Manual on the
Global Telecommunication System

Weather • Climate • Water

Manual on the
Global Telecommunication System

Volume I

(Annex III to WMO Technical Regulations)

Global Aspects

WMO-No. 386

**World
Meteorological
Organization**

Weather • Climate • Water

2009 edition

NOTE

CONTENTS

INTRODUCTION

Purpose

1.   The *Manual on the Global Telecommunication System* is issued in accordance with the decision of Sixth Congress.

2.   This *Manual* is designed:

   (a)   To facilitate cooperation in respect of meteorological telecommunications between Members;

   (b)   To specify obligations of Members in the implementation of the World Weather Watch (WWW) Global Telecommunication System (GTS);

   (c)   To ensure uniformity and standardization in the practices and procedures employed in achieving (a) and (b) above.

3.   The *Manual* is composed of Volumes I and II, which contain the regulatory material for the global and regional aspects, respectively, of the WWW Global Telecommunication System. This regulatory material stems from recommendations of the Commission for Basic Systems (CBS) and resolutions of regional associations, as well as from decisions taken by Congress and the Executive Council.

4.   Volume I of the *Manual* — Global Aspects — forms part of the *Technical Regulations* and is referred to as Annex III to the Technical Regulations (with the exceptions indicated in paragraphs 9 to 11 below).

Types of regulation

5.   Volume I of the *Manual* (with the exceptions indicated in paragraphs 9 to 11 below) comprises *standard* practices and procedures and *recommended* practices and procedures. In the *Manual* the definitions of these two types of practices and procedures are as follows:

   The *standard* practices and procedures:

   (a)   Shall be the practices and procedures which it is necessary that Members follow or implement; and therefore

   (b)   Shall have the status of requirements in a technical resolution in respect of which Article 9 (b) of the Convention is applicable; and

   (c)   Shall invariably be distinguished by the use of the term "shall" in the English text and by suitable equivalent terms in the French, Russian and Spanish texts.

   The *recommended* practices and procedures:

   (a)   Shall be the practices and procedures which it is desirable that Members follow or implement; and therefore

   (b)   Shall have the status of recommendations to Members, to which Article 9 (b) of the Convention shall not be applied; and

   (c)   Shall be distinguished by the use of the term "should" in the English text (except where specifically otherwise provided by decision of Congress) and by suitable equivalent terms in the French, Russian and Spanish texts.

6.   In accordance with the above definitions, Members shall do their utmost to implement the standard practices and procedures. In accordance with Article 9 (b) of the Convention and in conformity with the provisions of General Regulation 127, Members shall formally notify the Secretary-General, in writing, of their intention to apply the "standard practices and procedures" of the *Manual*, except those for which they have lodged a specific deviation. Members shall also inform the Secretary-General, at least three months in advance, of any change in the degree of their implementation of a "standard practice or procedure" as previously notified and of the effective date of the change.

7.   With regard to recommended practices and procedures, Members are urged to comply with these, but it is not necessary to notify the Secretary-General of non-observance.

8.   In order to clarify the status of the various regulatory material, the standard practices and procedures are distinguished from the recommended practices and procedures by a difference in typographical practice as indicated in the editorial note below.

Notes, attachments

9.   Certain notes are included in the *Manual* for explanatory purposes. They do not have the status of the annexes to the *Technical Regulations*.

10.   A number of detailed guidelines in respect of meteorological telecommunication practices and procedures are included in Volume I of the *Manual*. Taking into account the rapid development of telecommunication techniques and increasing requirements of WWW and other WMO programmes, these guidelines are given in "attachments" to the *Manual* and do not have the status of the annexes to the *Technical Regulations*. This will enable the Commission for Basic Systems to update them as necessary.

11.   Volume II of the *Manual* — Regional Aspects — does not form part of the *Technical Regulations*.

12.   The words "shall" and "should" in the attachments and in Volume II have their dictionary meanings and do not have the regulatory character mentioned in paragraph 5 above.

Note: The *Manual on the Global Telecommunication System* replaces the regulatory material contained in Chapters I and II of WMO Publication No. 9, Volume C, with effect from 15 January 1975, in accordance with Rec. 17 (CBS-VI) approved by Res. 3 (EC-XXVI).

EDITORIAL NOTE

The following typographical practice has been followed:

Standard practices and procedures have been printed in semi-bold roman.

Recommended practices and procedures have been printed in light face roman.

Notes have been printed in smaller type, light face roman, and preceded by the indication Note.

PART I

ORGANIZATION OF THE GLOBAL TELECOMMUNICATION SYSTEM

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ORGANIZATION OF THE GLOBAL TELECOMMUNICATION SYSTEM

1. FUNCTIONS, ORGANIZATION AND PRINCIPLES OF THE GLOBAL TELECOMMUNICATION SYSTEM

1.1 Functions

The functions of the Global Telecommunication System (GTS) shall be to facilitate the flow of data and processed products to meet the WWW requirements in a timely, reliable and cost-effective way, ensuring that all Members have access to data and products in accordance with approved procedures and within the limits of the agreed WWW system.

Note: It also gives telecommunication support to other programmes, as decided by the WMO Congress or the Executive Council, within the limits of its primary objectives.

1.2 Organizational principles of the GTS

1.2.1 The Global Telecommunication System shall be so organized as to accommodate the volume of meteorological information and its transmission within the required time limits to meet the needs of World, Regional Specialized and National Meteorological Centres, resulting from the implementation of the WWW.

1.2.2 The GTS shall be organized on a three-level basis, namely:

(a) The Main Telecommunication Network (MTN), linking together the WMCs as well as designated Regional Telecommunication Hubs (RTHs);
(b) The regional telecommunication networks; and
(c) The national telecommunication networks.

1.3 Design principles of the GTS

The design principles for the planning of the GTS shall be as follows:

Principle 1

The Global Telecommunication System shall be designed as an integrated network for the collection, exchange and distribution of information on a worldwide basis, with a view to meeting, efficiently and effectively, the requirements of all National Meteorological Services and also the requirements of World and Regional Specialized Meteorological Centres, within the agreed WWW system.

Principle 2

The system shall comprise an integrated network of point to point circuits, point to multipoint circuits, broadcast and multipoint to point circuits which are reliable and have suitable technical and operational characteristics. These circuits may be established via a combination of terrestrial and satellite telecommunication links, and data-communication network services.

Principle 3

The circuits to be provided and the techniques to be employed shall be adequate to accommodate the volume of meteorological and related information and its transmission within the required time limits to meet the needs of World, Regional Specialized and National Meteorological Centres.

Principle 4

In the planning of the circuits and transmission schedules, daily volume of traffic to be passed over any one circuit shall not exceed 80 per cent of its theoretical capacity. The circuits shall be designated to ensure the highest practicable reliability and availability.

Principle 5
          The system shall be based mainly on the interconnection of a number of centres, namely, National Meteorological Centres (NMCs), Regional Specialized Meteorological Centres (RSMCs), Regional Telecommunication Hubs (RTHs) and World Meteorological Centres (WMCs). The WMCs, RSMCs and RTHs shall be provided with suitable equipment for selection, switching and editing in order to provide NMCs with the data selected to meet the NMCs' specified needs.

Principle 6
          Provision shall be made for alternative routeings where practicable, to ensure the reliability and efficiency of the system, particularly the reliability and efficiency of the MTN.

1.4   Responsibilities for the GTS

1.4.1   General responsibilities of regional associations

          The following shall be the general responsibilities of regional associations:

(a) Each regional association shall assume responsibility for the establishment and maintenance of an effective telecommunication system which shall include the optimal and appropriate use of terrestrial and/or satellite telecommunication means. The system shall be adequate to meet the developing requirements stipulated by the Commission for Basic Systems for the interchange of meteorological and related information within the Region and with adjacent Regions;
(b) To ensure rapid and reliable collection of meteorological data from all observing stations, each regional association shall, when adopting its telecommunication plan, comply with the design and operational principles given in this *Manual*. These principles apply to those centres and circuits within its Region which are situated on the MTN;
(c) Each regional association shall decide on the implementation within its Region of the regional options provided for in the global specifications and procedures;
(d) For data dissemination systems (either terrestrial or via satellite), each regional association shall establish, after consultation with known or probable recipients inside and outside the Region and the Member responsible for the operation of such systems, the content, schedule, and other coordinated aspects of operations.

1.4.2   General responsibilities of Members

          In addition to the responsibilities stated explicitly in Technical Regulation [A.3.1.]2.1, the following principles shall apply:

(a) Members shall ensure that their national collecting system for observational reports allows both national and international needs to be met;
(b) When adopting international and regional telecommunication plans, Members shall ensure that technical characteristics and operational methods are compatible with the regional telecommunication networks.

Note: The contents and schedules of meteorological transmission programmes are published in WMO-Publication No. 9, Volume C.

2.   FUNCTIONS AND RESPONSIBILITIES OF THE METEOROLOGICAL TELECOMMUNICATION CENTRES

2.1   The WMCs (as regards telecommunications) and the RTHs shall be responsible for:

(a) Collecting the bulletins from their associated NMCs and transmitting them in the appropriate form on the MTN, either directly or through the appropriate WMC/RTH;
(b) Transmitting on the MTN, either directly or through the appropriate RTH, as internationally agreed and in the appropriate form, the processed meteorological information produced by the WMC or RSMC associated with them;
(c) Relaying selectively on the circuits of the MTN, as agreed, the bulletins which they receive from these circuits and/or from RTHs not situated on the MTN;

(d) Ensuring the selective distribution of bulletins to the associated NMCs and to the RTHs not situated on the MTN which they serve;

(e) Before relaying a message issued from their zones of responsibility (as an RTH in a Region and/or as an RTH located on the MTN) on the GTS, checking the parts related to the telecommunications of the message in order to maintain standard telecommunication procedures. The RTH informs the associated centre originating or compiling the message of any correction to be made to the message. The RTH and its associated centres make arrangements for the insertion of the message without telecommunication errors on the GTS. Messages issued from outside the zone of responsibility of an RTH shall not be corrected by the RTH except in case of special arrangements for inserting data into the GTS;

(f) Establishing data dissemination systems (terrestrial and/or via satellite) as required in accordance with regional plans;

(g) Carrying out the monitoring of the operation of the GTS of the WWW;

(h) For WMCs/RTHs on the MTN, maintaining the Catalogue of Meteorological Bulletins as regards bulletins issued from the zone for which they are responsible for the collection, exchange and distribution of data, as given in paragraph 1, Attachment I-3, and also including data from the Antarctica, as appropriate. WMCs/RTHs on the MTN may share their responsibility with the RTHs (not on the MTN) included in their zone of responsibility through regional arrangements.

Note: The plan for monitoring the operation of the WWW is given in Attachment I-5.

2.2   RSMCs not combined with RTHs should ensure distribution of their products by agreement with an appropriate GTS centre or centres.

2.3   **With regard to telecommunications, the NMCs shall be responsible for:**

(a) Collecting observational data from their own territory or that of one or more Members according to bilateral agreements, as well as observational data from aircraft and ships received by centres located within the area of responsibility. This collection shall take place as soon as possible and shall be completed within 15 minutes of the observing station's filing time;

Notes:
1. The observing station's filing time is defined as the time at which the coded meteorological report is first presented to the telecommunication system. For an aircraft or ship weather report, it is the time when it is received by the appropriate communication station (land station/coast station).

2. Under normal conditions, the report should be presented to the telecommunication system not later than five minutes after the completion of its coding.

(b) Compiling such data into bulletins and transmitting them to the associated RTH, in compliance with standard telecommunications procedures;

Note: NMCs may be associated with more than one RTH.

(c) Receiving and distributing for their benefit and that of Members that request them, in accordance with bilateral agreements, observational data and processed meteorological information, to meet the requirements of the Members concerned;

(d) Carrying out the relevant monitoring of the operation of the GTS of the WWW.

Notes:
1. Checking of meteorological content of national observational data is to be accomplished by the responsible NMCs, or the other originating centres as appropriate (see paragraph 2.4 below), before such data are compiled into bulletins for further transmission on the GTS.

2. The plan for monitoring the operation of the WWW is given in Attachment I-5.

2.4   **Each member shall designate an NMC, or other centre as appropriate, for performing the functions mentioned in paragraph 2.3 above, as well as for the meteorological checking of national observational data before such data are presented for further transmission on the GTS.**

2.5   General responsibility for the collection of meteorological reports

Members shall operate centres responsible for the assembly of reports from individual land stations, as well as meteorological reports from stations at sea and aircraft.

2.6   Responsibility for the collection of meteorological reports from stations at sea through coast stations and coast Earth stations

2.6.1   Members should make the necessary arrangements with telecommunication authorities or appropriate telecommunication administrations to establish procedures for the collection of meteorological reports from ships through coast stations and coast Earth stations (INMARSAT), in order to ensure an effective transmission link between a coast station/coast Earth station and a collecting centre.

2.6.2   Members should be encouraged to develop the use of automatic transmission from ships to the designated collecting centres without relay by operators.

2.6.3   **Members responsible for the collection of meteorological reports from ships shall provide the Secretariat with a list of their coast stations and coast Earth stations designated for this purpose, including information on location, call signs, working transmission and reception frequencies.**

Note: The list of coast stations and coast Earth stations accepting ships' weather reports is published in WMO Publication No. 9, Volume D, Part B.

2.6.4   **Members shall send necessary amendments to the information supplied under paragraph 2.6.3 above to the Secretariat.**

2.6.5   **Each Member designating a coast station for reception of meteorological reports from ships or designating a coast Earth station for reception of meteorological reports from ships in a defined geographical area of interest to the Member shall confirm to the Secretariat that the Member will be responsible for any transmission cost of such reports being sent to its collecting centre.**

2.6.6   **Members shall provide their designated ship stations and ship Earth stations with details of the procedures for addressing and routeing meteorological reports in different sea areas.**

Note: Details of these procedures are given in Attachment I-1. Additional special procedures adopted by regional associations are given in Volume II of this *Manual*.

2.6.7   **Members responsible for the insertion into the GTS of meteorological reports from ships shall ensure that the reports are in conformity with WMO standards and that they are transmitted under appropriate bulletin headings.**

2.6.8   Members responsible for the reception of meteorological reports from ships should arrange that coast stations adequate in number, staffing and telecommunication capacity are available to discharge this responsibility.

2.6.9   Members should request ships to transmit their meteorological reports to a coast station or a coast Earth station as soon as possible after the time of observation.

2.6.10   **Each Member shall arrange with the services responsible for operating coast stations designated to accept meteorological reports from ships so that those stations:**

(a) **Accept such reports with the least possible delay;**
(b) **Transmit them immediately to the designated collecting centres.**

2.6.11   Members should ask ships not to send the same meteorological report to more than one address.

2.6.12   **Each Member, in consultation with its telecommunication administration, shall arrange that the service indicator OBS is used in the original call from observing ships to the coast stations for securing the appropriate priority of answer by the coast station. The abbreviation OBS shall also be included as a paid service indicator in the preamble of ships' weather messages transmitted from observing ships to coast stations for securing appropriate priority handling of messages by coast stations.** This does not apply in cases where automatic access codes over satellites or automatic radiotelex are employed.

2.6.13   Members should arrange for the word METEO to be employed as the first word in the address of ships' weather reports. This does not apply in cases where automatic access codes over satellites or automatic radiotelex are employed.

2.6.14   Members should arrange with their telecommunication administrations for the inclusion of call signs of ships, when available, in the preamble of meteorological reports from selected, supplementary and auxiliary ship stations when transmitted from coast stations to collecting centres.

2.6.15   Meteorological reports from ships, when included in collective transmissions, should include the call sign of the ship.

2.6.16   Whenever meteorological reports from ships received at collecting centres are insufficient or unduly delayed, the Member responsible for the collection should first take local or regional action in an endeavor to correct the deficiency and, if such action is not effective, notify the Secretariat.

2.6.17   Members should make every effort to encourage ships in ocean areas where shipping is relatively sparse to relay weather messages through other ships when the reporting ship is unable to communicate with coast stations or coast Earth stations or when communication conditions are difficult.

2.6.18   Members should encourage ships to exchange radio weather messages for the benefit of each other when in areas where shipping is sparse or where no regular weather bulletin is issued.

2.7   Responsibility for collection (reception) of reports from aircraft

2.7.1   **Collecting centres designated in the ICAO Regional Air Navigation Plans for the collection of aircraft weather reports shall send all available aircraft weather reports to the NMC situated in the respective country or to other meteorological centres designated by agreement between the aeronautical and meteorological authorities concerned.**

2.7.2   **RTHs shall collect the aircraft weather reports from the NMCs in their respective zones of responsibility.**

2.8   Responsibility for meteorological reports from automatic surface synoptic stations

2.8.1   Messages from automatic surface synoptic stations put in international code form by an editing station should be transmitted expeditiously to appropriate collecting centres.

2.8.2   Messages directly transmitted by automatic surface synoptic stations in code form for international exchange should be transmitted with sufficient strength to ensure reception at appropriate collecting centres.

2.8.3   Members operating automatic synoptic surface stations on drifting buoys should make every effort to communicate to other interested Members all of the necessary information (e.g. radio frequencies and code forms) to enable them to receive the transmissions from those drifting automatic stations which may have moved beyond the range of the receiving stations of the Members that launched the station.

2.8.4   Other observational data from drifting buoys available at satellite data-processing centres should be made available to the appropriate WMCs/RTHs for regional and global distribution over the GTS, using the appropriate code form for international exchange.

Note: Additional guidance concerning the functions and capabilities of meteorological telecommunication centres is given in Part III of this volume.

2.9   Responsibilities for exchange and distribution of processed meteorological information

The GTS should be capable of exchanging and distributing the output products of WMCs and RSMCs as well as World Area Forecast Centres (WAFCs) and Regional Area Forecast Centres (RAFCs), as required.

3.   FUNCTIONS AND CHARACTERISTICS OF THE NETWORKS OF THE GLOBAL TELECOMMUNICATION SYSTEM

3.1   The Main Telecommunication Network (MTN)

3.1.1   **The MTN shall be an integrated system of circuits linking together the WMCs and designated RTHs. The circuits which directly link WMCs and/or RTHs situated on the MTN may, at the request of Members concerned, be designated as circuits of the MTN.**

Note: The names of these centres, together with a diagram indicating the configuration of the MTN, are given in Attachment I-2.

3.1.2   **The MTN shall be designed in such a way that the traffic originating from each centre (WMC, designated RTH) will be routed selectively towards the addressee centre(s). Each centre on the MTN shall ensure selective relay of the traffic which it receives towards the circuit(s) which it serves.**

3.1.3   **The MTN shall have the function of providing an efficient, reliable communication service between the designated centres, in order to ensure:**

(a) Rapid and reliable exchange of observational data required to meet the GDPFS requirements;
(b) Exchange of processed information between the WMCs, including data received from meteorological satellites;
(c) Transmission of processed information produced by the WMCs, to meet the requirements of RSMCs and NMCs;
(d) Transmission of other observational data and processed information required for interregional exchange.

Note: Responsibilities of centres located on the MTN for the transmission of observational data and processed information are given in Attachment I-3.

3.2   Regional meteorological telecommunication networks (RMTNs)

3.2.1   The regional meteorological telecommunication networks shall consist of an integrated network of point-to-point circuits, point-to-multipoint circuits and multipoint-to-point circuits which interconnects RTHs, NMCs, and in some regions WMCs and/or RSMCs and also, where needed, radio broadcasts in accordance with the regional meteorological telecommunication plans for WWW established by the regional associations. These networks shall be designed so as to enable the WMCs, RTHs and NMCs to perform the functions defined in section 2 above.

Note: The centres which are situated on the regional meteorological telecommunication networks are specified by the regional associations (see Volume II of this *Manual*).

3.2.2   The regional meteorological telecommunication networks comprise the following meteorological transmission systems and circuits:

(a) The circuits of the MTN which pass through the Region;
(b) The main regional circuits, consisting of point-to-point circuits (either landline or satellite) interconnecting the RTHs in the Region;
(c) The regional circuits, consisting of point-to-point circuits, point-to-multipoint circuits and multipoint-to-point circuits (landline, satellite or radio) connecting the NMCs to the RTHs or other NMCs in the Region;
(d) Interregional circuits, consisting of point-to-point circuits (landline, satellite or radio) interconnecting RTHs or WMCs to RTHs in different Regions;
(e) Supplementary interregional circuits, consisting of point-to-point circuits (landline, satellite or radio) which connect WMCs, RTHs and NMCs to RSMCs or NMCs located in other Regions;
(f) Radio broadcasts and other radio facilities.

