing over the working channel comprise command and data messages used within a protocol which controls the link and passes data with minimum end-to-end residual errors. The command and data messages and the protocol used for a communication exchange on the working channel are described in Annex 3.

2. Mobile to gateway

2.1 When the mobile calls the gateway it indicates its position (latitude and longitude) in the DSC message. The gateway's acknowledgement indicates the transmit and receive frequencies of the working channel to be used for subsequent communications and data transfer.

3. Gateway to mobile

3.1 When the gateway calls the mobile it indicates, in the DSC message, the transmit and receive frequencies of the working channel over which subsequent communications and data transfer will take place.

3.2 If the gateway wishes to call the mobile and the position of the mobile is not known or is more than six hours old, the gateway transmits a series of DSC ship's position request calls sequentially on one DSC frequency in each of the HF bands. If no response is received from the mobile then, unless the mobile calls the gateway, the gateway repeats the position request calls six hours later.

4. Fixed user to gateway

4.1 The exact method for fixed users on the PSTN to access the gateway in order to send facsimile and data to mobile users may vary in different countries since it depends on the type of PSTN signalling system available and the method of routing the call in the PSTN.

4.2 An important consideration is to be able to automatically identify the telephone number of the fixed user for billing purposes.

4.3 One method, which requires fixed users to be registered in advance at the gateway and requires the allocation of a PIN to each user, is outlined below.

4.4 Facsimile calls from fixed users on the PSTN to the gateway use a standard tone dialling telephone associated with a Group 3 facsimile machine to call an appropriate gateway telephone number. When the gateway answers the call, it uses a synthesized or pre-recorded voice message to prompt the fixed user for their PIN number and the MMSI(s) of the mobile users to which the facsimile is to be sent. The gateway validates the fixed user's identity and checks whether the mobile users specified are registered on the gateway before instructing the fixed user to enter their facsimile and attempting any delivery.

4.5 Data calls from fixed users use a data terminal with a communication software package and a suitable ITU-T V-series data modem to access the gateway. When the gateway answers the call, it uses screen messages to prompt the fixed user for their PIN number and the MMSI(s) of the mobile users to which the data messages are to be sent. The gateway carries out validation checks as for facsimile messages.

ANNEX 2

Contents of DSC messages used to establish initial contact between the maritime mobile user and the gateway

1. General

The format of all DSC call and acknowledgement messages and the coding of the message fields complies with those detailed in Recommendation ITU-R M.493. A summary of the messages used is given below.

2. DSC calling messages originated by mobile user and gateway acknowledgements

Mobile calling message

DSC field	Dot pattern	Phasing sequence	Format specification	Address	Category	Self-ID	Message 1		Message 2	EOS	Error check
							tc-1	tc-2			
Length	20 bits	6 DX, 8 RX	2 char	5 char	1 char	5 char	1 ch	1 ch	6 char	3 DX 1 RX	1 ch
Content (symbol)	0101 etc.	125 DX 111-104 RX	123 123	Gateway MMSI	100	Mobile MMSI	106	113	Position	117 (RQ)	

Gateway acknowledgement message

DSC field	Dot pattern	Phasing sequence	Format specification	Address	Category	Self-ID	Message 1		Message 2	EOS	Error check
							tc-1	tc-2			
Length	20 bits	6 DX, 8 RX	2 char	5 char	1 char	5 char	1 ch	1 ch	6 char	3 DX 1 RX	1 ch
Content (symbol)	0101 etc.	125 DX 111-104 RX	123 123	Mobile MMSI	100	Gateway MMSI	106	113	Freqs	122 (BQ)	

3. DSC calling messages originated by gateway and mobile acknowledgements

Gateway calling message

DSC field	Dot pattern	Phasing sequence	Format specification	Address	Category	Self-ID	Message 1 tc-1	Message 1 tc-2	Message 2	EOS	Error check
Length	200 bits	6 DX, 8 RX	2 char	5 char	1 char	5 char	1 ch	1 ch	6 char	3 DX 1 RX	1 ch
Content (symbol)	0101 etc.	125 DX 111-104 RX	123 123	Mobile MMSI	100	Gateway MMSI	106	113	Freqs	117 (RQ)	