3.2.3   Functions specified within the framework of the GTS

In order to obtain rapid collection and distribution of observational data or processed information for all National Meteorological Services, the regional meteorological telecommunication networks shall be engineered so as to ensure:

(a) Exchange and distribution of observational data within the Region, as required to meet the needs of Members of the Region;
(b) Collection of observational data originating in, or being received by, stations located in the Region (e.g. reports from aircraft and ships);
(c) Collection of observational data from associated NMCs in adjacent Regions provided that this is found to be of use to the GTS and provided that this is agreed upon by the Members concerned and the corresponding regional associations;
(d) Exchange and distribution of processed (conventional and satellite) information as required to meet the needs of Members of the Region;
(e) Interchange of observational data and processed information with other Regions.

3.2.4   Contents of meteorological transmissions by point-to-point circuits

3.2.4.1   The contents of meteorological transmissions on main regional circuits and regional circuits shall be determined by the regional associations to meet the requirements of the Members of the Region concerned.

3.2.4.2 **The contents of meteorological transmissions on interregional circuits and supplementary interregional circuits shall be established by interregional and/or bilateral agreements between Members.**

3.3 National meteorological telecommunication networks (NMTNs)

3.3.1 General functions within the framework of the WWW

3.3.1.1 **The national meteorological telecommunication networks shall be engineered so as to enable the NMCs to perform the functions defined in paragraph 2.3 above.**

3.3.1.2 **The choice of telecommunication networks and facilities for the collection of information from stations located within a country or territory shall be a matter for decision by the Member concerned.**

3.3.1.3 The arrangements for national collections should comply at least with the WWW requirements as regards maximum tolerable delay and reliability of reception.

3.3.1.4 In order to meet the needs of the WWW for timely and reliable transmission and reception, telecommunication networks intended solely for meteorological requirements should be established.

3.3.1.5 Where facilities mentioned in paragraph 3.3.1.4 above are not available or are not practicable, arrangements should be made for the use of other facilities, such as:

(a) Special-purpose telecommunication systems (e.g. aeronautical circuits);
(b) Commercial telecommunication services available to the public.

3.3.1.6 Provision should be made, whenever possible, for a mutilated or erroneous report to be repeated by the observing station at the request of the NMC concerned.

3.3.2 Programmes of transmissions from NMCs to RTHs

Transmissions from NMCs to the appropriate RTH or RTHs shall include at least the following information:

(a) **Surface and upper-air synoptic reports from land stations and fixed ship stations required by regional agreement for regional and interregional exchange;**
(b) **All reports from mobile ship stations and aircraft received either directly or from other collecting centres, within the area covered by the NMC transmission;**
(c) **Other information as required by regional agreement.**

Note: In order that the observational data may reach the centres of the GTS in time, priority is first given to:
    (a) The collection of the required observational data on a national basis;
    (b) The transmission of the data so collected to the associated RTHs.

3.4 Satellite-based data collection and dissemination systems

3.4.1 Introduction

3.4.1.1 Satellite-based data collection and distribution systems are integrated in the GTS as an essential element of the global, regional and national levels of the GTS.

3.4.1.2 They should comply with the organization and principles of the GTS, particularly with respect to the functions and responsibilities of meteorological telecommunication centres.

3.4.1.3 They operate through communication functions of meteorological satellites and through public telecommunication services via satellite.

3.4.1.4 The principles for the planning of satellite-based data distribution should be as follows:

(a) A satellite-based distribution system should be a telecommunication technique complementing the point-to-point GTS circuits;
(b) RSMCs, RTHs and NMCs should have the capacity to insert meteorological information (either directly or indirectly) into the regional/multi-regional satellite-based distribution system.

3.4.2   Data collection systems via meteorological satellite

3.4.2.1   Data collection systems and associated data retransmission systems, when available, operated via geostationary or near-polar orbiting meteorological satellites constitute an integral part of the GTS for the collection of observations. Basic meteorological data collected in this way normally requires validation by the NMC before it is disseminated on the GTS for general use. By agreement, data not subject to verification may be inserted onto the GTS via a nominated NMC.

3.4.2.2   **Data collection platforms (DCPs) shall be maintained by the DCP operators. Quality control of the output from these platforms is the responsibility of the operator and the nominated NMC.**

3.4.2.3   **Unless agreed upon otherwise, the meteorological satellite operator shall ensure the prompt transmission of the received DCP message to the NMC responsible for quality control and verification prior to its general dissemination on the GTS.**

3.4.2.4   The data collection platforms must operate in accordance with the parameters as defined by the meteorological satellite operator.

3.4.3   Data distribution systems via meteorological satellites

3.4.3.1   Data distribution systems operated via geostationary meteorological satellites constitute an integral part of the GTS for the point-to-multipoint transmission of observational data and processed information in character, binary, graphical and pictorial form, within the agreed WWW system.

3.4.3.2   **The point-to-multipoint service to be provided by the meteorological satellite operator shall be subject to agreement between the NMCs concerned and the agencies participating in the programmes. The NMC acting as data provider to the meteorological satellite operator whether they originate the data or not shall be responsible for relaying the input data.**

3.4.3.3   **The contents and schedules of transmission, as well as frequencies, orbital data and area coverage of meteorological satellites shall be provided by satellite operators.**

Notes:

1. The contents and schedules of transmission by meteorological satellites are published in WMO Publication No. 9, Volume C.

2. Information on meteorological satellite programmes operated by Members and organizations is published in WMO Publication No. 411.

3.4.4   Point-to-multipoint and multipoint-to-point transmission via telecommunication satellites

3.4.4.1   Point-to-multipoint telecommunication service via satellite provided by telecommunication administrations/agencies may be used as an integral part of the GTS for the direct distribution to NMCs of observational data and processed information from WMCs, RSMCs and NMCs at the global, multi-regional or regional level.

3.4.4.2   Multipoint-to-point telecommunications service via satellite provided by telecommunication administrations/agencies may be used as an integral part of the GTS for the implementation of regional meteorological telecommunications networks, in accordance with the plans established by the regional associations.

3.5   HF-radio broadcasts of meteorological information

3.5.1   General

Until the integrated network, as defined in principle 2 (see paragraph 1.3 above), is completed, HF-radio broadcasts may be used in order to meet the requirements of the WWW for the dissemination of meteorological information.

3.5.2   Responsibilities of Members

3.5.2.1   **When a Member establishes within its territory a routine meteorological broadcast intended for use by other Members, the Member shall send the following information, as appropriate, to the Secretariat:**

(a) **Name and call sign, or other identification, of transmitting station;**

(b) **Power supplied to the antenna;**

(c) **Class of emission, necessary band width;**

(d) **Frequencies;**

(e) **Contents, detailed time schedules and WMO category of the broadcast;**

(f) Index of cooperation and drum speed(s) of facsimile transmitter;

(g) Specific point(s) or area(s) in which the broadcast is intended to be received.

3.5.2.2   Amendments to the information supplied under paragraph 3.5.2.1 above shall be sent to the Secretariat at least two months before a routine meteorological broadcast is established or a change is made in an existing routine broadcast.

3.5.2.3   In addition to the information supplied to the Secretariat under paragraph 3.5.2.2 above, notification of impending changes in frequencies or in time schedules of any routine meteorological radio broadcasts shall be included by the Member concerned in the broadcasts for main synoptic hours for at least three days immediately prior to the change.

3.5.2.4   When it is necessary to discontinue a broadcast intended primarily for reception by other Members, provision shall be made to continue to meet the requirements of all recipients of the broadcast.

Note: Broadcasts by a Member intended primarily for its own use are not affected by the above, even if they are used by other Members.

3.5.2.5   When it is necessary or desirable to change the mode of a broadcast intended primarily for reception by other Members, notice of a duration agreed regionally or multilaterally shall be given to the recipients.

Notes:

1. On expiry of this notice it will be assumed that the requirements of the recipients are met by the broadcasts in the new mode.

2. Broadcasts by a Member intended primarily for its own use are not affected by the above, even if they are used by other Members.

3.5.2.6   A Member experiencing difficulties in receiving or observing any deficiencies in a broadcast intended for its reception, as agreed, should first take corrective action of a local nature and, if unsuccessful, notify in detail the Member making this broadcast and also keep the president of the relevant regional association informed as necessary.

3.5.3   The system of radio broadcasts shall be as follows:

3.5.3.1   RTT broadcasts

Classification	*Content*	*Intended reception area*	*Responsibility for operations*
A. Territorial broadcasts	Meteorological information from the territory or territories of one or more Members and ship and aircraft reports as received in this territory or territories	(a) At one or more designated RTHs (b) Within the area of origin of the information (c) In adjacent countries as regionally or inter-regionally agreed	Mandatory for NMCs until a reliable point-to-point system is available to the associated RTH. Otherwise optional for national purposes
B. Regional broadcasts	Selection of meteorological information as agreed regionally and coordinated interregionally as necessary	Within a specified area in a Region and in an interregionally agreed area	WMCs and RTHs in accordance with the regional meteorological telecommunication plans

3.5.3.2   Radio-facsimile broadcasts

Classification	*Content*	*Intended reception area*	*Responsibility for operations*
Regional broadcasts*	Products of the RSMCs in the Region, products of WMCs and other RSMCs as agreed regionally and coordinated inter regionally as necessary	Within a specified area in a Region and in an interregionally agreed area	WMCs, RSMCs and RTHs in accordance with the regional meteorological tele-communication plans

* This classification does not preclude the establishment of facsimile broadcasts by NMCs.

ARRANGEMENTS FOR THE COLLECTION OF SHIPS' WEATHER REPORTS AND OCEANOGRAPHIC REPORTS (BATHY/TESAC)

1. ZONES FOR THE COLLECTION OF SHIPS' WEATHER REPORTS

Oceanic and sea areas are divided first into WMO Regions and the Antarctic and then, within each Region, into a small number of zones determined by the regional associations concerned in accordance with the following principles:

(a) As a rule, zones should be linked to RTHs responsible for the international dissemination of the reports collected by coast stations and coast earth stations in the zone;

(b) By way of exception, zones pertaining to one Region may extend into the sea area of an adjacent Region, if so agreed between the two regional associations concerned;

(c) Along the border line between two Regions, zones pertaining to each Region may overlap each other, if so agreed between the two regional associations concerned.

The zones for the collecting of ships' weather reports, as agreed by regional associations and the Executive Council, are shown in Figure 1.

2. TRANSMISSION OF SHIPS' WEATHER REPORTS TO COAST STATIONS AND COAST EARTH STATIONS

2.1   Weather reports from ship stations and ship earth stations should be transmitted to a coast station or a coast earth station as soon as possible after the time of observation.

2.2   Weather reports from ship stations should be compiled in 10-figure groups, where desirable and appropriate. The ship's call sign should appear alone at the beginning of the report. Thereafter, the groups are simply run together to form 10-figure groups. If a 5-figure group is left over, it is sent as a 5-figure group. If the identifier 333 appears, it will run together with the adjacent five figures to form an 8-figure group. The restoration to 5-figure groups should be carried out not later than at the point of insertion in the GTS – usually at the NMC involved. The above arrangements do not apply to the parts of ships' weather reports prepared in plain language.

Example:

WLGT 0518499568 7020141498 5231410083 2001640198 5301270282 8323222200
0010320303 3263040907 50805333 8381583360

2.3   Weather reports from ship stations and ship earth stations should (without special request) be transmitted to the nearest available coast station or appropriate coast earth station situated in the zone in which the ship is navigating.

2.4   In a case where no ship earth station is available or if it is difficult, owing to radio propagation conditions or other circumstances, to contact promptly the nearest coast station in the zone in which the ship is navigating, the weather messages should be cleared by applying the following procedures in the order given below:

(a) Transmission to any other coast station in the zone in which the ship is navigating;

(b) Transmission to any coast station in an adjacent zone within the same Region;

(c) Transmission to any coast station in any other zone within the same Region;

(d) Transmission to a coast station in an adjacent zone in a neighbouring Region or, failing that, to any other station in a neighbouring Region;

(e) Transmission to another ship or an ocean weather station with the function of, or willing to act, as a relay station.

2.5   In zones situated along the border line between two Regions, the order of procedures for the transmission of ships' weather reports to coast stations, as laid down in subparagraphs (a), (b), (c), (d) and (e) of paragraph 2.4 above, may be interchanged subject to agreement between the two regional associations involved. Any agreement reached on this matter should specify the limits of the area concerned.

2.6   Members may issue instructions to their ship stations to the effect that their weather reports may be transmitted via one of their home coast stations designated for the collection of reports from the zone, if the application of such procedures may facilitate efficient contact with coast stations and the clearing of weather messages. Members may also issue instructions to their ship stations to transmit weather reports via particular coast earth stations through which the Member will be responsible for the transmission costs.

3.   CRITERIA AND PERFORMANCE OF COAST STATIONS AND COAST EARTH STATIONS ACCEPTING SHIPS' WEATHER REPORTS

3.1   Members should ensure that the coast stations designated to receive ships' weather messages satisfy the following criteria:

(a) Accept ships' weather reports free of charge to ships;
(b) For the purpose of receiving ships' weather reports;
   (i) Keep a continuous 24-hour watch; or
   (ii) Keep a watch for at least 30 minutes beginning at 0000, 0600, 1200 and 1800 UTC daily; watch should also be kept for a similar minimum time at the beginning of the nearest "single-operator period" following those standard synoptic hours;* or
   (iii) Keep watch for shorter periods (stations with limited hours of operations) than those mentioned under (ii) above, when those stations are considered of particular value.

3.2   If any particular coast station is shown to consistently fail to accept ships' weather reports promptly or if the subsequent retransmission is deficient the president of the regional association concerned should take steps with a view to improving the situation and, if such action does not succeed, action should be taken to remove that station from the list of designated coast stations.

3.3   Members whose ships repeatedly encounter difficulties in clearing ships' weather reports with coast stations in certain reporting areas should communicate promptly with the Members concerned giving full particulars as to dates and times; the presidents of the Commission for Basic Systems and the Joint WMO/IOC Technical Commission for Oceanography and Marine Meteorology and the Secretary-General should also be informed.

3.4   Members should ensure that coast earth stations designated to receive ships' weather messages accept these reports free of charge to ships.

4.   ADDITIONAL PROCEDURES FOR SINGLE-OPERATOR SHIPS

4.1   Owing to the difficulties resulting from fixed radio watch hours, single-operator ships, in making weather observations and in transmitting messages, should be guided by the procedures in the order given below.

4.2   When operational difficulties on board ship make it impracticable to make and/or transmit a surface synoptic observation at a main standard time (0000, 0600, 1200 and 1800 UTC), the actual time of observation should be as near as possible to the main standard time to ensure transmission of a message to a coast station before the radio officer goes off duty. Alternatively, in special cases, observations may be taken one full hour earlier than the main standard time and be timed accordingly (i.e. 2300, 0500, 1100 or 1700 UTC, respectively). However, it is emphasized that these departures should be regarded only as an exception.

4.3   When an observation is made at 0300, 0900, 1500 or 2100 UTC, in order to ensure its transmission to a coast station, the observation at the next main standard synoptic time, i.e. 0600, 1200, 1800 or 0000 UTC, should be made for climatological purposes and, if possible, transmitted as indicated in paragraph 4.4 below.

4.4   Observations made at any of the standard times 0000, 0600, 1200 and 1800 UTC should be transmitted even after a period of delay after the time of observation and:
(a) In most parts of the world they should be transmitted up to 12 hours after the time of observation if it is not possible to do so earlier;

———

* A table showing the international watchkeeping hours on board ships is given in Figure 2.

(b) In the southern hemisphere and other areas where few ships' weather reports are available, they should be transmitted up to 24 hours after the time of observation.

It is important that this procedure be followed even if an observation for a more recent time is also being transmitted.

5.   COLLECTION OF OCEANOGRAPHIC REPORTS (BATHY/TESAC)

5.1   BATHY and TESAC reports should be transmitted to METEO or METEOCEAN addresses through specified coast stations and coast earth stations.

Note: The list of coast stations and coast earth stations accepting BATHY and TESAC reports free of charge to ships together with their radio addresses is given in WMO Publication No. 9, Volume D, Part B and IOC Manuals and Guides Series No. 3, Guide to Operational Procedures for the Collection and Exchange of Oceanographic Data (BATHY and TESAC).

5.2   When reports are relayed by operators to coast stations, the abbreviation OBS should be included as a paid service indicator before the address in BATHY and TESAC messages transmitted from observing ships to coast stations. This does not apply in cases where automatic access codes over satellites or automatic radio telex are employed.

5.3   BATHY and TESAC reports should be transmitted separately from meteorological (surface or upper-air) reports. They should be transmitted to a specified coast station at times which do not interfere with the transmission of meteorological reports, avoiding as far as possible the following periods:

2330 UTC–0200 UTC; 0530 UTC–0800 UTC;

1130 UTC–1400 UTC; 1730 UTC–2000 UTC

5.4   BATHY and TESAC reports should be transmitted from ships to coast stations as soon as possible after the time of observation. However, the reports may be transmitted up to 30 days after the time of observation in cases where operational difficulties do not permit their earlier transmission. The international date-time group in the abbreviated heading of the bulletins should be the time of origin of these bulletins in UTC (see Part II, paragraph 2.3.2.2 of this volume).

Note: The time of origin of bulletins refers to the time of compilation of bulletins by the GTS centres.

5.5   Geographical designators of the abbreviated heading of BATHY/TESAC bulletins should be in accordance with Table C2 of Attachment II-5.

Note: All BATHY/TESAC bulletins should be notified to the WMO Secretariat for inclusion in the Catalogue of Meteorological Bulletins, WMO Publication No. 9, Volume C1.

5.6   Specific monitoring of a BATHY/TESAC exchange over the MTN should be carried out in conjunction with the internationally coordinated monitoring on a non-real time basis as prescribed in Attachment I-5.

*

*   *
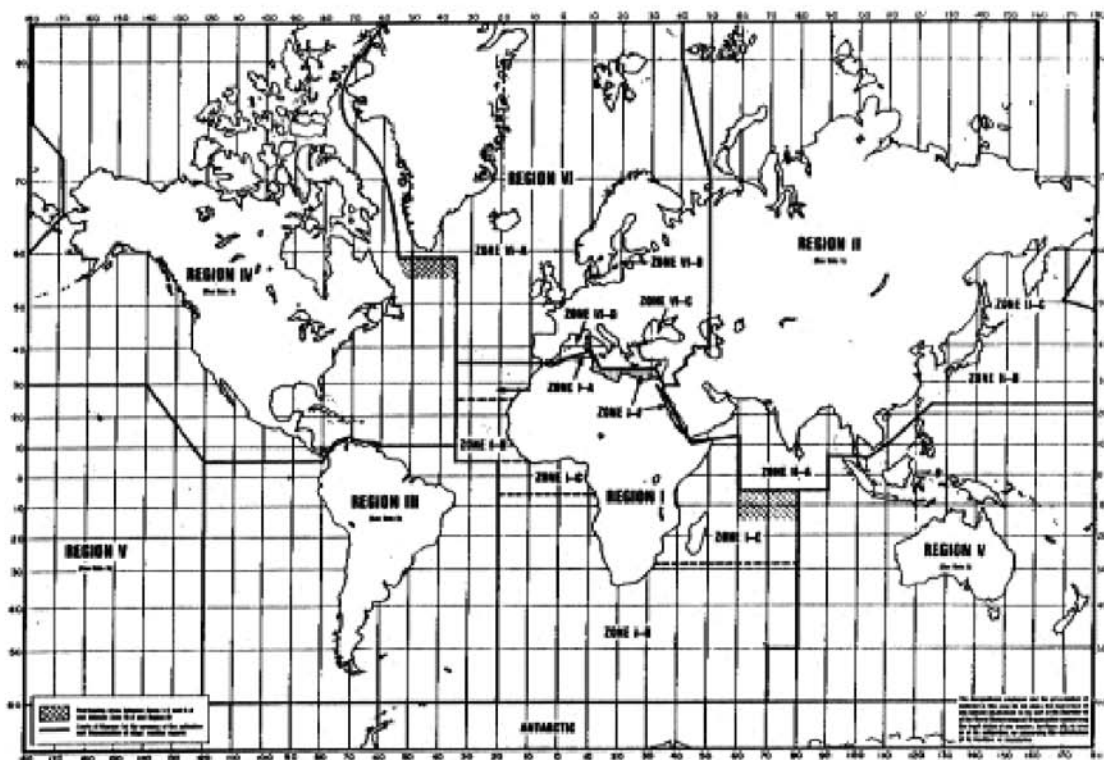
Figure 1. Broad outline of zones for the collection and dissemination of ships' weather reports

Notes:

1. While Zone II–C should comprise the northern part of the Sea of Japan and other portions of the North Pacific in Region II, and Zone II–B should comprise the southern part of the Sea of Japan and the southern part of the Pacific in Region II, a strict boundary has not been defined between Zones II–B and II–C.

2. For the collection of ships' weather reports, Region III is a single zone. Ships navigating in Region III should therefore transmit their weather reports through the nearest coastal radio station within the Region. As a temporary measure, ships plying the Pacific waters of the Region should continue to clear their weather reports through the coastal radio station Balboa – NBA, if unable to contact other HF coastal radio stations within Region III.