Mobile acknowledgement message

DSC field	Dot pattern	Phasing sequence	Format specification	Address	Category	Self-ID	Message 1 tc-1	Message 1 tc-2	Message 2	EOS	Error check
Length	20 bits	6 DX, 8 RX	2 char	5 char	1 char	5 char	1 ch	1 ch	6 char	3 DX 1 RX	1 ch
Content (symbol)	0101 etc.	125 DX 111-104 RX	123 123	Gateway MMSI	100	Mobile MMSI	106	113	Position	122 (BQ)	

4. DSC position request messages originated by gateway and mobile acknowledgements

Position request call

DSC field	Dot pattern	Phasing sequence	Format specification	Address	Category	Self-ID	Message 1 tc-1	Message 1 tc-2	Message 2	EOS	Error check
Length	200 bits	6 DX, 8 RX	2 char	5 char	1 char	5 char	1 ch	1 ch	6 char	3 DX 1 RX	1 ch
Content (symbol)	0101 etc.	125 DX 111-104 RX	120 120	Mobile MMSI	100	Gateway MMSI	121	126	6×126	117 (RQ)	

Position request acknowledgement

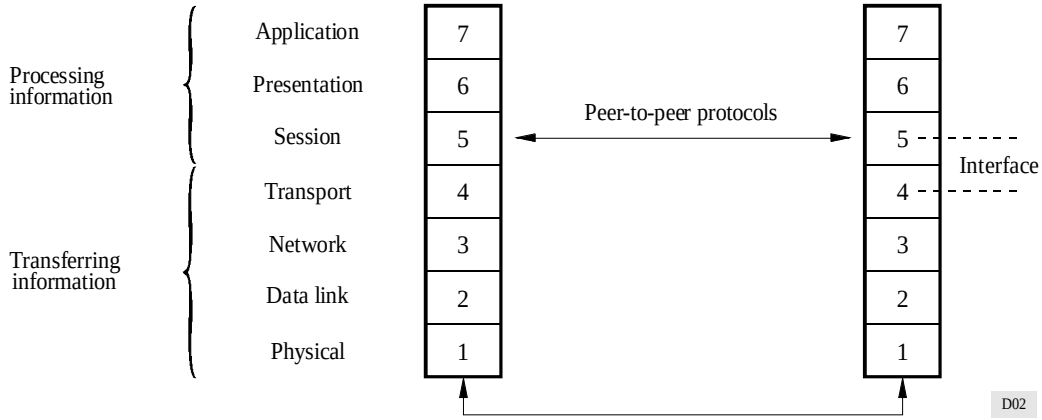
DSC field	Dot pattern	Phasing sequence	Format specification	Address	Category	Self-ID	Message 1 tc-1	Message 1 tc-2	Message 2	Message 3	EOS	Error check
Length	20 bits	6 DX, 8 RX	2 char	5 char	1 char	5 char	1 ch	1 ch	6 char	2 char	3 DX 1 RX	1 ch
Content (symbol)	0101 etc.	125 DX 111-104 RX	120 120	Gateway MMSI	100	Mobile MMSI	121	126	Position	Time	122 (BQ)	

ANNEX 3

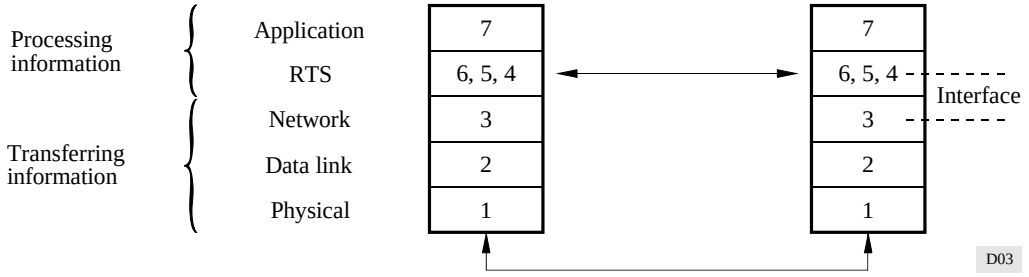
Protocol and structure of messages used to pass data over the working channel between the maritime mobile user and the gateway