3. No subdivision of Regions IV and V into zones has been found necessary. Ships navigating in Region IV or V should therefore transmit their weather reports through the nearest coastal radio station within the Region concerned.

4. The border lines between Regions VI and IV shall be considered flexible in order to facilitate the transmission of ships' weather reports from the sea areas near these borders to a coastal station in one or the other Region.
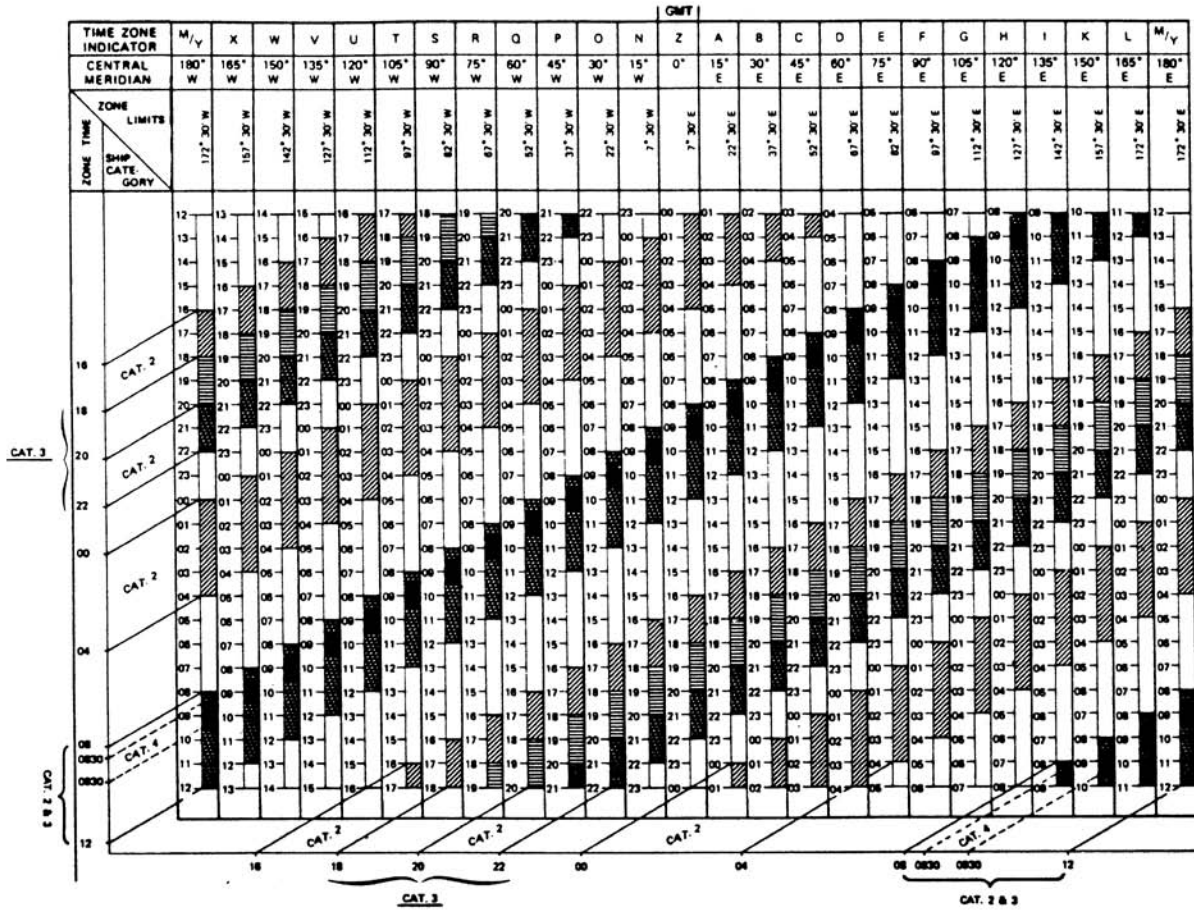
Figure 2. Time zones and hours of service of ship stations

Notes:

1. The above figure indicates the fixed and elected hours of service maintained by ships of the second and third categories in terms of zone time. (The hours of service shown exclude those which are determined by the administration, master, or person responsible.)

   The fixed hours of watch are shown thus:

   (a) ▨ For ships of the second category;

   (b) ▉ For ships of the second and third categories;

   (c) ▥ For ships of the third category, period over which two continuous hours of service may be elected.

2. Also shown (in black) is the specific service period 0830–0930 that ships of the fourth category are encouraged to provide.

CONFIGURATION OF THE MAIN TELECOMMUNICATION NETWORK

MOSCOW
SOFIA
PRAGUE
CAIRO
NEW DELHI
OFFENBACH
NAIROBI
JEDDAH
BEIJING
MELBOURNE
TOULOUSE
ALGIERS
DAKAR
EXETER
TOKYO
WASHINGTON
BRASILIA
BUENOS AIRES

WMC
RTH
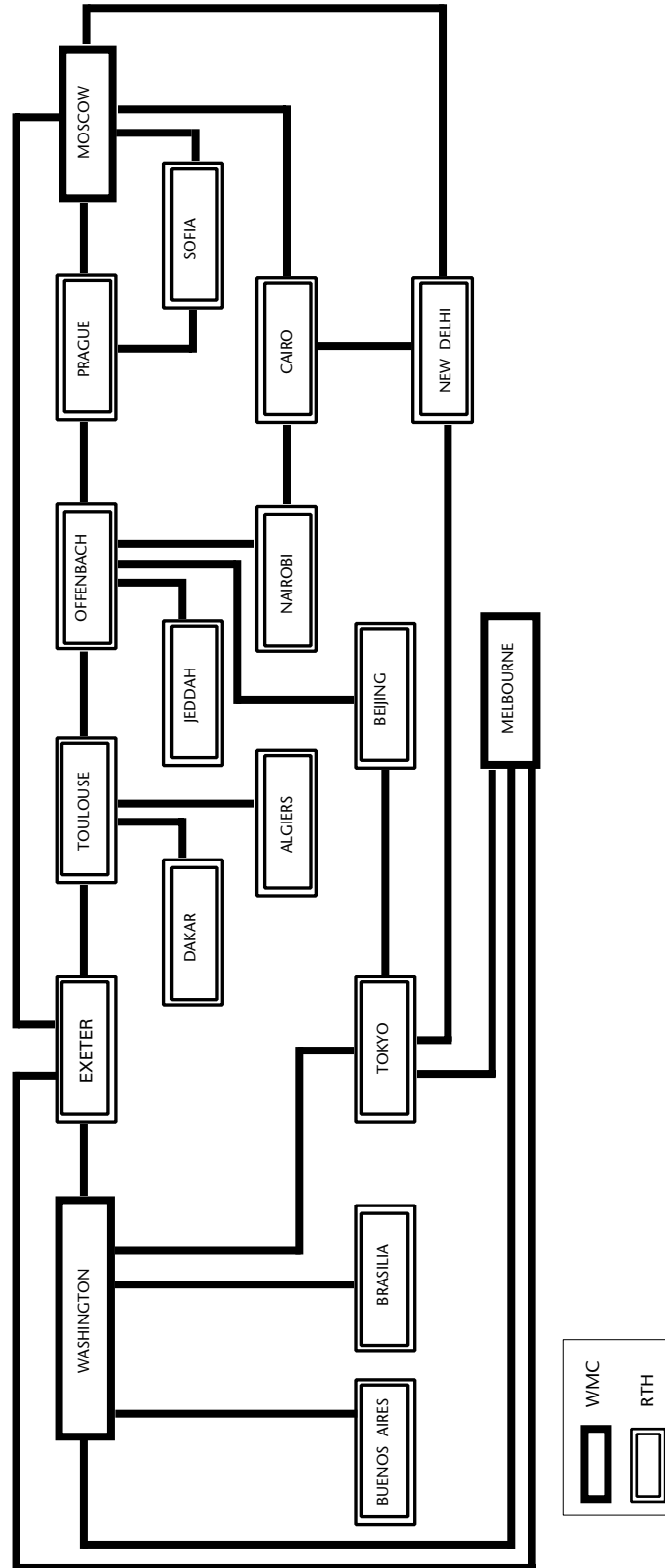
ATTACHMENT I-3

RESPONSIBILITIES OF CENTRES ON THE MAIN TELECOMMUNICATION NETWORK FOR THE TRANSMISSION OF OBSERVATIONAL DATA AND PROCESSED INFORMATION

1. **RESPONSIBILITIES FOR THE COLLECTION, EXCHANGE AND DISTRIBUTION OF OBSERVATIONAL DATA OF WMCs AND RTHs LOCATED ON THE MAIN TELECOMMUNICATION NETWORK**

The responsibilities are given in the following table:

WMC/RTH	Collection of observational data from the zones of responsibilities (associated NMCs) of the following RTHs
Melbourne	Melbourne (51), Wellington (52)
Tokyo	Tokyo (25), Bangkok (26)
Washington	Washington (41)
Exeter	Exeter (61)
Toulouse	Toulouse (63), Rome (66)
Offenbach	Offenbach (64), Norrköping (62), Vienna (68)
Prague	Prague (67)
Moscow	Moscow (65), Khabarovsk (24), Novosibirsk (23), Tashkent (22)
Cairo	Cairo (11)
New Delhi	New Delhi (27), Tehran (21)
Brasilia	Brasilia (31), Maracay (33)
Buenos Aires	Buenos Aires (32)
Nairobi	Nairobi (12), Lusaka (13), Pretoria (14)
Beijing	Beijing (28)
Dakar	Dakar (15), Brazzaville (17), Niamey (18)
Jeddah	Jeddah (29)
Sofia	Sofia (69)
Algiers	Algiers (16)

2. **PRINCIPLES FOR THE ESTABLISHMENT OF THE EXCHANGE PROGRAMME FOR OBSERVATIONAL DATA ON THE MAIN TELECOMMUNICATION NETWORK**

The types of meteorological messages containing observational data to be exchanged on the Main Telecommunication Network are given below.

2.1 Type of information

(a) Surface observations on land and sea, including data from ships and buoys;
(b) Upper-air observations including data from aircraft;
(c) Climatological data;
(d) Selected satellite data;
(e) Seismic data (level 1), tsunami and other types of data as agreed.

Note: Items (a) to (e) do not indicate priorities.

2.2   Stations/areas from which reports should be included in the bulletins that are to be exchanged

The list of stations from which reports should be included in the bulletins that are to be exchanged are established as follows:

(a) All surface stations. The SYNOP reports from land stations exchanged on the MTN shall include at least Sections 0 and 1 of the SYNOP code form. As an interim measure, Section 3 of the SYNOP code form shall also be included in the global exchange on the MTN;
(b) All stations (on land or at sea) making radiosonde/radiowind observations;
(c) All aircraft;
(d) All climatological stations;
(e) All oceanographical stations.

3.   RESPONSIBILITIES OF CENTRES LOCATED ON THE MAIN TELECOMMUNICATION NETWORK FOR THE EXCHANGE AND DISTRIBUTION OF PROCESSED INFORMATION AND SATELLITE DATA

The exchange of processed information and satellite data on the MTN should be arranged between the MTN centres to meet the requirements of the WWW centres.

*

*   *

MOSCOW

SOFIA

PRAGUE

OFFENBACH

TOULOUSE

EXETER

WASHINGTON

BRASILIA

BUENOS AIRES

JEDDAH

ALGIERS

DAKAR

CAIRO

NAIROBI

NEW DELHI

BEIJING

TOKYO

MELBOURNE

22-24, 65

14, 15, 16, 17, 22, 23, 24, 41, 61-69

22, 23, 24, 41, 61-69

11-14, 21-28, 62, 65

11, 21-28, 62, 65

69

15-18, 28-33, 41, 51, 52, 63, 64, 66-68

16, 41, 61, 63, 64, 67, 68

69

21-24, 65, 67, 69

12-18, 28-33, 41, 51, 52, 61, 63, 64, 66

11, 29, 31-33, 41, 61-69

11, 12, 14-16, 61-69

11-14

25, 26, 27

11-14, 21, 26-29, 62, 64, 67-69

11, 12, 21-28, 31-33, 41, 51, 52, 61-69

21, 29

11, 15-17, 27

12-14

11-18, 29

21, 25-28, 31-33, 41, 51, 52

15-18, 25-27, 31-33, 41, 51, 52, 61, 63, 68, 69

14, 29, 61, 63, 64

11-14

21-24, 27, 29

11-18, 21, 29, 62-69

11, 12, 14, 29, 31-33, 41, 61, 63, 64

16

26-28, 51, 52

11-18, 28, 61-69

22-25, 31-33, 41, 51, 52, 61, 65

15, 17, 18

21-27, 29, 31-33, 41, 51, 52

25, 26, 28, 31, 32, 33, 41, 51, 52

51, 52

61

14, 25-28, 31-33, 41, 51, 52

11-18, 21-24, 29, 61-69

21-28, 51, 52

11-18, 21-29, 41, 61-69

11-18, 29, 31-33, 41, 61-69

11-18, 21, 22-29, 41, 51, 52, 61, 62-69

31, 33

25, 27, 41, 51, 52, 61, 65

32

WMC

RTH

REGION I
11. Cairo
12. Nairobi
13. Lusaka
14. Pretoria
15. Dakar
16. Algiers
17. Brazzaville
18. Niamey

REGION II
21. Tehran
22. Tashkent
23. Novosibirsk
24. Khabarovsk
25. Tokyo
26. Bangkok
27. New Delhi
28. Beijing
29. Jeddah

REGION III
31. Brasilia
32. Buenos Aires
33. Maracay

REGION IV
41. Washington

REGION V
51. Melbourne
52. Wellington

REGION VI
61. Exeter
62. Norrköping
63. Toulouse
64. Offenbach
65. Moscow
66. Rome
67. Prague
68. Vienna
69. Sofia

Figure 1. Plan for routeing observational data on the Main Telecommunication Network

Note: The responsibilities of centers and routeing arrangements for the exchange of processed information on the MTN are the same as for observational data.

ATTACHMENT I-4
(NOT USED)

ATTACHMENT I-5

PLAN FOR MONITORING THE OPERATION OF THE WORLD WEATHER WATCH

1. OBJECTIVES

1.1　　　The objectives of the monitoring effort are to improve the performance of the World Weather Watch (WWW), in particular the efficiency and effectiveness of the operation of the WWW Global Observing System (GOS), the Global Data-processing and Forecasting System (GDPFS) and the Global Telecommunication System (GTS) on a national, a regional and a global level. As the operation of these three elements of the WWW (GOS, GDPFS and GTS) is so interrelated, each element cannot be monitored independently; therefore, for efficient monitoring of the operation of the WWW as an integrated system, close coordination between all the centres concerned, as well as with the WMO Secretariat, is essential in order to identify the deficiencies and initiate corrective action as quickly as possible.

1.2　　　The implementation of the monitoring plan involves all three sub-systems of the WWW. Thus, in the context of monitoring, the GOS is responsible for ensuring that the observations are made according to the prescribed standards, are encoded correctly and are presented for transmission at the times laid down; in addition, the GOS responds in timely fashion to requests for checks, corrections, etc. The GTS is responsible for ensuring the regular flow of meteorological information, both raw and processed. This involves keeping a close watch on the receipt and transmission of information, generating requests for missing bulletins and other products when necessary, checking telecommunication formats, arranging for the re-routeing of traffic in case of outages and other difficulties, and so on. The GDPFS provides processed information for timely distribution and also has an important role in the quality control of data.

1.3　　　An important objective of any monitoring activity must include provision for the identification of deficiencies and also for corrective action to improve the efficiency and effectiveness of the WWW. Success is measured in terms of how many deficiencies are corrected.

1.4　　　In accordance with the decision of Seventh Congress, the following items should be included in the monitoring programme:

(a) Regularity of observations;
(b) Quality of observational data and correct coding;
(c) Completeness and timeliness of collection of observational data at the NMC concerned;
(d) Adherence to WMO standard codes and telecommunication procedures;
(e) Collection of observational data at RTHs and WMCs;
(f) Exchange of data and processed information on the regional meteorological telecommunication networks and the MTN;
(g) Evaluation of the observations and processed information received at NMCs, RSMCs and WMCs in respect of their data needs.

2. BASIC COMPONENTS

2.1 Real-time monitoring

2.1.1　　　Real-time monitoring is the term used to describe monitoring which is carried out quickly enough to allow remedial action to be taken in time to be of value in day-to-day meteorological work. Ideally, it should be carried out within the times specified in the appropriate manuals and guides as the maximum acceptable time delays for the receipt of meteorological information, but in practice it is still valuable if it can be carried out before similar subsequent information is received.

2.1.2　　　In view of the short time available, corrective action on real-time monitoring should be restricted to departures from the normal, e.g. bulletins or observations which are not received in time, obvious or suspected errors, and so on. Thus real-time monitoring requires the provision of information concerning:

• Bulletins not received by the specified time;
• Observations not received by the specified time, or which are incorrect or suspect, or cannot be interpreted with confidence;
• Inadequacies in receipt of processed information.

2.2   Non-real-time monitoring

Non-real-time monitoring is the term used to describe monitoring which is carried out over a specific time period. The purpose of non-real-time monitoring is to keep under review the general performance of the WWW and to identify shortcomings which may persist after real-time monitoring has been carried out. Non-real-time monitoring requires the preparation of summaries and various statistics which become available after a certain time, which may vary from a few hours to several months.

2.3   Follow-up action for coordination and assistance

In the real-time mode, the initial corrective action will be immediate and will be taken at the centres concerned or at the point of observation. In the non-real-time mode, follow-up action will be taken by the Members concerned to remedy any deficiencies with respect to the WWW plan. In some cases, this might involve obtaining advice on the procedures for obtaining external assistance and information on the maintenance and operation of their WWW facilities. In addition, the Secretary-General will take action, as indicated in paragraph 5.6 below.

3.   DEFINITIONS AND STANDARDS

In the monitoring context, the terms used and the minimum standards to be attained should be as defined in the *Manual on the Global Observing System*, the *Manual on the Global Telecommunication System*, the *Manual on Codes*, the *Manual on the Global Data-processing and Forecasting System* and relevant parts of the *Technical Regulations*.

4.   PRIORITIES

4.1   The monitoring scheme should concentrate, in the order of priority given below, on the establishment of checks on the following information:

(a) TEMP, TEMP SHIP and TEMP MOBIL, Parts A and B;
(b) PILOT, PILOT SHIP and PILOT MOBIL, Parts A and B;
(c) SYNOP (global exchange);
(d) SHIP and AIREP/AMDAR (global exchange);
(e) CLIMAT and CLIMAT TEMP;
(f) All other observational data and processed information, regularly exchanged.

4.2   Monitoring of satellite data presents a special case. There are only a few operators and their standards for monitoring, including quality control of satellite data, are already high. Monitoring of satellite data bulletins and GRID-code bulletins shall be a special event for a limited time as designated by the WMO Secretariat.

4.3   In implementing this monitoring plan, it is important to establish the capability for quick responses at the observing points and at all centres to requests for checks and repetition in real time. It will also be found useful to give particular attention to ensuring the following elements of the monitoring plan:

(a) The correct telecommunication formats of messages in the GTS;
(b) The correct coding of messages and reports;
(c) The timely availability of data;
(d) The quality of the meteorological content of messages.

5.   RESPONSIBILITIES

5.1   The basic responsibilities for monitoring the operation of the WWW rest with the Members.

5.2   The responsibilities for carrying out the real-time and non-real-time monitoring activities are given in Tables A and B. An essential part of the monitoring plan is that information should be exchanged between adjacent centres on the GTS in order that telecommunication problems in particular may be readily identified. A special aspect of the exchange of information is that procedures should be developed to ensure that no doubts exist that a bulletin contains all the observations available for inclusion in it. In the case of standard bulletins containing routine observations, the contents of the bulletins should always conform to the list included in the appropriate WMO publication, as amended. When the observations from some stations included in the publication are not available for any reason, the reports

should be properly encoded as NIL reports. As a further check on completeness, NMCs should send messages to the associated RTH, preferably in advance, when it is known that observations from listed stations are not (or will not be) available. It is important that all WWW centres (NMCs, RSMCs, RTHs and WMCs) make a contribution to the overall monitoring effort. Obviously, centres having a multiple role will make more than one contribution. In the contributions, the following points should be taken into account:

(a) For the monitoring at bulletin level, additional or subsequent (RRx) and corrected (CCx) bulletins should be included;

(b) For the monitoring at report level, corrected reports should not be counted as additional reports, but retard reports should be counted;

(c) Duplicated reports and duplicated bulletins should be counted only once;

(d) The contributions should clearly indicate the data base used for monitoring (telecommunications or data-processing);

(e) The contributions should also report any outages of centres and/or circuits occurring during the monitoring period;

(f) In the contributions every possible effort should be made to adhere to the times included in the headings of the tables.

5.3   The frequency with which monitoring reports should be prepared and/or exchanged is illustrated in the following table:

Every day	–	Every centre carries out continuous real-time monitoring;
At intervals of not more than one month	–	NMCs should prepare a summary of relevant information on monitoring for use on a national and international level as appropriate;
At least once every three months	–	RTHs/RSMCs send a summary of monitoring information to their associated NMCs;
At least once every three months	–	RTHs/RSMCs send a summary of monitoring information to adjacent RTHs which supply them with data;
Once every six months	–	WMCs send a summary of monitoring information to adjacent RTHs/RSMCs.

Reports called for at intervals of three months or more should always be forwarded to the Secretary-General in an agreed format for further action. As regards content, reports should include as many items for Table B as are practical and useful.

5.4   Members should implement the plan for monitoring the operation of the WWW at the earliest possible date, in particular the real-time monitoring.

5.5   In order to keep under review the efficient operation of the WWW, internationally co-ordinated monitoring on a non-real-time basis should be carried out periodically, once a year in October, on the full range of global observational data and with the participation of a limited number of major WWW centres. During other periods, particular problem areas should be monitored, in respect of either selected information only or limited parts of the world. The Secretary-General will arrange, in consultation with the appropriate centres, details of the special monitoring exercises and the periods during which they should be carried out, and will provide adequate notice well in advance.

5.6   The Secretariat will carry out the necessary analyses of the non-real-timemonitoring reports from WWW centres and will make the results of the analyses available to the centres concerned. The Secretary-General will coordinate and advise on assistance necessary to rectify the deficiencies revealed from the results of the monitoring. The Secretary-General will also arrange (as required) for the specific monitoring exercises mentioned in paragraph 5.5 above to be carried out.

6.   PROCEDURES

6.1   As far as real-time monitoring is concerned, each centre should develop the necessary detailed procedures for this purpose. These procedures will vary from centre to centre, but should be designed to facilitate the real-time checking of the receipt of bulletins and observations as appropriate. At fully

automated centres, these procedures may include the use of telecommunication system records, visual display units, special programmes in telecommunication and data-processing computers, and so on. At manual centres, check lists or sheets may be developed for the same purposes using ticks, crosses or the entry of times to indicate when selected bulletins and/or reports have been received. To avoid excessive use of paper forms, it may be convenient to place transparent sheets of plastic over the check sheets and make entries using soft wax pencils. The entries can be removed very easily when a suitable period has elapsed and the sheets made ready for the checks to be repeated for a later period. Some further guidance on the operation of real-time monitoring, together with examples of the kind of forms which might be developed, are given in Table C.

6.2   As far as non-real-time monitoring is concerned, when special exercises are requested by the Secretariat, an indication of the form in which contributions should be made will be provided at the time the request is made. It is important that, as far as possible, centres should follow closely the procedures indicated in order that results from various centres be directly comparable with each other. It is particularly important that this should be the case when the annual global monitoring exercise is carried out. The procedures, together with the standard forms to be used for the provision of results, are given in Table D.

6.3   It is emphasized that nothing in the formal monitoring procedures prescribed in the attachment is intended to replace the normal day-to-day exchange of information and advice between adjacent centres. As far as possible, all problems should be resolved in this way and, after a time, only serious difficulties will be reflected in the formal monitoring reports.

Table A
Real-time monitoring

Item	National units	NMC	RTH/RSMC	RTH/WMC
1. Bulletins not received in time	←	← →	← →	
2. Observations not received in time	←			
3. Processed information not received in time		→	→	
4. Errors in observations	←	(← →)		
5. Special bilateral checks	← →	← →	← →	

(Items are indicative rather than mandatory)

Notes:

1. *Bulletins not received in time* are bulletins which appear on the transmission schedule and have not been received by a time agreed bilaterally between two adjacent centres.
2. *Observations not received in time* are observations which appear in the published contents of the bulletins listed for transmission but which have not been received by the time agreed.
3. *Processed information not received in time* refers to data not received by the time agreed but known to be in the transmission schedule.
4. *Errors in observations* are errors detected or suspected in the coding and/or meteorological content of messages.
5. *Special bilateral checks* are checks on any of the previous elements 1–4 or other elements which may have been arranged temporarily or on a more continuous basis by the centres concerned.

       The phrase *national* units is understood in this context to mean national observing, collecting and dissemination systems.

       The arrows indicate the direction in which messages concerning monitoring will normally be sent. Thus, for example, messages concerning suspected errors in observations will normally be sent only by NMCs to the observing network – unless a special bilateral agreement has been made between an NMC and an appropriate RSMC to carry out real-time quality control on its behalf. To cover this possibility, an entry in parentheses has been made under RSMC.

Table B
Non-real-time monitoring

Items	NMC	RTH/RSMC	WMC
1. Bulletins not received	x	x	x
2. Bulletins received late	x	x	x
3. Observations not received	x	x	x
4. Observations received late	x	x	x
5. Processed information not received	x	x	
6. Processed information received late	x	x	
7. Non-adherence to telecommunication format	x	x	x
8. Completeness of observational data	x	x	x
9. Quality of observational data	x	x	x
10. Deficiencies in processed information	x	x	x
11. Statistical verification of numerical weather prediction	x	x	x
12. Special bilateral or multilateral checks	x	x	x
13. Notes on recurrent problems	x	x	x
14. Monitoring reports	x	x	x

(Items are indicative rather than mandatory)

Notes:

1. *Bulletins not received* are bulletins scheduled for transmission but not received.

2. *Bulletins received late* are bulletins received later than the time periods specified by WMO or agreed bilaterally.

3. *Observations not received* are observations scheduled for transmission but not received.

4. *Observations received late* are defined in a similar way as "bulletins received late" in Note 2 above.

5. *Processed information not received* is products in alphanumeric or pictorial form scheduled for transmission but not received.

6. *Processed information received late* is defined in a similar way as "bulletins received late" in Note 2 above.

7. *Non-adherence to telecommunication format* refers to errors made consistently or frequently by transmitting stations which interfere with the regular transmission of messages.

8. *Completeness of observational data.*

9. *Quality of observational data.*

10. *Deficiencies in processed information* are shortcomings (e.g. data missing, messages garbled, facsimile products unreadable) which seriously interfere with the operational value of the products.

11. *Statistical verification of numerical weather prediction* would be supplied only by centres having a special interest in, and capability for, this type of information.

12. *Special bilateral or multilateral checks* means supplementary checks arranged between two or more centres by mutual agreement, on either a temporary or a continuous basis, to deal with special problems.

13. *Notes on recurrent problems* indicate areas of difficulty not covered by Notes 1–12 inclusive.

14. *Monitoring reports* are reports in the format to be developed by the Secretary-General, in consultation with the president of the CBS and the chairmen of the appropriate working groups.

The crosses in the various columns indicate the centres at which these functions would normally be carried out.

Table C

Guidance for real-time monitoring

1.   CHECK ON THE RECEPTION OF OBSERVATIONAL REPORTS FROM LAND STATIONS

In order to implement real-time monitoring, suitable forms should be used for checking the reception of observational reports from land stations. Separate tables may be prepared for SYNOPs for global exchange, for TEMP/PILOTs for global exchange, for SYNOPs for regional exchange, and so on in order to check the availability of various types of observational data. If an observation from a particular station has not been received within the appropriate time, a request should be made to the station. Detailed procedures must be developed to meet the needs of centres of various kinds.

2.   CHECK ON THE RECEPTION OF AIRCRAFT AND SHIPS' WEATHER REPORTS FROM COASTAL RADIO STATIONS OR AERONAUTICAL RADIO STATIONS

Each centre should ensure that all bulletins have been received, and procedures to ensure that this is the case (for example by introducing the use of channel sequence numbers and similar ideas) should be developed to meet local needs.

3.   CHECK ON CODING OF OBSERVATIONAL REPORTS

Observational reports should be checked before transmission of bulletins, in order to eliminate coding errors. This check should be made by the observer when the observation is first made and by suitably qualified staff when the bulletins are prepared. Such checking procedures, however, must not result in appreciable delays in the transmission of bulletins.

4.   CHECK ON THE STANDARD FORMAT OF METEOROLOGICAL MESSAGES

Meteorological messages shall be checked to ensure that the standard format has been used and corrections shall be made as required. In particular, the following points shall be checked:

(a) The starting line, the abbreviated heading and the end-of-message signal of messages shall be completely free of error;

(b) Reports included in a bulletin shall be separated by the report separation signal.

It is emphasized that messages which can be handled without difficulty at manual centres may still give serious problems at automated centres, unless the procedures are scrupulously observed. Even a single incorrect character can lead to difficulties in some cases.

5.   CHECK ON THE RECEPTION OF SCHEDULED BULLETINS WITHIN SPECIFIED TIMES

Each RTH should check the reception of bulletins form the NMCs in the zone of responsibility. For this purpose, forms such as Examples 1 and 2 below may be useful. If channel sequence numbers (nnn) have not been received in sequential order, queries should be made of the centre concerned immediately. Where no channel sequence number procedures are in operation, other measures must be taken to ensure that no transmissions have been missed, and no individual observations missed because of garbling, radio fading, or other causes.

Example 1

Real-time monitoring

(Check for individual meteorological bulletins, not received, incorrect format or mutilated)

CENTRE:	DATE:		CIRCUIT:		PAGE:
Abbreviated heading	Description of fault	Time of receipt	Time of request	Time of receipt of repeat	Remarks (e.g. circuit outage times)

Example 2

Monitoring of the reception of SHIP/AIREP bulletins and number of reports

SHIP			AIREP		
Abbreviated heading	*Time of receipt*	*Number of reports*	*Abbreviated heading*	*Time of receipt*	*Number of reports*

Table D

Procedures for internationally coordinated non-real-time monitoring

1.   MONITORING PERIODS

The internationally coordinated monitoring of data for global exchange will be carried out once a year in October with a view to check periodically the efficiency of the operation of the WWW. Statistics should be compiled by manually operated and automated centres for the periods 1–5 October and 1–15 October, respectively. In order to facilitate the comparison of results between manually operated and automated centres, automated centres should also provide results for the two periods of 1–5 October and 1–15 October.

Note: As regards CLIMAT/CLIMAT TEMP, the monitoring period should be extended to 15 days, even if (for other observations) a return for a period of only five days is made.

2.   TYPES OF DATA TO BE MONITORED

The types of data listed in the following table should be monitored:

Types of data	Abbreviated headings of bulletins $T_1T_2A_1A_2$	Reference format for presentation of results
SYNOP reports	SMA_1A_2	A
Parts A and B of TEMP reports	USA_1A_2/UKA_1A_2	B_1/B_2
Parts A and B of PILOT reports	UPA_1A_2/UGA_1A_2	B_1/B_2
SHIP reports	SMA_1A_2	C_1/C_2
Parts A and B of TEMP SHIP reports	USA_1A_2/UKA_1A_2	$D_1/D_2/D_3/D_4$
Parts A and B of PILOT SHIP reports	UPA_1A_2/UGA_1A_2	$D_5/D_6/D_7/D_8$
BUOY reports	SSA_1A_2	E
AIREP reports	UAA_1A_2	F
AMDAR reports	UDA_1A_2	G
BATHY/TESAC/TRACKOB reports	SOA_1A_2	H
CLIMAT reports	CSA_1A_2	I_2
CLIMAT TEMP reports	CUA_1A_2	I_2

(a) *Monitoring of* SYNOP *reports*
   For each monitored station identified by the station index number (IIiii), the number of SYNOP reports made at the main standard synoptic hours (0000, 0600, 1200 and 1800 UTC) and available during the monitoring period within one hour, 2 hours and 6 hours of the standard bulletins times should be inserted in the appropriate columns of Format A;

(b) *Monitoring of Parts A and B of* TEMP and PILOT *reports*
   For each monitored station identified by the station index number (IIiii), the number of parts A and B of TEMP and PILOT reports (made by tracking a free balloon by electronic or optical means at the main standard synoptic hours (0000, 0600, 1200 and 1800 UTC) and available during the monitoring period within 2 hours and 12 hours of the standard bulletin times should be inserted in the appropriate columns of the forms, formats B_1 and B_2;

(c) *Monitoring of* SHIP *reports*
   The number of bulletins identified by their abbreviated headings ($T_1T_2A_1A_2$ii CCCC) including SHIP reports made at the main synoptic hours (0000, 0600, 1200 and 1800 UTC) and available during the monitoring period within 2 hours and 12 hours of the standard bulletin times with the number of reports included in these bulletins should be inserted in the appropriate columns of the forms, formats C_1 and C_2;

(d) *Monitoring of parts A and B of* TEMP SHIP *and* PILOT SHIP *reports*
   The number of bulletins identified by their abbreviated headings ($T_1T_2A_1A_2$ii CCCC) including parts A and B of TEMP SHIP and PILOT SHIP reports made at the main synoptic hours (0000, 0600, 1200 and 1800 UTC) and available during the monitoring period within 12 hours and 24 hours of the standard

bulletin times with the number of reports included in these bulletins, should be inserted in the appropriate columns of the forms, formats D_1 to D_8;

(e) *Monitoring of* BUOY, AIREP *and* AMDAR *reports*

The number of bulletins identified by their abbreviated headings ($T_1T_2A_1A_2$ii CCCC) including BUOY, AIREP and AMDAR reports compiled between 2100 to 0259 UTC, 0300 to 0859 UTC, 0900 to 1459 UTC and 1500 to 2059 UTC and available during the monitoring period before 0500, 1100, 1700 and 2300 UTC, respectively, as well as the number of reports included in these bulletins, should be inserted in the appropriate columns of the forms, formats E, F and G;

(f) *Monitoring of* BATHY/TESAC/TRACKOB

The time of receipt of bulletins identified by their complete abbreviated headings ($T_1T_2A_1A_2$ii CCCC YYGGgg (BBB)) containing BATHY/TESAC/TRACKOB reports as well as the number of reports included in these bulletins should be inserted in the appropriate columns of format H;

(g) *Monitoring of* CLIMAT *and* CLIMAT TEMP *reports*

For each station monitored and identified by the station index number (IIiii), "1" should be inserted in the appropriate column of the form, format I1, if the September CLIMAT report is received between 1 and 5 October or 6 and 15 October, otherwise "0" should be inserted in these columns. The same procedure should be applied to the September CLIMAT TEMP report in the forms, format I2.

3.   GLOBAL DATA SET TO BE MONITORED

3.1   The global data set to be monitored is determined by:

(a) The list of surface stations comprising the Regional Basic Synoptic Networks (RBSNs) for SYNOP and CLIMAT reports; the list of radiowind/radiosonde stations comprising the RBSNs for Parts A and B of TEMP reports and CLIMAT TEMP reports; the lists of radiowind stations comprising the RBSNs for Parts A and B of PILOT reports;

(b) The lists of abbreviated headings of bulletins containing SHIP, TEMP SHIP, PILOT SHIP, BUOY, AIREP/ AMDAR and BATHY/TESAC/TRACKOB reports which have to be globally exchanged according to the Catalogue of Meteorological Bulletins. For ease of reference, the Secretariat will compile these lists of abbreviated headings which will be attached to the relevant format for each monitoring.

3.2   The references of the lists mentioned (including the references to the relevant amendment to the *Manual on the GTS* and of the edition of the Catalogue of Meteorological Bulletins) are given in the formats prepared by the Secretariat for each monitoring.

4.   GEOGRAPHICAL AREA IN WHICH DATA SHOULD BE MONITORED

GTS centres should monitor the global data set or part of it as follows:

(a) NMCs or centres with similar functions should monitor at least the availability of the data from the zone for which they are responsible for the data collection and their insertion into the GTS;

(b) RTHs not located on the MTN should monitor at least the availability of the observational data from their zone of responsibility for the collection of observational data as prescribed in Volume II of the *Manual on the GTS*. RTHs should also monitor the availability of observational data from the Region in which they are located and from any other Region to which they are linked by an interregional circuit;

(c) WMCs and RTHs located on the MTN should monitor the availability of the complete set of data for global exchange.

5.   IMPLEMENTATION OF MONITORING PROCEDURES AND QUESTIONNAIRES

5.1   Questionnaires related to the procedures implemented at the centres, suspension of observing programmes at observing stations and suspension of transmission on circuits are given in formats J, K and L, respectively.

5.2   Monitoring procedures should be implemented at centres in such a way that all replies to the questions included in format J should be positive (reply: Yes). Questions 7, 8 and 10 are only applicable to SYNOP, TEMP, PILOT, CLIMAT and CLIMAT TEMP reports.

6.   STANDARD FORMAT FOR STATISTICS

6.1   With a view to enabling the easy comparison of results of internationally-coordinated monitoring carried out by the different centres, the standard formats attached should be used. All centres carrying out monitoring should state clearly the period covered. In each format, centres should present the results region by region as well as for the Antarctic and give totals of the number of bulletins or reports received within the specified time region by region and for the Antarctic.

6.2   If the report or bulletin indicated in the first column is not scheduled to be received, "N" should be inserted in the second column of the format concerned, otherwise "S" should be inserted.

6.3   The statistics should be sent to the adjacent centres concerned and to the WMO Secretariat at the earliest possible date after the end of the monitoring period but not later than 15 November.

7.   ROLE OF THE WMO SECRETARIAT

The Secretariat will ensure that the Members are aware of their respective responsibilities and will collect the statistical results of internationally-coordinated monitoring from the Members concerned. The Secretariat will make a summary of the statistics and will evaluate the deficiencies and effectiveness of the operation of the WWW as a whole and in part. In this connection, the Secretariat will check the observing programme of individual observing stations. The results of the monitoring will be made available to the Executive Council and the CBS by correspondence or at sessions as appropriate. The Secretariat will take up the possibility or remedial action with Members concerned in order to eliminate shortcomings in the operation of the GOS and the GTS as quickly as possible.

8.   SPECIAL TYPES OF NON-REAL-TIME MONITORING OF THE WWW

If necessary, monitoring of the WWW may be undertaken in different regions and for various types of observational data. The purpose of such monitoring is to identify, in greater detail, deficiencies in the collection and exchange of data in different parts of the GTS and the reason for such deficiencies. Special types of monitoring should be initiated by the Secretary-General or by some of the Members concerned. The dates and duration of such monitoring would have to be agreed upon by those Members.

*

*   *

FORMAT A – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: SYNOP

Monitoring centre: .... *Monitoring period:* ....

Station index number* Iliii	S/N **	*Number of SYNOP reports received between HH (standard bulletin time) and*													
		HH (UTC) + 1 hour				*HH (UTC) + 2 hours*				*HH (UTC) + 6 hours*				
		00	*06*	*12*	*18*	*Total*	*00*	*06*	*12*	*18*	*Total*	*00*	*06*	*12*	*18*	*Total*

* Reference for the global exchange list: *Manual on the GTS* – Amendment ....

** S = if data are scheduled to be received.

    N = if data are not scheduled to be received.

FORMAT B₁ – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: TEMP AND PILOT (PART A)

Monitoring centre: .... Monitoring period: ....

Station index number* IIiii	S/N **	Number of TEMP reports (Part A) received between HH (standard bulletin time) and								Number of PILOT reports (Part A) received between HH (standard bulletin time) and							
		HH (UTC) + 2 hour				HH (UTC) + 12 hours				HH (UTC) + 2 hours				HH (UTC) + 12 hours			
		00	06	12	18	Total	00	06	12	18	Total	00	06	12	18	Total	00	06	12	18	Total

* Reference for the global exchange list: *Manual on the GTS* – Amendment ....
** S = if data are scheduled to be received.
   N = if data are not scheduled to be received.

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FORMAT B₂ – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: TEMP and PILOT (PART B)

Monitoring centre: .... Monitoring period: ....

Station index number* IIiii	S/N **	Number of TEMP reports (Part B) received between HH (standard bulletin time) and		Number of PILOT reports (Part B) received between HH (standard bulletin time) and	
		HH (UTC) + 2 hour	HH (UTC) + 12 hours	HH (UTC) + 2 hours	HH (UTC) + 12 hours
		00 06 12 18 Total	00 06 12 18 Total	00 06 12 18 Total	00 06 12 18 Total

*   Reference for the global exchange list: *Manual on the GTS* – Amendment ....

**   S = if data are scheduled to be received.

      N = if data are not scheduled to be received.

FORMAT C$_1$ – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: SHIP

Monitoring centre: .... Monitoring period: ....

Number of SHIP bulletins and reports received within 2 hours of the standard bulletin time

Abbreviated heading* T$_1$T$_2$A$_1$A$_2$ii CCCC	S/N **	00 UTC		06 UTC		12 UTC		18 UTC		Total	
		Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports

* See attached list of abbreviated headings of SHIP bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference Catalogue of Meteorological Bulletins – Edition....)

S = if data are scheduled to be received.

N = if data are not scheduled to be received.

**

FORMAT C₂ – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: SHIP

Monitoring centre: .... Monitoring period: ....