1. General

The complete data communications system is based on a simplified version of the OSI seven-layered model described in ITU-T Recommendation X.200 and illustrated below:



To simplify implementation and to reduce overheads, layers 6, 5 and 4 are combined into one layer called a reliable transfer server (RTS) based on a simplified version of that defined in ITU-T Recommendation X.218 as illustrated below:



The function of each layer of the simplified communications system is as follows:

1.1 Physical layer

To transfer data information from the data link layer over the radio path using suitable radio equipment and modems.

1.2 Data link layer

To provide protocols to control the transfer of data over the radio path. The protocol used to establish initial contact between the mobile user and the gateway on the calling channels is included in the DSC system described in Annex 2. The data transactions that take place during a data communication session on the working channels use an ARQ protocol as described in § 3 of this Annex.

1.3 Network layer

To select the best radio channel for data communications and to control call and link set-up and cleardown.

1.4 Reliable transfer server (RTS)

To ensure error-free, secure and transparent data transfer with the highest possible throughput. The RTS is described in § 2 of this Annex.

1.5 Application layer

To provide the interface to the mobile and fixed users and offer them the services required.

2. Reliable transfer server (RTS)

2.1 General

The RTS ensures that a message or any other data will be successfully transferred. It provides the following functions:

- data file compression and decompression;
- data file segmentation and de-segmentation;
- data flow control and synchronization;
- encryption and decryption.

2.2 Messages

2.2.1 Types of message

The following types of message can be exchanged between the mobile user and the gateway over the working channel:

Control message: Used to control the communication link and the exchange of messages between the mobile user and gateway.

e.g.:
- connection set-up and release;
- communication mode setting;
- acknowledgement messages.

Data message: Used to convey facsimile and data file data between the mobile user and gateway.

2.2.2 Control messages

2.2.2.1 Layout of control messages

The layout of a control message is as follows:

Header	Opcode	Length and data

2.2.2.2 Header

The control message header comprises:

2.2.2.2.1 Identifier field

The identifier is one byte long.

Control messages are identified by a value of 00 Hex.

2.2.2.2.2 Sender's identity field

The sender's identity field is 5 bytes long and contains the MMSI of the sending station, i.e. mobile user or gateway, coded in BCD format.

2.2.2.2.3 Receiver's identity field

The receiver's identity field is 5 bytes long and contains the MMSI of the receiving station, i.e. mobile user or gateway, coded in BCD format.

2.2.2.3 Opcode

The opcode is 1 byte long and indicates the type of control message, e.g. call request, message received, user selection, etc.

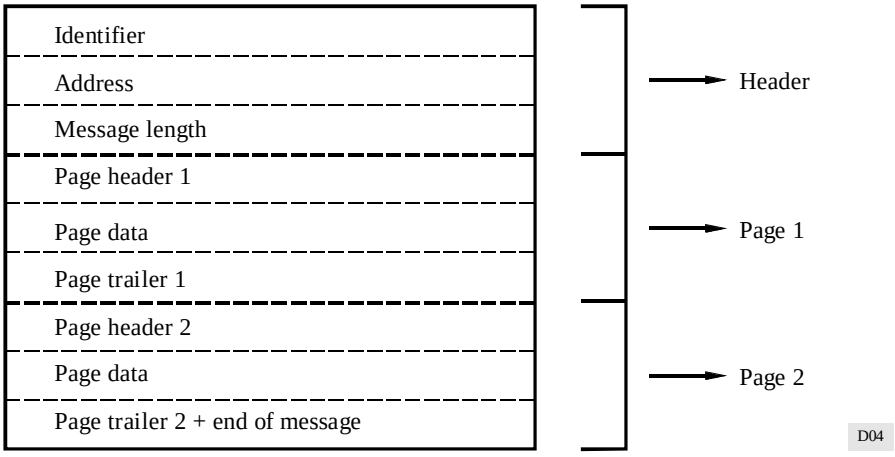
2.2.2.4 Length and data

The length is 2 bytes long and indicates the length of the following data field. The length of the data field varies with the amount of information associated with the particular opcode.