Abbreviated heading* $T_1T_2A_1A_2ii$ CCCC	S/N **	Number of SHIP bulletins and reports received within 12 hours of the standard bulletin time											
		00 UTC		06 UTC		12 UTC		18 UTC		Total			
		Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports		

*   See attached list of abbreviated headings of SHIP bulletins for global exchange as prepared by the WMO Secretariat for each monitoring
(Reference Catalogue of Meteorological Bulletins – Edition.....)
S = if data are scheduled to be received.
N = if data are not scheduled to be received.

**

FORMAT D₁ – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: TEMP SHIP (PART A)

Monitoring centre: ....

Monitoring period: ....

Number of TEMP SHIP *bulletins and reports (Part A) received within 12 hours of the standard bulletin time*

Abbreviated heading* T₁T₂A₁A₂ii CCCC	S/N **	00 UTC		06 UTC		12 UTC		18 UTC		Total	
		Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports

*   See attached list of abbreviated headings of TEMP SHIP (Part A) bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference Catalogue of Meteorological Bulletins – Edition....)

**   S = if data are scheduled to be received.
       N = if data are not scheduled to be received.

FORMAT D₂ – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: TEMP SHIP (PART A)

Monitoring centre: ....   Monitoring period: ....

Number of TEMP SHIP bulletins and reports (Part A) received within 24 hours of the standard bulletin time

Abbreviated heading* $T_1T_2A_1A_2ii$ CCCC	S/N **	00 UTC		06 UTC		12 UTC		18 UTC		Total	
		Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports

* See attached list of abbreviated headings of TEMP SHIP (Part A) bulletins for global exchange as prepared by the WMO Secretariat for each monitoring
(Reference Catalogue of Meteorological Bulletins – Edition....)

** S = if data are scheduled to be received.
N = if data are not scheduled to be received.

FORMAT D₃ – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: TEMP SHIP (PART B)

Monitoring centre: .... *Monitoring period:* ....

Number of TEMP SHIP bulletins and reports (Part B) received within 12 hours of the standard bulletin time

Abbreviated heading* $T_1T_2A_1A_2ii$ CCCC	S/N **	00 UTC		06 UTC		12 UTC		18 UTC		Total	
		Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports

*   See attached list of abbreviated headings of TEMP SHIP (Part B) bulletins for global exchange as prepared by the WMO Secretariat for each monitoring
        (Reference Catalogue of Meteorological Bulletins – Edition....)
**   S = if data are scheduled to be received.
        N = if data are not scheduled to be received.

FORMAT D₄ – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: TEMP SHIP (PART B)

Monitoring centre: ....   Monitoring period: ....

Number of TEMP SHIP *bulletins and reports (Part B) received within 24 hours of the standard bulletin time*

Abbreviated heading* $T_1T_2A_1A_2ii$ CCCC	S/N **	00 UTC		06 UTC		12 UTC		18 UTC		Total	
		Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports

*   See attached list of abbreviated headings of TEMP SHIP (Part B) bulletins for global exchange as prepared by the WMO Secretariat for each monitoring
(Reference Catalogue of Meteorological Bulletins – Edition....)

**   S = if data are scheduled to be received.
N = if data are not scheduled to be received.

FORMAT D_5 – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: PILOT SHIP (PART A)

Monitoring centre: .... Monitoring period: ....

Abbreviated heading* $T_1T_2A_1A_2ii$ CCCC	S/N **	Number of PILOT SHIP bulletins and reports (Part A) received within 12 hours of the standard bulletin time									
		00 UTC		06 UTC		12 UTC		18 UTC		Total	
		Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports

* See attached list of abbreviated headings of PILOT SHIP (Part A) bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference Catalogue of Meteorological Bulletins – Edition....)

** S = if data are scheduled to be received.
N = if data are not scheduled to be received.

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FORMAT D$_6$ – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: PILOT SHIP (PART A)

Monitoring centre: ....   Monitoring period: ....

Abbreviated heading* T$_1$T$_2$A$_1$A$_2$ii CCCC	S/N **	Number of PILOT SHIP bulletins and reports (Part A) received within 24 hours of the standard bulletin time										
		00 UTC		06 UTC		12 UTC		18 UTC		Total	
		Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports

*   See attached list of abbreviated headings of PILOT SHIP (Part A) bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference Catalogue of Meteorological Bulletins – Edition....)

**   S = if data are scheduled to be received.
          N = if data are not scheduled to be received.

FORMAT D$_7$ – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: PILOT SHIP (PART B)

Monitoring centre: ....   Monitoring period: ....

Number of PILOT SHIP bulletins and reports (Part B) received within 12 hours of the standard bulletin time

Abbreviated heading* $T_1T_2A_1A_2ii$ CCCC	S/N **	00 UTC		06 UTC		12 UTC		18 UTC		Total	
		Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports

*   See attached list of abbreviated headings of PILOT SHIP (Part B) bulletins for global exchange as prepared by the WMO Secretariat for each monitoring
      (Reference Catalogue of Meteorological Bulletins – Edition....)
      S = if data are scheduled to be received.
      N = if data are not scheduled to be received.

**

FORMAT D$_8$ – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: PILOT SHIP (PART B)

Monitoring centre: ....   Monitoring period: ....

Number of PILOT SHIP bulletins and reports (Part B) received within 24 hours of the standard bulletin time

Abbreviated heading* $T_1T_2A_1A_2ii$ CCCC	S/N **	00 UTC		06 UTC		12 UTC		18 UTC		Total	
		Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports	Bulletins	Reports

*   See attached list of abbreviated headings of PILOT SHIP (Part B) bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference Catalogue of Meteorological Bulletins – Edition....)

**   S = if data are scheduled to be received.

    N = if data are not scheduled to be received.

FORMAT E – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: BUOY

Monitoring centre: ....

Monitoring period: ....

Abbreviated heading** $T_1T_2A_1A_2ii$ CCCC	S/N ***	Bulletins compiled from 2100* to 0259* UTC and received before 05 UTC		Bulletins compiled from 0300* to 0859* UTC and received before 11 UTC		Bulletins compiled from 0900* to 1459* UTC and received before 17 UTC		Bulletins compiled from 1500* to 2059* UTC and received before 23 UTC		Total	
		Number of bulletins	Number of reports	Number of bulletins	Number of reports	Number of bulletins	Number of reports	Number of bulletins	Number of reports	Number of bulletins	Number of reports

*   Hour of compilation = GGgg included in the abbreviated heading.

**   See attached list of abbreviated heading of BUOY bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference Catalogue of Meteorological Bulletins – Edition....)

        S = if data are scheduled to be received.

***   N = if data are not scheduled to be received.

FORMAT F – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: AIREP

Monitoring centre: ....   Monitoring period: ....

Abbreviated heading** $T_1T_2A_1A_2ii$ CCCC	S/N ***	Bulletins compiled from 2100* to 0259* UTC and received before 05 UTC		Bulletins compiled from 0300* to 0859* UTC and received before 11 UTC		Bulletins compiled from 0900* to 1459* UTC and received before 17 UTC		Bulletins compiled from 1500* to 2059* UTC and received before 23 UTC		Total	
		Number of bulletins	Number of reports	Number of bulletins	Number of reports	Number of bulletins	Number of reports	Number of bulletins	Number of reports	Number of bulletins	Number of reports

*   Hour of compilation = GGgg included in the abbreviated heading.

**   See attached list of abbreviated heading of AIREP bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference Catalogue of Meteorological Bulletins – Edition....)

       S = if data are scheduled to be received.

       N = if data are not scheduled to be received.

***

FORMAT G – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: AMDAR

Monitoring centre: ....   Monitoring period: ....

Abbreviated heading** $T_1T_2A_1A_2ii$ CCCC	S/N ***	Bulletins compiled from 2100* to 0259* UTC and received before 05 UTC		Bulletins compiled from 0300* to 0859* UTC and received before 11 UTC		Bulletins compiled from 0900* to 1459* UTC and received before 17 UTC		Bulletins compiled from 1500* to 2059* UTC and received before 23 UTC		Total	
		Number of bulletins	Number of reports	Number of bulletins	Number of reports	Number of bulletins	Number of reports	Number of bulletins	Number of reports	Number of bulletins	Number of reports

*   Hour of compilation = GGgg included in the abbreviated heading.

**   See attached list of abbreviated heading of AMDAR bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference Catalogue of Meteorological Bulletins – Edition....)

***   S = if data are scheduled to be received.
          N = if data are not scheduled to be received.

FORMAT H – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: BATHY/TESAC/TRACKOB

Monitoring centre: .... Monitoring period: ....

BATHY/TESAC/TRACKOB			BATHY/TESAC/TRACKOB		
Abbreviated heading* $T_1T_2A_1A_2ii$ CCCC YYGGgg (BBB)	S/N**	Date/Time of receipt	Number of reports	Abbreviated heading* $T_1T_2A_1A_2ii$ CCCC YYGGgg (BBB)	S/N**	Date/Time of receipt	Number of reports

*   See attached list of abbreviated heading of BATHY/TESAC/TRACKOB bulletins for global exchange as prepared by the WMO Secretariat for each monitoring (Reference Catalogue of Meteorological Bulletins – Edition....)

**   S = if data are scheduled to be received.
        N = if data are not scheduled to be received.

FORMAT I₁ – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: CLIMAT

Monitoring centre: ....

Monitoring period: ....

Station index number IiIII*	S/N**	CLIMAT Reports received 1–5 October	Reports received 6–15 October	Station index number IiIII*	S/N**	CLIMAT Reports received 1–5 October	Reports received 6–15 October

*   Reference to the global exchange list : *Manual on the GTS* – Amendments...

**   S = if data are scheduled to be received.

     N = if data are not scheduled to be received.

FORMAT I$_2$ – STATISTICS ON GLOBAL EXCHANGE DATA RECEIVED: CLIMAT TEMP

Monitoring centre: .... *Monitoring period:* ....

CLIMAT TEMP

Station index number IiIII*	S/N**	Reports received 1–5 October	Reports received 6–15 October

CLIMAT TEMP

Station index number IiIII*	S/N**	Reports received 1–5 October	Reports received 6–15 October

* Reference to the global exchange list: *Manual on the GTS* – Amendments…

** S = if data are scheduled to be received.

N = if data are not scheduled to be received.

FORMAT J – QUESTIONNAIRE RELATED TO THE IMPLEMENTATION OF PROCEDURES AT THE MONITORING CENTRES

Monitoring centre: ....   *Monitoring period:* ....

Question:	1	2	3	4	5	6	7	8	9	10	11
	Is the monitoring automated?	Is the counting of bulletins and reports performed before quality control?	Are bulletins and reports counted only if received or transmitted on the GTS channels?	Are duplicated bulletins disregarded?	Are bulletins including only NIL reports counted?	Are bulletins including COR or CCx counted in addition to bulletins to be corrected?	Are duplicated reports included in bulletins having the same abbreviated heading disregarded?	Are duplicated reports included in bulletins having a different abbreviated heading disregarded?	Are NIL reports disregarded?	Are reports included in in bulletins including the indicator COR or CCx disregarded in addition to reports to be corrected?	Are all AIREP/ AMDAR reports made at different positions during the flight counted as different reports?
Reply: (yes or no)											

Note: Monitoring procedures should be implemented at centres in such a way that all replies to the questions included in Format J are positive (reply: yes)

Comments: ....

....

Note: Questions 7, 8 and 10 are only applicable to SYNOP, TEMP, PILOT, CLIMAT and CLIMAT TEMP reports.

FORMAT K – SUSPENSION OF OBSERVING PROGRAMMES AT OBSERVING STATIONS

Monitoring centre: ....   Monitoring period: ....

Station index IIiii	Details of suspension and reasons	Type of report	Number of reports (SYNOP, TEMP or PILOT) not made for each observation time			
			00 UTC	06 UTC	12 UTC	18 UTC

Example of entry:

Station index IIiii	Details of suspension and reasons	Type of report	Number of reports (SYNOP, TEMP or PILOT) not made for each observation time			
			00 UTC	06 UTC	12 UTC	18 UTC
IIiii	Delayed delivery of balloons	TEMP	2		1	
IIiii	Delayed delivery of caustic soda	PILOT	5	5	5	4
IIiii	Lack of manpower	SYNOP	7	7	7	7

FORMAT L – SUSPENSION OF TRANSMISSION ON CIRCUITS

Monitoring centre: .... *Monitoring period:* ....

Circuit suspended	Duration of suspension	Remarks

Example of entry:

Circuit suspended	Duration of suspension	Remarks
(1) Iliii — NMC	48 hours from 0645 UTC, 2 October	Failure of transmitter
(2) NMC — NMC (RTH — RTH)	15 hours from 0900 UTC, 3 October	Poor HF propagation

Note: In cases where reasons of suspension are known, details should be given in column "Remarks".

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Note: See *Weather Reporting* (WMO-No. 9), Volume C1 – Catalogue of Meteorological Bulletins for lists of the abbreviated headings of global exchange bulletins for SHIP; TEMP SHIP, Part A and Part B; PILOT SHIP, Part A and Part B; DRIFTER; AIREP; AMDAR; and BATHY/TESAC reports. Those lists will be included by the WMO Secretariat in the letter of invitation to participate in the monitoring exercise.

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PART II

OPERATIONAL PROCEDURES FOR THE GLOBAL TELECOMMUNICATION SYSTEM

PART II

OPERATIONAL PROCEDURES FOR THE GLOBAL TELECOMMUNICATION SYSTEM

Explanations of terms used

Terms used frequently throughout this section, and their meanings, are listed below.

Meteorological information	Meteorological information that may be in alphanumeric, binary or pictorial form.
Meteorological data	Meteorological information presented in alphanumeric or binary form.
Meteorological message	A message comprising a single meteorological bulletin, preceded by a starting line and followed by end-of-message signals.
Routine meteorological message	A meteorological message transmitted according to a predetermined distribution plan.
Non-routine meteorological message	A meteorological message for which there is no predetermined distribution plan.

1. OPERATIONAL PRINCIPLES FOR THE GLOBAL TELECOMMUNICATION SYSTEM

Principle 1

On the Main Telecommunication Network and the regional meteorological telecommunication networks of the Global Telecommunication System, meteorological data shall be collected, exchanged and distributed in the meteorological bulletin format.

Principle 2

The meteorological message format shall depend on the mode of operation and engineering of circuits and centres.

Principle 3

The formats of messages shall meet the requirement for automatic switching, selection and editing processes and for manual operations at telecommunication centres, and shall take account of the requirement for automatic processing of the contents of bulletins.

Principle 4

Transmission of meteorological information over the GTS shall be in accordance with agreed distribution plans.

Principle 5

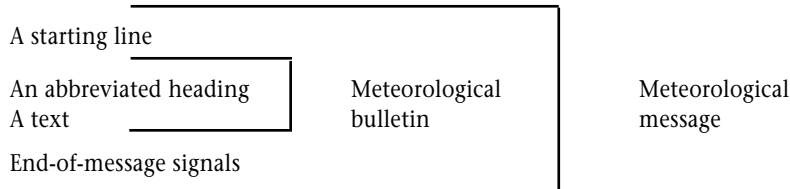Non-routine meteorological messages and service messages shall be transmitted as addressed messages.

Principle 6

Scheduling of transmissions shall be made on the basis of four levels of priority.

2.   OPERATIONAL PROCEDURES APPLICABLE TO THE TRANSMISSION OF METEOROLOGICAL DATA ON THE GLOBAL TELECOMMUNICATION SYSTEM

2.1   Format of meteorological messages

2.1.1   A routine meteorological message transmitted on the Global Telecommunication System shall comprise:

```
A starting line
                        ┌──────────────────────┐
An abbreviated heading  │  Meteorological      │   Meteorological
A text                  │  bulletin            │   message
                        └──────────────────────┘
End-of-message signals
```

2.1.2   There shall be only one meteorological bulletin per meteorological message.

2.1.3   A non-routine meteorological message shall have the format of an addressed message (see section 2.4 below).

2.1.4   The starting line, abbreviated heading and end-of-message signals shall be in alphanumeric form.

2.2   Alphanumeric character set used on the GTS

2.2.1   The alphabets to be used on the GTS shall be the following:

(a) International Telegraph Alphabet No. 2;
(b) International Alphabet No. 5.

Note: International Telegraph Alphabet No. 2 and International Alphabet No. 5 are reproduced in Attachments II-1 and II-2, respectively.

2.2.2   Only printed characters for which corresponding characters exist in both alphabets shall be used. The conversion shall be made in accordance with the conversion table approved for use on the GTS. The control characters from International Alphabet No. 5 which are approved for use on the GTS shall be used.

Note: The conversion table and the control characters from International Alphabet No. 5 which are approved for use on the GTS are given in Attachment II-3.

2.2.3   When it is required to convert characters of Alphabet No. 5 which do not appear in the conversion table (Attachment II-3) to Alphabet No. 2, the Signal No. 2 (?) in the latter alphabet shall be used.

2.2.4   International Alphabet No. 5 shall be used for the starting line, abbreviated heading and end-of-message signals of a meteorological message containing information in binary representation.

2.3   Message format for routine meteorological messages

The procedures outlined below shall apply to transmission of routine meteorological messages on the GTS.

2.3.1   Starting line

2.3.1.1   The starting line shall have the following format:

(a) International Telegraph Alphabet No. 2:

⇐ ⇐ ≡ ↓ ZCZC → ↑nnn → → → → →

(b) International Alphabet No. 5:

┌───┐ ┌───┐ ┌───┐ ┌───┐
│ S │ │ C │ │ C │ │ L │ nnn
│ O │ │ R │ │ R │ │ F │
│ H │ │   │ │   │ │   │
└───┘ └───┘ └───┘ └───┘

Note: Examples of routine meteorological messages and the meaning of the symbols used for the signals in both International Telegraph Alphabet No. 2 and International Alphabet No. 5 are given in Attachment II-4.

2.3.1.2   The symbols have the following meanings:

nnn   Transmission sequence number. It is a three-digit group giving the transmission sequence of messages from one centre over a particular channel to the receiving centre on that channel. Numbers 000 to 999 inclusive must be used in a cyclic manner. (When International Alphabet No. 5 is used, the group nnn may be a fixed combination of three characters, if agreed between the centres concerned.)

Note: A five digit-group could be used by bilateral agreement; it should be used on circuits with a speed of 64 Kbit/s or above to enable appropriate recovery procedures.

2.3.2   Abbreviated heading

2.3.2.1   The abbreviated heading shall have the following format:

(a) International Telegraph Alphabet No. 2:

$$\Leftarrow \quad \Leftarrow \quad \equiv \ \downarrow T_1T_2A_1A_2 \ \uparrow ii \rightarrow \downarrow CCCC \rightarrow \uparrow YYGGgg \ (\rightarrow \downarrow BBB)$$

(b) International Alphabet No. 5:

$$\boxed{\begin{smallmatrix}C\\R\end{smallmatrix}} \ \boxed{\begin{smallmatrix}C\\R\end{smallmatrix}} \ \boxed{\begin{smallmatrix}L\\F\end{smallmatrix}} \ \ T_1T_2A_1A_2 \ i \ \boxed{\begin{smallmatrix}S\\P\end{smallmatrix}} \ \ CCCC \ \boxed{\begin{smallmatrix}S\\P\end{smallmatrix}} \ \ \ YYGGgg \ \ \ (\ \boxed{\begin{smallmatrix}S\\P\end{smallmatrix}} \ BBB)$$

Note: Examples of routine meteorological messages used for the signals in both International Telegraph Alphabet No. 2 and International Alphabet No. 5 are given in Attachment II-4.

2.3.2.2   The symbols shall have the following meanings:

$T_1T_2A_1A_2ii$ Data designators.

Note: The WMO standard data designators are given in Attachment II-5.

T_1T_2 Data type and/or form designators.

A_1A_2 Geographical and/or data type and/or time designators.

ii   **It shall be a number with two digits. When an originator or compiler of bulletins issues two or more bulletins with the same $T_1T_2A_1A_2$ and CCCC the ii shall be used to differentiate the bulletins and will be unique to each bulletin.**

Alphanumeric bulletins containing reports prepared at the main synoptic hours for the stations included in the Regional Basic Synoptic Networks or stations included in the Regional Basic Climatological Networks shall be compiled into bulletins with ii in the series 01 to 19. This does not apply to bulletins compiled in CREX code.

Alphanumeric bulletins containing "additional" data as defined in Resolution 40 (Cg-XII) shall be compiled into bulletins with ii above 19. This does not apply to bulletins compiled in CREX code.

For bulletins compiled in GRIB, BUFR or CREX code or containing pictorial information, the use of ii is defined in the tables contained in Attachment II-5. Originators or compilers of bulletins shall use the ii values from these tables when they are defined for the purpose for which a bulletin is being intended.

For all bulletins ii shall only be used to designate "additional" data as defined in Resolution 40 (Cg-XII) if the same heading is never used for essential data and it complies with all the requirements above. If this is not the case, a unique CCCC shall be used as described below.

CCCC   International four-letter location indicator of the station or centre originating or compiling the bulletin, as agreed internationally, and published in WMO-No. 9, Volume C1, Catalogue of Meteorological Bulletins.

In order to differentiate sets of bulletins that cannot be distinguished using the $T_1T_2A_1A_2ii$ allocations, a centre may establish additional CCCCs where the final two characters differ from its original CCCC. **The two first letters of any additional CCCCs established by a centre shall remain the same as the original CCCC.** For instance, the additional CCCCs could be used to indicate different satellites, different models or to differentiate between bulletins containing "additional" or "essential" data as defined in Resolution 40 (Cg-XII)). **All CCCCs established by any centre shall be published and defined in Publication No. 9, Volume C1 – Catalogue of Meteorological Bulletins.**

Once a bulletin has been originated or compiled, the CCCC must not be changed. If the contents of a bulletin is changed or recompiled for any reason, the CCCC should be changed to indicate the centre or station making the change.

YYGGgg International date-time group.

YY   Day of the month.

GGgg   For bulletins containing meteorological reports intended for standard times of observation, the time shall be the standard time of observation in UTC.

For aerodrome, route and area (aeronautical) forecasts: the full hour in UTC (the last two digits shall be 00) preceding the transmission time.

For other forecasts and analyses: standard time of observation in UTC on which forecast or analysis is based.

For other messages the time shall be the time of compilation in UTC.

BBB   An abbreviated heading defined by T$_1$T$_2$A$_1$A$_2$ ii CCCC YYGGgg shall be used only once. Consequently, if this abbreviated heading has to be used again for an addition, a correction or an amendment, it shall be mandatory to add an appropriate BBB indicator, identified by a three-letter indicator which shall be added after the date-time group.

The BBB indicator shall have the following forms:

RR$_x$ for additional or subsequent issuance of bulletins;

CC$_x$ for corrections to previously relayed bulletins;

AA$_x$ for amendments to previously relayed bulletins;

where x is an alphabetic character of A through as described in Attachment II-12;

Bulletins containing observational or climatic data (surface or upper-air) from land stations will be compiled from a defined list of stations. **The abbreviated headings and the contents of bulletins shall be published in WMO Publication No. 9 Volume C1 – Catalogue of Meteorological Bulletins.**

2.3.3   Contents of meteorological bulletins

2.3.3.1   **The following procedures shall apply to the compilation of the text of a meteorological bulletin:**
(a) Text of a bulletin shall be in one code form only;
(b) The text of a bulletin shall not contain both "essential" and "additional" data as defined in Resolution 40 (Cg-XII);
(c) The text of a bulletin shall be in alphanumeric or binary representation. It shall start by the following sequence:
(i) When International Alphabet No. 5 is used:

C		C		L
R		R		F

(ii) When International Telegraph Alphabet No. 2 is used:

⋞ ⋞ ≡ ↑ or ⋞ ⋞ ≡ ↓ as appropriate.

(d) When all the reports normally contained in a routine message are not available at the normal time of transmission, the text NIL shall be sent.

2.3.3.2   *Text of meteorological bulletins in alphanumeric representation*

2.3.3.2.1   **Each individual meteorological report shall start at the beginning of a new line.**

2.3.3.2.2   **Signal No. 22 (figure case position) of the International Telegraph Alphabet No. 2 or Signal 3/13 of International Alphabet No. 5 shall be used as a meteorological report separation signal. The signal shall follow the last figure of the last group of each report, with no intervening space.**

2.3.3.2.3   Format of SYNOP and SHIP bulletins

(a) The presentation of bulletins containing SYNOP reports and SHIP reports, in the code forms FM 12 and FM 13 respectively, should be in one of the formats (a) or (b) as given in Attachment II-4, paragraph 4;

(b) **When using format (a), all Sections 1, 2, 3 and 4 shall be transmitted consecutively without any insertion of spaces and solidus in the identifier groups of Sections 3 and 4. If format (b) is used, Sections 1, 2, 3 and 4 shall start at the beginning of a line but identifiers of Sections 3 and 4 shall begin with two spaces.**

Note: For examples of presentation of formats, see Attachment II-4.

2.3.3.2.4   **In upper-air bulletins (TEMP and PILOT), each successive part (A, B, C and D) shall be preceded immediately by an alignment function (see paragraph 2.6.1 below) and followed by a separation signal.** In upper-air bulletins (TEMP and PILOT), each report relating to one station is separated from the preceding report by an additional line-feed signal. **Additionally, whenever Parts A and B or Parts C and D are transmitted together, they shall be separated by eight carriage return signals.**

2.3.3.2.5   **AMDAR and AIREP reports shall correspond to the information relating to each single point of observation during a flight.**

2.3.3.2.6   **Whenever practicable, and unless special provisions exist to the contrary, the text of a meteorological bulletin shall be transmitted in such a manner that full use is made of the capacity of a teleprinter line (69 characters per line).**

2.3.3.2.7   **NIL – In the case of routine messages containing meteorological reports, NIL shall be inserted following the appropriate station index number (which should however retain its proper place in the coded message) when the report from that station is included in the published contents of the bulletin (in the Catalogue of Meteorological Bulletins and elsewhere) but is not available at the time of transmission.** The same procedures also apply to other coded information (such as CLIMAT, CLIMAT TEMP).

2.3.3.2.8   **The solidus (/) shall be used to indicate missing figures or letters in the text of meteorological bulletins.** The solidus is represented in International Telegraph Alphabet No. 2 by the figure case position of Signal No. 24, and in International Alphabet No. 5 by Signal 2/15.

2.3.3.2.9   **The procedures given above which refer to bulletins containing meteorological reports shall also apply to bulletins containing other coded information (such as TAF, CLIMAT, CLIMAT TEMP) from specified locations.**

2.3.3.3   *Text of meteorological bulletins in binary representation*

2.3.3.3.1   **The text of meteorological bulletins in binary representation shall consist of one single message and start by the sequence**

CR	CR	LF

followed by the code indicator coded in International Alphabet No. 5.

2.3.3.3.2   **NIL – In the case of BUFR routine bulletins containing meteorological reports, all fields in the relevant subsets within Section 4 (Data Section) of the BUFR message, other than the station identifier and delayed replication factors, shall be set to the appropriate missing value, when the report from that station is included in the published contents of the bulletin (in the Catalogue of Meteorological Bulletins and elsewhere) but is not available at the time of transmission.**

2.3.4   End-of-message signals

    The format for the end-of-message signals shall be as follows:

(a) **International Telegraph Alphabet No. 2:**

↓ ← ← ≡ ≡ ≡ ≡ ≡ ≡ ≡ ≡ NNNN ↓↓↓↓↓↓↓↓↓↓↓↓

Note: The end-of-message signals are used for ensuring page-feed and tape-feed.

(b) **International Alphabet No. 5:**

CR	CR	LF	ETX

2.4   Addressed messages

2.4.1   Categories of addressed messages

2.4.1.1   *Service messages*

Priority: 1

Messages concerning the operation of the system, e.g. breakdown, resumption after breakdown, etc.

2.4.1.2   *Request for GTS messages*

Priority: 2

Messages used for a request for bulletins normally available on the GTS, including request for repetition.

2.4.1.3   *Administrative messages*

Priority: 4

Messages used for communicating between one administration and another. In exceptional circumstances a very urgent administrative message could be transmitted as a service message.

2.4.1.4   *Data messages*

Priority: 2

Messages consisting of meteorological data. These messages may be either replies to requests for GTS messages in the case when the reply is in the form of an addressed message, or replies to requests to databases, or data in accordance with a special agreement.

2.4.1.5   *Request-to-database*

Priority: 2

Messages used for a request for data addressed to a database.

2.4.2   Abbreviated headings for addressed messages

The specifications of the abbreviated headings of addressed messages are the following:

$T_1T_2A_1A_2ii$ $C_aC_aC_aC_a$ YYGGgg (BBB)
T_1T_2 = BM, designator for addressed messages in alphanumeric form;
T_1T_2 = BI, designator for addressed messages in binary form;
A_1A_2 = AA, administrative message
        BB, service message
        RR, request of GTS messages
        RQ, request-to-database
        DA, data message
ii = 01

$C_aC_aC_aC_a$ = location indicator of the addressed centre
YYGGgg = time of insertion on the GTS.

2.4.3   Text of addressed messages

The first line of the text of an addressed message shall contain the international location indicator of the centre originating the message. The actual content of the addressed message shall start at the second line of the text.

2.5   Requests for GTS messages

2.5.1   An existing GTS message shall be the smallest unit requested. All requests for GTS messages, and in particular requests for repetition, shall be made as soon as possible; otherwise the requested message(s) may no longer be available (see also paragraph 2.10.2.2 below).

2.5.2   Request messages

2.5.2.1   Requests for GTS messages shall be made by addressed message-requests for GTS messages (see paragraphs 2.4.1.2, 2.4.2 for abbreviated headings and paragraph 2.4.3 above for the first line of the text of the message).

2.5.2.2 **The requested messages shall be identified by their abbreviated headings, and all designators shall be used to specify a particular message. One request message shall not contain more than eight requests, when addressed to a centre beyond an adjacent centre.**

2.5.2.3 **Each line of the text of the message shall begin with the indicator AHD (except the first line, see paragraph 2.4.3 above).** Each line will end with the report separation signal. Each line should contain a single abbreviated heading of a requested message.

2.5.3 Request for repetition

2.5.3.1 **Requests for repetition of GTS messages shall be made by addressed messages as requests for GTS messages, transmitted to the adjacent centre upstream.**

2.5.3.2 In addition to the procedures for request messages as defined in paragraphs 2.5.2.2 and 2.5.2.3 above, the messages requested for repetition may be identified in the request by their transmission sequence numbers on the circuit concerned. **In this case, the second line of the text of the message shall begin with the indicator SQN, followed by the transmission sequence number or a series of sequence numbers separated by "/", or consecutive sequence numbers (nnn – nnn).**

2.5.3.3 **One request-for-repetition message shall only contain a single type of identification for requested messages, i.e. abbreviated headings (see paragraph 2.5.2.3 above) or transmission sequence numbers (see paragraph 2.5.3.2 above).** The maximum number of messages requested in one single request message and identified by abbreviated headings may be agreed upon on a bilateral basis between adjacent centres.

2.5.4 Replies to requests for GTS messages

2.5.4.1 **A reply shall use the format for addressed data messages (see paragraph 2.4.1.4 above).** By bilateral agreement between adjacent centres, in particular for replies to requests for repetition, replies may be made in the format of a routine message.

2.5.4.2 **An addressed data message in reply to a request for GTS messages shall contain a single GTS message.**

2.5.4.3 **Requests shall be answered in all cases. If a requested message is not available, an addressed data message (see paragraph 2.4.1.4 above) shall be sent to the originator of the request with the indicator NIL followed by the identifier of the message concerned.** If a request for GTS messages is incorrect, an addressed data message should be sent to the originator of the request with the indicator ERR followed by the incorrect identifier, when possible.

2.5.4.4 **Replies to messages requesting repetitions shall be transmitted within 30 minutes of the filing time of the requests.**

Note: If all the requests cannot be met at one time, the remainder of the replies may be transmitted later.

2.5.5 Requests for repetition of analogue facsimile transmissions

2.5.5.1 **Requests for repetition of analogue facsimile transmissions shall be made by addressed messages (see paragraph 2.4.1.2 above).**

2.5.5.2 **A request shall contain a unique identification of the required document.** The request should preferably be made in the same format as requests for meteorological messages, but using the abbreviated heading as the identifier.

2.5.5.3 Before making a request for repetition of an analogue facsimile transmission, account should be taken of probable limiting factors such as established transmission schedules and priorities of other products.

Note: When a point-to-point link is used, a centre requesting a repetition might indicate to the transmitting centre that the desired product could be substituted for a specified document for that one occasion.

2.5.6 Replies to requests for repetition of analogue facsimile transmissions

Before starting the repetition of an analogue facsimile transmission an addressed data message should be sent to the originator of the request indicating the expected time of repetition.

2.5.7 Acknowledgment messages

Acknowledgment procedures from a centre receiving a bulletin to its originating centre or to other centre (e.g. a relaying centre) should comply with standard GTS addressed messages (see section 2.4

above, as very urgent administrative messages transmitted as a service message. The format for the content of an addressed message for acknowledgment of receipt of bulletin should be as follows:

BMBB01 $C_aC_aC_aC_a$ YYGGgg (BBB)
CCCC
QSL TTAAii YYGGgg $C_oC_oC_oC_o$ (BBB) (DDHHMM)
(optional text)

Notes:

$C_aC_aC_aC_a$ = location indicator of the destination centre, usually the originating centre of the message being acknowledged.

CCCC = international location indicator of the centre sending the acknowledgement.

TTAAii $C_oC_oC_oC_o$ YYGGgg (BBB) is the abbreviated heading of the message being acknowledged, prefixed by the word QSL.

DDHHMM is the day-time group (day, hour, minute in UTC) of actual reception of the acknowledged message at the centre CCCC and is inserted when required.

The third line of the text of the message is added as necessary.

Example:

BMBB01 PHEB 051132
AMMC
QSL WEIO21 PHEB 051130 051132

2.6   Additional procedures applicable to both routine and addressed messages in alphanumeric form

2.6.1   Alignment function

2.6.1.1   **The alignment function shall ensure correct placement of the components of messages on the page copy of teleprinters and shall consist of the following signals:**

Two "carriage return";   One "line feed".

2.6.1.2   **The signals for the alignment functions shall be transmitted before each line of text.**

2.6.1.3   **When using International Telegraph Alphabet No. 2, in order to render ineffective any accidental shifts from figure to letter case and vice versa on transmission of the alignment function, one figure shift (Signal No. 30) or one letter shift (Signal No. 29), as appropriate, shall immediately follow the alignment function.**

2.6.2   Procedures for correction

The following procedures for correction shall be applicable for both International Telegraph Alphabet No. 2 and International Alphabet No. 5:

(a) **Errors made and immediately detected during the preparation of a tape shall be corrected by backspacing the tape, where possible, and eliminating the error by overpunching the incorrect portion with the letter shift in International Telegraph Alphabet No. 2 and Signal 7/15 (DEL) in International Alphabet No. 5;**

(b) **Where equipment is incapable of backspacing, corrections shall be made immediately by making the error sign: letter E and space repeated alternately three times, transmitting the last correct word or group, and then continuing with the tape preparation;**

(c) **The starting line, the abbreviated heading and the end of message of a routine meteorological message shall be completely free from all telecommunication errors. Any form of correction, such as use of the error sign or overpunching of errors by use of the letter-shift character (Signal No. 29 of Alphabet No. 2), is prohibited.**

2.7   Length of meteorological messages

2.7.1   **The length of meteorological bulletins shall be determined according to the following:**

2.7.1.1   **Prior to 7 November 2007:**

(a) Any meteorological bulletin not segmented for transmission on the GTS should not exceed 15 000 octets;

(b) Any meteorological bulletin segmented into a series of meteorological bulletins for transmission on the GTS should not exceed 250 000 octets in its original form or when reassembled.

2.7.1.2   **On or after 7 November 2007:**

(a) Meteorological bulletins for alphanumeric data representation transmitted on the GTS should not exceed 15 000 octets;

(b) **The limit for meteorological bulletins for binary data representation or pictorial form shall be increased from 15 000 to 500 000 octets;**

(c) **Meteorological bulletins shall no longer be segmented for transmission on the GTS.**

Note: Meteorological information may be exchanged using the file transfer technique described in Attachment II-15, particularly when the information exceeds 250 000 octets.

2.7.2   Observational data should not be unnecessarily held up for transmission merely for the purpose of retention until a message of appropriate length can be compiled.

2.7.3   **It is to be noted that, for messages that might possibly be transmitted in transit over the AFTN, the length of the text shall not exceed 200 groups.**

2.8   Procedures applicable to the transmission of reports from ships and other marine stations

2.8.1   **Reports from ships and other marine stations in the SHIP code form shall start with the call sign of the ship, or with a suitable alternative designator.**

2.8.2   **In case of ocean station vessels while on station, the indicator for the ocean station shall precede the report on a separate line.**

2.8.3   **In the case of mobile ships, the call sign shall be placed at the beginning of the first line of each report. If the call sign is not known, the word SHIP shall be used in its place.**

2.9   Time accuracy in telecommunication centres

        Each centre shall take steps to ensure that the difference between the actual time at the telecommunication centre and the universal time shall never exceed the following limits:

(a) **Thirty seconds in manual centres and automated centres using the hardware system;**

(b) **Five seconds in automated centres using the software system.**

2.10   Procedures relating to the telecommunication processing functions of centres

        The procedures outlined below are given in the form of guidance in order that the telecommunication processing functions of centres may be executed in an efficient manner.

2.10.1   Time delays

2.10.1.1   The functions of meteorological telecommunication centres (see Part I, section 2) should include speed and alphabet conversion, procedure checking, and bulletin editing.

Note: The execution of these functions will take time and result in delays. The delay is defined as the interval between completion of receipt of a message and availability for retransmission on an outgoing channel.

2.10.1.2   For the automatic switching of messages the acceptable time delay should not exceed 15 seconds when no speed or alphabet conversion is involved and three minutes when speed or alphabet conversion is required.

2.10.1.3   For procedure checking, composition and editing of bulletins, the time spent by centres should be in the order of 15 seconds when only high-speed circuits are involved, and in the order of two minutes when a low-speed circuit is involved.

2.10.2   Storage capability

        With respect to storage capability for retransmission purposes, the procedures outlined below should be applied.

2.10.2.1   Centres should store data until the onward transmission of the data to the next centre is completed. For this purpose, where the onward transmission is over a circuit on which acknowledgement procedures are used, storage of a message on a short-time access memory is required only until acknowledgement of the message is received. For circuits on which acknowledgement procedures are not used, storage of a message on a short-time access memory for 30 minutes is sufficient. Acknowledgement of reception of a message should be assumed if no request for retransmission is received within this time period.

2.10.2.2   With respect to storage capability to meet requests for messages, WMC and RTHs should store messages they exchange over the GTS for a period of 24 hours.

2.10.3   Routeing catalogues

2.10.3.1   The procedures described here are recommended for the exchange of the routeing catalogues of GTS Centres. The routeing catalogue is exchanged in the form of a file which can be directly ingested into most database software packages to help in GTS data flow analysis. The files containing "routeing catalogues" should be obtained using FTP file transfer over the Internet where possible and should be either available at each Centre or from the WMO server. The WMO server should contain a list (with hyperlinks) of all Centres who have routeing catalogues available for exchange. All Centres should provide the WMO Secretariat with URL addresses of where their respective files are located.

2.10.3.2   The routeing catalogue of a GTS centre should provide the following information for each bulletin identified by its abbreviated heading TTAAii CCCC:

(a) The GTS circuit on which the bulletin is received;
(b) The list of the GTS circuits on which the bulletin is sent.

2.10.3.3   Each RTH should prepare a routeing catalogue and make it accessible by the other GTS centres, in particular by its associated NMCs. The routeing directory should be updated monthly if possible, but not less than every three months.

2.10.3.4   A GTS centre should include in its routeing catalogue the abbreviated headings of all bulletins received and/or transmitted on any GTS circuit connected to this GTS centre (GTS point-to-point circuits, GTS point-to-multipoint circuits such as satellite distribution systems, including the remaining HF broadcasts). Any bulletin scheduled to be received by the GTS centre, even if not actually forwarded on the GTS, should be included in the routeing catalogue.

2.10.3.5   The bulletins received and/or transmitted on a circuit established under a bilateral agreement for meteorological data exchange should also be included in the routeing catalogue.

2.10.3.6   The format of the routeing catalogue and the procedures for the access to the routeing catalogues are given in the Attachment II-7.

2.10.4   Review of the content of switching directories

        In addition to the regular updating of the switching directories, all automated GTS centres should clean regularly (e.g. once every six months) their switching directories thereby removing all abbreviated headings of bulletins which are no longer expected for exchange on the GTS.

2.11   Procedures for store-and-forward data transmissions

2.11.1   Priorities for store-and-forward data transmission

2.11.1.1   The messages shall be forwarded on the basis of four levels of priority. The level of priority shall be allocated according to the data type (T$_1$T$_2$) and is indicated in Table A of Attachment II-5.

2.11.1.2   Within a level of priority, the messages shall be forwarded according to the "first in, first out" principle.

2.11.1.3   The messages of a higher level of priority shall be forwarded before those of a lower level of priority. However, the forwarding of a message of a higher level of priority shall not interrupt the transmission of a message already started.

2.11.2   Detection and cancellation of duplicated messages

        Duplicated messages received within at least three hours of the original message should be detected and eliminated.

2.12   Data communication protocols for the Global Telecommunication System

2.12.1   The transmission protocols for use on the GTS shall be elements of procedures as specified in ITU-T Recommendation X.25 and the Transmission Control Protocol/Internet Protocol (TCP/IP).