2.2.3 Data messages

2.2.3.1 Layout of data messages

An illustration of a multi-paged message (e.g. two pages) is as follows:



2.2.3.2 Data message header

The data message header comprises:

2.2.3.2.1 Identifier field

The identifier is 1 byte long.

Data messages are identified by a value of FF Hex.

2.2.3.2.2 Address field

The address field comprises the following subfields:

Originator ID	–	20 bytes	–	e.g. Ship's MMSI
Line modem	–	2 bytes	–	e.g. V-series modem
Facilities	–	2 bytes	–	e.g. Delivery advice
Future use	–	12 bytes	–	e.g. File name
Recipient IDs	–	101 bytes	–	e.g. Phone numbers (up to 10).

2.2.3.2.3 Message length field

The length field is 1 byte long representing the number of pages.

2.2.3.3 Data message page

The data message page comprises:

2.2.3.3.1 Page header field

The page header field comprises the following subfields:

Type of data	–	1 byte	–	e.g. Fax, Semi-Fax, ASCII
Page length	–	3 bytes	–	Amount of page data in bytes.

2.2.3.3.2 Page data field

The page data field contains the facsimile or data file data itself.

2.2.3.3.3 Page trailer field

The page trailer field contains four bytes of Control Z (ASCII decimal 026). The end of message is also four bytes of Control Z, hence the last page trailer, plus the end of message is eight bytes of Control Z.

2.3 Data file compression and decompression

Data files to be transferred are compressed/decompressed to achieve the highest possible user data throughput. File compression takes place before the file is segmented for transmission. Decompression takes place after all segments have been received error free and recombined.

2.4 Data file segmentation and desegmentation

Data files are segmented into RTS data units with the following structure:

Header (1 byte)	Control (1 byte)	Information field (*N* bytes (256 max.))	Data unit control sequence (1 byte)

2.4.1 Header field

The header maintains the synchronization between the sending RTS and the receiving RTS and delimits the RTS data unit.

2.4.2 Control field

The eight bits that comprise the control field byte indicate the sequence number (four bits), information data status (two bits) and the RTS data unit type (two bits).

The four bits of the sequence number indicate a number in the range 0 to 15 (modulo 16).

The two bits of the information data status indicate whether the information field is less than 256 bytes long (see § 2.4.3) and whether the data is encrypted.

The two bits of the RTS data unit type indicate whether it is a control data unit, normal data unit, repeated data unit or last data unit.

2.4.3 Information field

The information field contains the control and user data. If the information field is less than 256 bytes long, the first byte of the information field gives the length of the field.

2.4.4 Data unit control sequence

The data unit control sequence is a 16 bit checksum which is calculated by the sender RTS using the content of the information field (length included).

2.5 Mechanism for data flow control and synchronization

The sending RTS sends control and user data in RTS data units as described above. When the receiving RTS receives a “message transfer” control RTS data unit it initializes all message storage buffers and RTS unit sequence counters ready to receive and rebuild the incoming user data. The receiving RTS computes the checksum of the incoming RTS data units. If the checksum is incorrect, it stores the data unit sequence number and requests a repeat transmission. If the checksum is correct, the user data in the information field is added to the data previously received. The user data is rebuilt from the user information received. If during transmission, the RTS detects that synchronization has been lost, it sends an RTS control data unit which indicates that synchronization has been lost and which includes the sequence number of the last successfully received data unit.