2.12.2   ITU-T Recommendation X.25 procedures

The methods and elements of ITU-T Recommendation X.25 procedures to be used in the GTS are as outlined below, and are given in Attachment II-13.

Note: References to OSI layers are taken from the Reference Model of Open Systems Interconnection (OSI) given in International Standard ISO 7498 and ITU-T Recommendation X.200.

2.12.2.1   *Physical layer (ITU-T Recommendation X.25, physical layer, paragraph 1/OSI layer 1)*

The provisions given in ITU-T Recommendation X.25, paragraph 1, shall be applied to point-to-point circuits and the interface between the data terminal equipment (DTE) and data circuit terminating equipment (DCE).

2.12.2.2   *Link layer (ITU-T Recommendation X.25, data link layer, paragraph 2/OSI layer 2)*

The following provisions shall be applicable only to point-to-point circuits between centres of the GTS:

Frame structure: The frame format shall be as described in Table 1/X.25, with the following parameters:
Address field: one octet; Control field: one octet.

Note: The extended control field of two octets or more needs further study.

Information field: 259 octets, 131 octets optional subject to bilateral agreement between centres concerned.

Elements of procedure: The elements of procedure shall be as described in section 2.3, "LAPB elements of procedures", of ITU-T Recommendation X.25.

Description of the procedures: The description of the procedures shall be as described in section 2.4, "Description of the LAPB procedures", of ITU-T Recommendation X.25.

It is recommended that WMCs and RTHs should take the role of DTE or DCE and NMCs should take the role of DTE, by bilateral agreement between centres concerned.

System parameters shall be as follows:

Timer T1 : T1 > Transmission time for three frames + two-way signal propagation time over the link + maximum time for processing one frame in a specific receiving centre.

Note: Examples of values of Timer T1 with processing time of ten milliseconds are as follows:
Cable links: 9600 bit/s: 0.4 s   4800 bit/s: 0.8 s   2400 bit/s: 1.6 s
Satellite links: 9600 bit/s: 1.2 s   4800 bit/s: 1.6 s   2400 bit/s: 2.4 s

Maximum number of transmissions N2:10
Number of outstanding frames k : $2 \leq k \leq 7$

Note: International Standard ISO 7776 – Information processing systems – Data communication – High-level data link control procedures – Description of the X.25 LAPB-compatible DTE data link procedures, describes the X.25 layer 2 procedures as viewed by the DTE for DTE to DCE operation and for DTE to DTE operation without an intervening packet-switched network.

2.12.2.3   *Network layer (ITU-T Recommendation X.25, packet layer, sections 3, 4, 5.1 to 5.5/OSI layer 3)*

The packet layer of ITU-T Recommendation X.25 shall be used in accordance with the procedures for permanent virtual circuit (PVC) and virtual call (VC) services.

The maximum length of the user data field shall be 256 octets or optionally 128 octets.

Window size W : $2 \leq W \leq 7$ depending on type of communication circuit and system equipment.

One or more logical channels (PVC and/or VC) should be established between two adjacent centres. Multiplexing provided by logical channels (PVCc and/or VCs) should be used in preference to multiplexing provided at the physical layer (e.g. by V.29 modems). The recommended procedures for the use of VCs – also called switched virtual circuits (SVCs) – are given in Attachment II-14.

Note: One or more PVC and/or VC could be used between non-adjacent centres by multilateral agreement.

When the transport layer procedures have not been implemented, "more data mark" (binary element M) shall be used to identify the sequence of packets containing the complete message.

Note: International Standard ISO 8208 – Information processing systems – Data communication – X.25 Packet layer protocol for data terminal equipment, describes the X.25 packet layer procedures as viewed by the DTE for DTE to DCE operation and for DTE to DTE operation without an intervening packet-switched network.

2.12.2.4   *Transport layer (OSI layer 4)*

A transport protocol should be employed in accordance with ITU-T Recommendation X.224. **When implemented, the class 2 procedures, including those for multiplexing, explicit flow control and expedited data transfer, shall be used.** Class 3 or 4 transport protocol may be provided in addition to class 2, when and where considered appropriate.

2.12.3   TCP/IP protocol

The recommended practices and procedures for the implementation, use and application of the Transmission Control Protocol/Internet Protocol (TCP/IP) on the GTS are as given in Attachment II.15.

2.13   Transmission and collection of meteorological bulletins on the Internet

The Internet may be used for transmitting and collecting meteorological bulletins on the Internet. The purpose is to serve as a complementary communication system to be used in test and special cases, or when a dedicated GTS link is unavailable. The practices for electronic mail (e-mail) and/or Web data ingest as given in Attachment II-16 should be used with a view to minimizing inherent security risks.

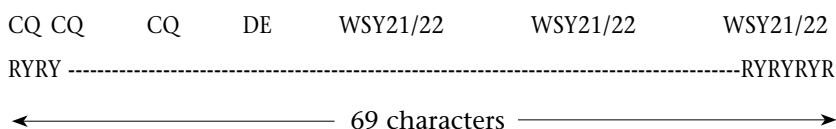### 2.14   Supplementary procedures applicable to radioteleprinter transmissions

In addition to the general telecommunication procedures given above, there are special procedures applicable to radioteleprinter transmissions.

2.14.1   Identification

A radioteleprinter broadcast shall be preceded by the transmission of call signals.

2.14.1.1   **The call signals shall comprise: the general call to all stations (transmitted three times), the conventional signal DE, the identification of the broadcasting station, consisting of the radio call sign followed by the frequency reference index or indices (transmitted three times), and the letters RY repeated without separation for one line (69 characters).**

Example:

```
CQ CQ      CQ      DE      WSY21/22      WSY21/22      WSY21/22

RYRY --------------------------------------------------------------------------------------RYRYRYR

        ◄─────────────── 69 characters ──────────────►
```

2.14.1.2   *Transmission of call signals*

Call signals shall be transmitted:

(a) **For at least the two minutes preceding the official starting time of broadcasts that begin at a fixed time;**
(b) **Each time the station has no traffic during assigned broadcast periods;**
(c) **For the five minutes preceding the first broadcast following a change of frequency.**

2.14.2   Special procedures for relay centres

2.14.2.1   **In radioteleprinter exchanges where a communication centre is responsible for the relay of bulletins originating from another centre, the abbreviated heading shall not be altered when the bulletin is retransmitted.**

2.14.2.2   **When a message is received with some of the text garbled, the relay centre shall retransmit the message as received and, if possible, obtain a retransmission from the originating centre.**

2.14.2.3   National instructions should cover the case of the measures to be taken when extensive garbling occurs, in order to ensure that all usable data are relayed with the minimum delay and with the elimination, where possible, of completely garbled portions. Whenever elimination of part of the text is performed, the abbreviation INC should be added at the end to indicate that the bulletin is incomplete; the relay centre should take all necessary steps to receive from the originating centre those parts of the bulletin which were garbled and retransmit them as soon as possible.

3.   PROCEDURES APPLICABLE TO THE TRANSMISSION OF METEOROLOGICAL INFORMATION IN PICTORIAL FORM OVER THE GLOBAL TELECOMMUNICATION SYSTEM

3.1   Format of meteorological information in pictorial form

The details which should appear in the panel for identification of pictorial information (to be placed in the lower left-hand corner of the chart and also, if possible, in the upper right-hand corner) are determined nationally. They should be easy to identify, read and understand and should therefore include at least the abbreviated heading of the pictorial information.

3.2   Requirements for relay of facsimile (analogue) transmissions

3.2.1   The relay of facsimile (analogue) transmissions should be accomplished by store-and-forward operation or by direct transmission (through-switching) of the signals.

3.2.2   In all cases, the relay of facsimile transmissions should be accomplished with the minimum possible delay.

3.2.3   High-quality recording/storage devices, such as magnetic tape recorders, should be used in the store-and-forward system of analogue facsimile relay in order to maintain the picture quality throughout the storage and retransmission process. **All the technical transmission characteristics specified in Part III, section 5 shall be maintained during the store-and-forward procedure.**

3.2.4   At some centres facsimile storage may be possible and convenient using a computer equipped with analogue/digital conversion of received signals and digital/analogue reconversion for relayed signals.

3.2.5   In some cases the transmission of facsimile signals in analogue form could be performed without storage in relay centres, thereby providing a minimum delay in transit through several consecutive segments of a telecommunication network.

3.2.6   **Centres not equipped to perform the store-and-forward operation within three minutes, nor for direct through-switching transmission, shall provide adequate storage, using a conventional magnetic tape system or equivalent methods, to accommodate the facsimile (analogue) relay transmissions. The storage shall be sufficient for at least one complete frame.**

3.2.7   For emergency back-up purposes only, page copy from chart recorders should be used to facilitate the store-and-forward mode of operation.

3.3   Periodic transmission of the WMO test chart

The WMO standardized test chart should be transmitted periodically, in accordance with requests made, on all parts of the GTS for which facsimile (analogue) transmissions are regularly provided.

Note: The WMO standardized test chart is given in Attachment II-8.

3.4   Coded and non-coded digital facsimile transmission procedures

Coded or non-coded digital facsimile transmission should be carried out by one of the following procedures:

(a) Alphanumeric data and digital facsimile information should be transmitted, on a time-sharing basis, on a single data link;
(b) Alphanumeric data and digital facsimile information should be transmitted on separate channels, multiplexed by a modem in accordance with ITU-T Recommendation V.29.

Note: The procedures to be applied are given in Attachment II-9.

4.   QUALITY OF METEOROLOGICAL TRANSMISSIONS

4.1   Monitoring and control

All transmissions of meteorological information shall be monitored periodically by the originator to ensure adherence to the recommended procedures and specifications, thereby permitting satisfactory performance of the GTS.

4.2   Reports of reception conditions

4.2.1   The code form RECEP shall be used for the reporting of reception conditions of meteorological radio transmissions.

Note: The code form RECEP is given in Attachment II-10.

4.2.2   Reports of reception conditions shall be made periodically by recipients to the originators of the radio transmissions.

5.   PROCEDURES FOR AMENDING WMO PUBLICATIONS AND METHODS OF NOTIFICATION

5.1   Responsibility for notification of amendments

Information for WMO publications shall be kept current. Notification of amendments shall be sent to the Secretariat at least two months in advance of the effective date of the change.

5.2   METNO and WIFMA

5.2.1   The code name METNO shall be used to identify messages concerning information relating to WMO Publication No. 9, Volumes A (Observing stations) and C (Catalogue of meteorological bulletins and transmissions schedules); the code name WIFMA shall be used to identify messages concerning information relating to WMO Publication No. 9, Volume D (Information for shipping). METNO messages shall also contain, as appropriate, information on important changes in international meteorological codes and telecommunication procedures.

Note: METNO and WIFMA messages issued by the Secretariat will provide advance notification of changes in WMO Publication No. 9, Volumes A, C and D, in addition to the normal supplement service.

5.2.2   METNO and WIFMA messages shall be transmitted from Geneva to Zurich and thence to the associated RTH for global dissemination through the Global Telecommunication System.

5.2.3   METNO and WIFMA messages shall be compiled in the standard format for routine meteorological messages using the abbreviated heading NOXX02 LSSW for changes related to Volume C1 – Catalogue of Meteorological Bulletins – of WMO Publication No. 9 and NOXX01 LSSW for the changes to the other Volumes of WMO Publication No. 9.

ATTACHMENT II-1

INTERNATIONAL TELEGRAPH ALPHABET No. 2*

1. INTRODUCTION

1.1 This Recommendation defines the repertoire of the graphic and control characters used in International Telegraph Alphabet No. 2 (ITA2) and the coded representation of these characters for communication purposes. It also contains provisions concerning the use of certain specific combinations.

1.2 The coded character set of ITA2 is based on a 5-unit structure.

1.3 ITA2 is also defined in Recommendation F.1 for the international public telegram service, and it is specified in Recommendation F.60 that it should also be used for the telex service. It may also be used for other applications, such as specialized or leased circuits.

1.4 For definitions concerning alphabetic telegraphy, see definitions in Recommendation R.140 and the International Electrotechnical Vocabulary (IEV), Chapter 721.

2. CHARACTER REPERTOIRE

2.1 Graphic characters that have a corresponding signal in ITA2 are:
the 26 latin alphabetic characters:
A B C D E F G H I J K L M N O P Q R S T U V W X Y Z;
decimal figures: 0 1 2 3 4 5 6 7 8 9;
punctuation marks and miscellaneous signs:

Full stop	.
Comma	,
Colon or division sign	:
Question mark	?
Apostrophe	'
Cross or addition sign	+
Hyphen or dash or subtraction sign	–
Fraction bar or division sign	/
Equal sign or double hyphen	=
Left-hand bracket (parenthesis)	(
Right-hand bracket (parenthesis)	)

2.2 Three graphic characters (such as accented letters and currency signs) may be applied for national or private use (see paragraph 4.2 below).

2.3 This Recommendation does not define the particular printing style, font or case (capital or small letters) of graphic characters, nor does it define the layout of keyboards in teleprinters or similar terminal devices.

2.4 The control characters provided in ITA2 are:

"Who are you?" (operation of the answerback unit of the corresponding installation);

operation of an audible signal of the corresponding installation;

carriage return;

line-feed;

figure-shift;

space or blank;

all-space or null (no tape perforation).

---

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3. CODING

3.1   The 32 combinations available in ITA2 are produced by a sequence of five units, each of which may assume one of two significant conditions (A or Z), as shown in Table 1/S.1.

3.2   Condition A corresponds to start polarity, no perforation in paper type and symbol 0 of the binary notation. Condition Z corresponds to stop polarity, perforation in paper tape and symbol 1 in binary notation.

          For the equivalent frequency and amplitude modulations corresponding to conditions A and Z in voice-frequency telegraph equipment, see Recommendation V.1 and the relevant Series R Recommendations.

Note 1: The level and polarity of voltage and current corresponding to conditions A and Z (e.g. in the local end with its termination) are national options and hence are not defined internationally.

Note 2: The terms "start" and "stop", "space" and "mark" have also been used to describe conditions A and Z respectively (see definition 31.37 in Recommendation R.140).

4. PARTICULAR COMBINATIONS

4.1   In accordance with Recommendation S.8 and the Series U Recommendations, "WRU" (who are you? combination No. 4 in figure case), is used to operate the answerback unit of the corresponding instrument in the international telex and gentex services, and may also provide a printed symbol (as in Table 2/S.1)

4.2   Since some Administrations assign combination Nos. 6, 7 and 8 in figure case for internal use whereas others do not, it is desirable to avoid varying interpretation in these circumstances that might result if they were used freely in international services. Consequently the use of combination Nos. 6, 7 and 8 in figure case is not defined and therefore should not be used in international services, except by direct agreement between Administrations; and it is recommended:

          that, in all services, they should be shown in some special manner on the keyboards, and that services in which they are not used should place on the secondary position on the printing blocks (or on the equivalent mechanism) an arbitrary sign, for the letters F, G and H such as, for instance, a square. The appearance of such sign on the paper is to indicate an abnormal impression.

4.3   Combination No. 10 "audible signal", may also provide a printed symbol (as in Table 2/S.1)

4.4   Combination Nos. 29 and 30, "letter-shift" and "figure-shift", respectively, are used to place the terminal installation in the "letter" or "figure" position, so that:

          any combination Nos. 1 to 26 received engenders a printed signal in the "letter" case (second column of Table 1/S.1) if the last shift signal received is a "letter-shift" signal;

          any combination Nos. 1 to 26 received engenders a printed signal in the "figure" case (third column of Table 1/S.1) if the last shift signal received is a "figure-shift" signal", except as noted for combinations Nos. 4 and 10 in paragraphs 4.1 and 4.3 above.

4.5   Combinations Nos. 29 (letter-shift), 30 (figure-shift) and 32 (all-space, null or no tape perforation) shall not affect the spacing movement of terminal machines, except where their reception is indicated by printing a symbol, as mentioned in paragraph 5 below.

4.6 Use of capital and small letters

4.6.1   In ITA2, it is possible to use teleprinters with two series of letter characters, capital and small letters.

4.6.2   It is possible to use sequences of the shift combinations of ITA2 for transfer from one series to the other.

4.6.3   If this possibility is used, it is essential to obtain compatibility with teleprinters having only one series of letter characters.

Table 1/S.1 – International Telegraph Alphabet No. 2 (ITA2)

Combination number	Letter case	Figure case	Coding				
			1	2	3	4	5
1	A	-	Z	Z	A	A	A
2	B	?	Z	A	A	Z	Z
3	C	:	A	Z	Z	Z	A
4	D	See paragraph 4.1	Z	A	A	Z	A
5	E	3	Z	A	A	A	A
6	F		Z	A	Z	Z	A
7	G	See paragraph 4.2	A	Z	A	Z	Z
8	H		A	A	Z	A	Z
9	I	8	A	Z	Z	A	A
10	J	Audible signal	Z	Z	A	Z	A
11	K	(	Z	Z	Z	Z	A
12	L	)	A	Z	A	A	Z
13	M	.	A	A	Z	Z	Z
14	N	,	A	A	Z	Z	A
15	O	9	A	A	A	Z	Z
16	P	0	A	Z	Z	A	Z
17	Q	1	Z	Z	Z	A	A
18	R	4	A	Z	A	Z	A
19	S	'	Z	A	Z	A	A
20	T	5	A	A	A	A	Z
21	U	7	Z	Z	Z	A	A
22	V	=	A	Z	Z	Z	Z
23	W	2	Z	Z	A	A	Z
24	X	/	Z	A	Z	Z	Z
25	Y	6	Z	A	Z	A	Z
26	Z	+	Z	A	A	A	Z
27	Carriage-return		A	A	A	Z	A
28	Line-feed		A	Z	A	A	A
29	Letter-shift	See paragraph 4.5	Z	Z	Z	Z	Z
30	Figure-shift	See paragraph 4.5	Z	Z	A	Z	Z
31	Space		A	A	Z	A	A
32	See paragraph 4.7		A	A	A	A	A

4.7   USE OF COMBINATION No. 32

4.7.1   Combination No. 32 can be used in certain sequences of switching signals; these uses are set out in Recommendations U.11, U.20, U.22 and S.4.

4.7.2   Combination No. 32 must not be used during the phase of communication (after a call is set up) in the international telex service.

4.7.3   Combination No. 32 can be used during the phase of communication after a call is set up in domestic national service or by bilateral agreement between two Administrations, as a command signal for certain functions, e.g. transfer to a national alphabet other than ITA2.

4.7.4   Combination No. 32 must not be used for transfer from one form of characters to another while remaining within ITA2, nor for transfer from one international telegraph alphabet to another.

5.   GRAPHIC REPRESENTATION OF CONTROL CHARACTERS

Where a graphic indication of the reception or transmission of certain control characters is required, this should be effected by printing the symbols shown in Table 2/S.1.

Table 2/S.1 – Printed symbols for control characters

Function	Combination No.	Case	Symbol	Alphabetic representation
Who are you? (WRU)	4	Figure	⊠ (see Note 1)	EQ
Audible signal (bell)	10	Figure	☊	BL
Carriage-return	27	Either	←	CR
Line-feed	28	Either	≡	LF
Letter-shift	29	Either	↓	SL or LS
Figure-shift	30	Either	↑	SF or FS
Space	31	Either	Δ	SP
All/space: Null	32	Either	▢	NU

Note 1: The pictorial representation shown is a schematic of ⌗ which may also be used when equipment allows.

Note 2: Each alphabetic representation is to be considered as a single symbol. It may occupy one position on a printed or displayed line.

INTERNATIONAL ALPHABET No. 5*

INTRODUCTION

A seven-unit alphabet capable of meeting the requirements of private users on leased circuits and of users of data transmission by means of connections set up by switching on the general telephone network or on telegraph networks has been established jointly by the CCITT and the International Organization for Standardization (ISO).

This alphabet – International Alphabet No. 5 (IA5) – is not intended to replace International Telegraph Alphabet No. 2 (ITA2). It is a supplementary alphabet for the use of those who might not be satisfied with the more limited possibilities of International Telegraph Alphabet No. 2. In such cases it is considered as the alphabet to be used as common basic language for data transmission and for elaborated message systems.

International Alphabet No. 5 does not exclude the use of any other alphabet that might be better adapted to special needs.

1. SCOPE AND FIELD OF APPLICATION

1.1 This Recommendation specifies a set of 128 characters (control characters and graphic characters such as letters, digits and symbols) with their coded representation. Most of these characters are mandatory and unchangeable, but provision is made for some flexibility to accommodate national and other requirements.

1.2 This Recommendation specifies a 7-bit coded character set with a number of options. It also provides guidance on how to exercise the options to define specific national versions and application-oriented versions. Furthermore it specifies the International Reference Version (IRV) in which such options have been exercised.

1.3 This character set is primarily intended for the interchange of information among data processing systems and associated equipment, and within data communication systems. The need for graphic characters and control functions in data processing has also been taken into account in determining this character set.