2.6 Encryption and decryption of segments of data

The algorithm described in the United States’ National Bureau of Standards Data Encryption Standard is used to encrypt and decrypt user data. The encryption of user data by the sending RTS takes place before the computation of the checksum. The decryption of user data by the receiving RTS only takes place if the computation of the checksum indicates that the data unit was received with no errors.

3. ARQ scheme

3.1 General

The ARQ protocol applied to the data link layer provides a means of transferring data with a low residual error rate between two stations.

The exchange of data is half-duplex alternate.

The data is divided into blocks and the blocks assembled into frames.

The station (mobile or gateway) which initiates the link and sends information frames is termed the primary station and controls the link.

The station which receives information frames is termed the secondary station and acknowledges every information frame.

To reverse the direction of communication the primary station sends a command to the secondary station. The primary station then becomes the secondary station and the secondary station becomes the primary station taking control of the link.

3.2 Data frames

3.2.1 Frame structure

The frame structure is as follows:

Header (15 bits)	Information field (256 or 512 blocks of 15 bits)	Trailer (15 bits)

3.2.1.1 Header and trailer fields

The header and trailer fields are identical and comprise two Barker sequences of 0001101 plus one stuffing bit. They are used for frame synchronization and delimitation. The trailer of one frame can also be the header of the following frame.

3.2.1.2 Information fields

The information field comprises of either 256 or 512 blocks of 15 bits. The data in each block is coded using BCH (15,10) or BCH (15,5) in the forward direction and Golay code in the reverse direction.

3.2.2 Types of frames

There are three types of frames as follows:

a) Information – To carry user data, e.g. facsimile file data.

b) Backward – To acknowledge or non-acknowledge the correct receipt of an information frame and request retransmission of incorrectly received data blocks.

c) Control – To control the connection/disconnection of the link or to perform flow control.

ANNEX 4

Technical characteristics of DSC and HF modems

1. DSC modems

The technical characteristics of the DSC modems are in accordance with Recommendation ITU-R M.493.

2. HF modems

The basic technical characteristics of a suitable HF modem are as follows:

2.1 The HF modem uses QPSK modulation and demodulation.

2.2 In the modulator, every two bits of input data are combined into one QPSK symbol, filtered with a square root raised cosine (SRRC) filter with a roll-off factor of 0.33 and then modulated with a 1 500 Hz carrier frequency. The input data rate of 3 600 bit/s results in an output symbol rate of 1 800 Bd.

2.3 In the demodulator, the received signal is sampled at 7 200 Hz, filtered and down-sampled to one sample per symbol. The signal samples are fed into a near maximum likelihood detector where the transmitted data signals are extracted using an estimate of the channel's response provided by a least mean square channel estimator. Carrier synchronization is obtained by a phase-locked loop which uses a hard limiting Costas loop with a loop gain of 0.02 Hz/cycle and a loop bandwidth of 5 Hz. Channel response estimation is performed using known training frames at the start of and during a data burst.

2.4 The frame structure of the data stream is as follows :

Field A	Field B	Field C	Field D	Field B	Field C				

where:

Field A : 14 pseudo-noise sequences of 16 symbols for signal acquisition and initial channel impulse response estimation.

Field B : Unique word of 32 symbols that indicates the beginning of a data block.

Field C : 256 data symbols (512 data bits).

Field D : Five pseudo-noise sequences of 16 symbols for re-training the channel estimator.

2.5 The frame structure yields a net useful bit rate of 2 504 bits/s.

2.6 The HF data modem transmissions are classified as G2C (facsimile) or G2D (data) emissions for frequency registration purposes.

2.7 The frequency of the output from the modulator, applied to a standard maritime transmitter in J3E mode, is contained within the limits of 350 Hz to 2 700 Hz as required for maritime radiotelephony (see RR Appendix 17). However, in order to comply with the RR which prohibit the use of emissions other than J3E on maritime mobile telephony channels (see RR Appendix 16), the only frequencies in the maritime mobile service suitable for this type of transmission are those assigned for wideband telegraphy, facsimile and special transmission systems. Additional frequencies may also be available in the mobile and fixed bands.