1.4 This character set is applicable to all alphabets of Latin letters.

1.5 This character set includes control characters for code extension where its 128 characters are insufficient for particular applications. Procedures for the use of these control characters are specified in ISO Standard 2022.

1.6 The definitions of some control characters in this Recommendation assume that data associated with them are to be processed serially in a forward direction. When they are included in strings of data which are processed other than serially in a forward direction or when they are included in data formatted for fixed-record processing they may have undesirable effects or may require additional special treatment to ensure that they result in their desired function.

2. CONFORMANCE AND IMPLEMENTATION

2.1 Conformance

A coded character set is in conformance with this Recommendation if it is a version in accordance with section 6 below. Equipment claimed to implement this Recommendation shall be able to interchange information by means of a version of the 7-bit coded character set, this version shall be identified in any such claim.

_____

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2.2   Implementation

The use of this character set requires definitions of its implementation in various media. For example, these could include punched tapes, punched cards, magnetic media and transmission channels, thus permitting interchange of data to take place either indirectly by means of an intermediate recording in a physical medium, or by local connection of various units (such as input and output devices and computers) or by means of data transmission equipment.

The implementation of this coded character set in physical media and for transmission, taking into account the need for error checking, is the subject of ISO publications.

3.   DEFINITIONS

For the purpose of this Recommendation the following definitions apply:

3.1   bit combination

An ordered set of bits used for the representation of characters.

3.2   character

A member of a set of elements used for the organization, control or representation of data.

3.3   coded character set; code

A set of unambiguous rules that establishes a character set and the one-to-one relationship between the characters of the set and their bit combinations.

3.4   code extension

The techniques for the encoding of characters that are not included in the character set of a given code.

3.5   code table

A table showing the character allocated to each bit combination in a code.

3.6   control character

A control function the coded representation of which consists of a single bit combination.

3.7   control function

An action that affects the recording, processing, transmission or interpretation of data and that has a coded representation consisting of one or more bit combinations.

3.8   graphic character

A character, other than a control function, that has a visual representation normally handwritten, printed or displayed.

3.9   position

That part of a code table identified by its column and row co-ordinates.

4.   SPECIFICATION OF THE CODED CHARACTER SET

The bits of the bit combinations of the 7-bit code are identified by b_7, b_6, b_5, b_4, b_3, b_2 and b_1, where b_7 is the highest-order, or the most-significant, bit and b_1 is the lowest-order, or least-significant, bit.

The bit combinations may be interpreted to represent integers in the range 0 to 127 in binary notation by attributing the following weights to the individual bits:

Bit:	b_7	b_6	b_5	b_4	b_3	b_2	b_1
Weight	64	32	16	8	4	2	1

In this Recommendation, the bit combinations are identified by notation of the form x/y, where x is a number in the range 0 to 7 and y is a number in the range 0 to 15. The correspondence between the notations of the form x/y and the bit combinations consisting of the bits b_7 to b_1 is as follows:

x is the number represented by b_7, b_6 and b_5 where these bits are given the weights 4, 2 and 1 respectively;

y is the number represented by b_4, b_3, b_2 and b_1, where these bits are given the weights 8, 4, 2 and 1 respectively.

The notations of the form x/y are the same as those used to identify code table positions, where x is the column number and y the row number (see paragraph 7 below).

The 128 bit combinations of the 7-bit code represent control characters and graphic characters. The allocation of characters to bit combinations is based on the following principles:

the bit combinations 0/0 to 1/15 represent 32 control characters;

the bit combination 2/0 represents the character SPACE, which is interpreted both as a control character and as a graphic character;

the bit combinations 2/1 to 7/14 represent up to 94 graphic characters as one or more of these bit combinations may be declared to be unused (see paragraph 4.3 below);

the bit combination 7/15 represents the control character DELETE.

The allocation of individual characters to the bit combinations of the 7-bit code is specified in paragraphs 4.1, 4.2 and 4.3 below.

This Recommendation assigns at least one name to each character. In addition, it specifies an acronym for each control character and for the character SPACE, and a graphic symbol for each graphic character. By convention, only capital letters and hyphens are used for writing the names of the characters, except for small letters. For acronyms only capital letters and digits are used. It is intended that the acronyms and this convention be retained in all translations of the text.

The names chosen to denote graphic characters are intended to reflect their customary meaning. However, this Recommendation does not define and does not restrict the meanings of graphic characters. Neither does it specify a particular style or font design for the graphic characters when imaged.

4.1   Control characters

The control characters of the 7-bit coded character set are classified in the following categories:

(a) *Transmission control characters*
Transmission control characters are intended to control or facilitate transmission or information over telecommunication networks. Procedures for the use of the transmission control characters on telecommunication networks are the subject of other ISO publications.

(b) *Format effectors*
Format effectors are mainly intended for the control of the layout and positioning of information on character-imaging devices such as printing and display devices.

(c) *Code extension control characters*
Code extension control characters are used to extend the character set of the code. They may alter the meaning of one or more bit combinations that follow them in the data stream. Procedures for the use of the code extension control characters are specified in ISO Standard 2022.

(d) *Device control characters*
Device control characters are intended for the control of local or remote devices or ancillary devices connected to a data processing or data communication system. These control characters are not intended to control data communication systems; this should be achieved by the use of transmission control characters.

(e) *Information separators*

Information separators are used to separate and qualify data logically. There are four such characters. They may be used either in hierarchical order or non-hierarchically; in the latter case, their specific meanings depend on the application.

(f) *Other control characters*

These are the control characters that fall outside the preceding categories.

The composition of each category, and the allocation of the individual control characters in each category to bit combinations of the 7-bit code are specified in paragraphs 4.1.1 to 4.1.6 below. Each of these sub-clauses contains a table consisting of three columns. The first column specifies the acronym of each control character, the second column specifies the standard name of the control character and the third column, labelled "Coded representation", specifies the bit combination representing the control character concerned.

Detailed functional descriptions of all control characters are given in section 8 below.

4.1.1 Transmission control characters

The transmission control characters and their coded representations are specified in Table 1/T.50.

Table 1/T.50 – Transmission control characters – coded representation

Acronym	Name	Coded representation
SOH	Start of heading	0/1
STX	Start of text	0/2
ETX	End of text	0/3
EOT	End of transmission	0/4
ENQ	Enquiry	0/5
ACK	Acknowledge	0/6
DLE	Data link escape	1/0
NAK	Negative acknowledge	1/5
SYN	Synchronous idle	1/6
ETB	End of transmission block	1/7

4.1.2 Format effectors

The format effectors and their coded representations are specified in Table 2/T.50

Table 2/T.50 – Format effectors – coded representation

Acronym	Name	Coded representation
BS	Backspace	0/8
HT	Horizontal tabulation	0/9
LF	Line feed	0/10
VT	Vertical tabulation	0/11
FF	Form feed	0/12
CR	Carriage return	0/13

4.1.2.1 *Concepts*

The definitions of the format effectors use the following concepts:

(a) A page is composed of a number of lines, each being composed of a number of character positions;

(b) Each character position is capable of imaging SPACE or a graphic symbol;

(c) The graphic symbol imaged at a character position represents a graphic character, a control function, or a combination of one or more graphic characters and/or control functions;

(d) The active position is the character position at which the action required by the next character in the data stream is to be effected. If the next character is a graphic character, it is imaged at that position; if it is a control character, the corresponding function is performed relative to that position;

(e) Movements of the active position are effected as follows:

    (i) The active position is advanced one character position immediately after imaging a SPACE or a graphic character, and upon the execution of the function corresponding to a control character for which a graphic symbol is required to be imaged;

    (ii) The active position is moved to a specified character position upon the execution of the function corresponding to a control character that is defined to cause a movement of the active position (i.e., a format effector);

(f) The active position is not moved upon execution of the function corresponding to a control character that is neither required to be imaged by a graphic symbol nor defined to cause a movement of the active position;

(g) The effect of an attempt to move the active position beyond the boundaries of a line or a page is not defined by this Recommendation.

4.1.2.2 *Combined horizontal and vertical movements of the active position*

The format effectors are defined for applications in which horizontal and vertical movements of the active position are effected separately. If a single control character is required to effect the action of CARRIAGE RETURN in combination with a vertical movement, the format effector for that vertical movement shall be used. For example, if the function "new line" (equivalent to the combination of CARRIAGE RETURN and LINE FEED) is required as a single control character, bit combination 0/10 shall be used to represent it. This substitution requires agreement between the sender and the recipient of the data, and the format effectors (LINE FEED, VERTICAL TABULATION and/or FORM FEED) that are affected shall be identified (see section 6 below).

In order to avoid the need for such prior agreement, to facilitate interchange and to avoid conflicts with specifications in other ISO publications, the use of format effectors for vertical movements is deprecated. It is strongly recommended to use two control characters, for example CARRIAGE RETURN (CR) and LINE FEED (LF) to obtain the effect of "new line".

4.1.3 Code extension control characters

The code extension control characters and their coded representations are specified in Table 3/T.50.

Table 3/T.50 – Coded extension control characters – coded representation

Acronym	Name	Coded representation
SO	Shift-out	0/14
SI	Shift-in	0/15
ESC	Escape	1/11

4.1.4 Device control characters

The device control characters and their coded representations are specified in Table 4/T.50.

Table 4/T.50 – Device control characters – coded representation

Acronym	Name	Coded representation
DC1	Device control one	1/1
DC2	Device control two	1/2
DC3	Device control three	1/3
DC4	Device control four	1/4

4.1.5 Information separators

The information separators and their coded representations are specified in Table 5/T.50

Table 5/T.50 – Information separators – coded representation

Acronym	Name	Coded representation
IS4 (FS)	Information separator four (file separator)	1/12
IS3 (GS)	Information separator three (group separator)	1/13
IS2 (RS)	Information separator two (record separator)	1/14
IS1 (US)	Information separator one (unit separator)	1/15

Each information separator is given two names. The names INFORMATION SEPARATOR FOUR, INFORMATION SEPARATOR THREE, INFORMATION SEPARATOR TWO and INFORMATION SEPARATOR ONE are the general names. The names FILE SEPARATOR, GROUP SEPARATOR, RECORD SEPARATOR and UNIT SEPARATOR are the specific names and are intended mainly for applications where the information separators are used hierarchically. The ascending order is then US, RS, GS, FS. In this case, data normally delimited by a particular separator cannot be split by a higher-order separator but will be considered as delimited by any higher-order separator.

4.1.6   Other control characters

The control characters outside the categories in paragraphs 4.1.1 to 4.1.5 above and their coded representation, are specified in Table 6/T.50.

Table 6/T.50 – Other control characters – coded representation

Acronym	Name	Coded representation
NUL	Null	0/0
BEL	Bell	0/7
CAN	Cancel	1/8
EM	End of medium	1/9
SUB	Substitute character	1/10
DEL	Delete	7/15

4.2   Character SPACE

The acronym of the character SPACE is SP and its coded representation is 2/0. This character is interpreted both as a graphic character and as a control character. As a graphic character, it has a visual representation consisting of the absence of a graphic symbol. As a control character, it acts as a format effector that causes the active position to be advanced one character position.

4.3   Graphic characters

The 94 bit combinations 2/1 to 7/14 are used for the representation of graphic characters as specified in paragraphs 4.3.1, 4.3.2 and 4.3.3 below. Paragraphs 4.3.1 and 4.3.2 below contain each a table consisting of three columns. The first column is labelled "Graphic" and specifies the graphic symbol of each graphic character, the second column specifies the standard name of the graphic character and the third column, labelled "Coded representation", specifies the bit combination representing the graphic character concerned.

All graphic characters of any version of the 7-bit coded character set are spacing characters, i.e. they cause the active position to advance.

4.3.1   Unique graphic character allocations

A unique graphic character is allocated to each of the 82 bit combinations 2/1, 2/2, 2/5 to 3/15, 4/1 to 5/10, 5/15 and 6/1 to 7/10. These characters are specified in table 7/T.50.

Table 7/T.50 – Unique graphic character allocations

Graphic	Name	Coded representation	Graphic	Name	Coded representation
!	Exclamation mark	2/1	M	Capital letter M	4/13
"	Quotation mark	2/2	N	Capital letter N	4/14
%	Percent sign	2/5	O	Capital letter O	4/15
&	Ampersand	2/6	P	Capital letter P	5/0
'	Apostrophe	2/7	Q	Capital letter Q	5/1
(	Left parenthesis	2/8	R	Capital letter R	5/2
)	Right parenthesis	2/9	S	Capital letter S	5/3
*	Asterisk	2/10	T	Capital letter T	5/4
+	Plus sign	2/11	U	Capital letter U	5/5
,	Comma	2/12	V	Capital letter V	5/6
–	Hyphen, minus sign	2/13	W	Capital letter W	5/7
.	Full stop	2/14	X	Capital letter X	5/8
/	Solidus	2/15	Y	Capital letter Y	5/9
0	Digit zero	3/0	Z	Capital letter Z	5/10
1	Digit one	3/1	–	Low line, underline	5/15
2	Digit two	3/2	a	Small letter a	6/1
3	Digit three	3/3	b	Small letter b	6/2
4	Digit four	3/4	c	Small letter c	6/3
5	Digit five	3/5	d	Small letter d	6/4
6	Digit six	3/6	e	Small letter e	6/5
7	Digit seven	3/7	f	Small letter f	6/6
8	Digit eight	3/8	g	Small letter g	6/7
9	Digit nine	3/9	h	Small letter h	6/8
:	Colon	3/10	i	Small letter i	6/9
;	Semicolon	3/11	j	Small letter j	6/10
<	Less-than sign	3/12	k	Small letter k	6/11
=	Equal sign	3/13	l	Small letter l	6/12
>	Greater-than sign	3/14	m	Small letter m	6/13
?	Question mark	3/15	n	Small letter n	6/14
A	Capital letter A	4/1	o	Small letter o	6/15
B	Capital letter B	4/2	p	Small letter p	7/0
C	Capital letter C	4/3	q	Small letter q	7/1
D	Capital letter D	4/4	r	Small letter r	7/2
E	Capital letter E	4/5	s	Small letter s	7/3
F	Capital letter F	4/6	t	Small letter t	7/4
G	Capital letter G	4/7	u	Small letter u	7/5
H	Capital letter H	4/8	v	Small letter v	7/6
I	Capital letter I	4/9	w	Small letter w	7/7
J	Capital letter J	4/10	x	Small letter x	7/8
K	Capital letter K	4/11	y	Small letter y	7/9
L	Capital letter L	4/12	z	Small letter z	7/10

4.3.2   Alternative graphic character allocations

Two alternative graphic characters are allocated to each of the bit combinations 2/3 and 2/4. These characters are specified in Table 8/T.50.

Either the character POUND SIGN or the character NUMBER SIGN shall be allocated to bit combination 2/3 and either the character DOLLAR SIGN or the character CURRENCY SIGN shall be allocated to bit combination 2/4 (see section 6 below).

Table 8/T.50 – Alternative graphic character allocations

Graphic	Name	Coded representation
£	Pound sign	2/3
#	Number sign	2/3
$	Dollar sign	2/4
⌷	Currency sign	2/4

Unless otherwise agreed between sender and recipient, the graphic symbols £, $ and ⌷ €do not designate the currency of a specific country.

4.3.3   National or application-oriented graphic character allocations

No specific graphic character is allocated to the ten bit combinations 4/0, 5/11 to 5/14, 6/0, and 7/11 to 7/14. These bit combinations are available for national or application-oriented use. A unique graphic character shall be allocated to each of these bit combinations, or bit combination shall be declared unused (see section 6 below).

5.   COMPOSITE GRAPHIC CHARACTERS

In any version of the 7-bit coded character set specified according to this Recommendation, all graphic characters are spacing characters which cause the active position to move forward. However, by using BACK-SPACE or CARRIAGE RETURN, it is possible to image two or more graphic characters at the same character position.

For example, SOLIDUS and EQUALS SIGN can be combined to image "not equals". The character LOW LINE, that may be used as a free-standing character, can also be associated with other character(s) to represent the graphic rendition "underlined".

Diacritical marks may be allocated to the bit combinations specified in paragraph 4.3.3 above and be available for composing accented letters. For such composition, it is recommended to use a sequence of three characters, the first or last of which is the letter to be accented and the second of which is BACKSPACE. Furthermore, QUOTATION MARK, APOSTROPHE or COMMA can be associated with a letter by means of BACKSPACE for the composition of an accented letter with a diaeresis, an acute accent or a cedilla, respectively.

6.   VERSIONS OF THE CODED CHARACTER SET

6.1   General

In order to use the 7-bit coded character set for information interchange, it is necessary to exercise the options left open in paragraph 4 above:

–   to each of the bit combinations 2/3 and 2/4 one of the alternative graphic characters specified in para-graph 4.3.2 above shall be allocated;
–   each of the bit combinations 4/0, 5/11 to 5/14, 6/0 and 7/11 to 7/14 shall have a unique graphic char-acter allocated to it, or be declared unused;
–   the format effectors, if any, to which the facility of paragraph 4.1.2.2 above applies, shall be identified.
         A graphic character allocated to a bit combination specified in paragraphs 4.3.1 and 4.3.2 above shall not be allocated to any other bit combination. For example the POUND SIGN, if not allocated to bit combination 2/3, shall not be allocated to any other bit combination.

A character set completed in this way is called a "version of ISO Standard 646/CCITT T.50" (see Appendix I).

6.2   National versions

6.2.1   The responsibility for defining national versions lies with the national standardization bodies. These bodies shall exercise the options available and make the required selection (see Appendix I).

6.2.2   If so required, more than one national version can be defined within a country. The different versions shall be separately identified. In particular when for a given bit combination, for example 5/12, alternative graphic characters are required, two different versions shall be identified, even if they differ only by this single character.

6.2.3   If there is in a country no special demand for specific graphic characters, it is strongly recommended that the characters of the International Reference Version (IRV) (see paragraph 6.4 below) be selected and allocated to the same bit combinations as in the IRV.

However, when graphic characters that are different from the characters of the IRV are required, they shall have distinct forms and be given distinctive names which are not in conflict with any of the forms or the names of any of the graphic characters in the IRV.

6.3   Application-orientated versions

Within national or international industries, organizations or professional groups, application-oriented versions can be used. They require precise agreement among the interested parties, who will have to exercise the options available and to make the required selection.

6.4   International Reference Version (IRV)

This version is available for use when there is no requirement to use a national or an application-oriented version. In information interchange, the IRV is assumed unless a particular agreement exists between sender and recipient of the data. The graphic characters allocated to the IRV are specified in Table 9/T.50.

Table 9/T.50 – IRV graphic character allocations

Graphic	Name	Coded representation
#	Number sign	2/3
◻	Currency sign	2/4
@	Commercial at	4/0
[	Left square bracket	5/11
\	Reverse solidus	5/12
]	Right square bracket	5/13
^	Circumflex accent	5/14
`	Grave accent	6/0
{	Left curly bracket	7/11
|	Vertical line	7/12
}	Right curly bracket	7/13
-	Tilde, overline	7/14

It should be noted that no substitution is allowed when using the IRV and that the facility of paragraph 4.1.2.2 above does not apply to any format effector.

According to paragraph 5 above it is permitted to use composite graphic characters and there is no limit to their number. Because of this freedom, their processing and imaging may cause difficulties at the receiving end. Therefore agreement between sender and recipient of the data is recommended if composite characters are used.

7.   CODE TABLES

A 7-bit code table consists of 128 positions arranged in 8 columns and 16 rows. The columns are numbered 0 to 7, and the rows are numbered 0 to 15.

The code table positions are identified by notations of the form x/y, where x is the column number and y is the row number.

The 128 positions of the code table are in one-to-one correspondence with the bit combinations of the 7-bit code. The notation of a code table position, of the form x/y, is the same as that of the corresponding bit combination (see paragraph 4 above).

Each code table position contains a symbol and/or a reference to a clause of this Recommendation. When a code table position corresponds to a bit combination that represents a control character or the character SPACE, the symbol is the acronym of the character allocated; otherwise it is the graphic symbol representing the character allocated, if any. A reference to paragraphs 4.1.2.2, 4.3.2 or 4.3.3 above is denoted by ①, ② or ③ respectively.

Table 10/T.50 is the basic 7-bit code table. It shows the 7-bit coded character set specified in paragraph 4 above and indicates the options related to format effectors (paragraph 4.1.2.2 above), alternative graphic characters (paragraph 4.3.2 above) and national or application-oriented use (paragraph 4.3.3 above).

Table 11/T.50 is the code table for the IRV of the 7-bit coded character set. It shows the result of exercising the three identified options in the manner specified in paragraph 6.4 above.

8.   DESCRIPTION OF THE CONTROL CHARACTERS

The control characters are listed below in the alphabetic order of their acronyms.

8.1   ACK Acknowledge

A transmission control character transmitted by a receiver as an affirmative response to the sender.

8.2   BEL Bell

A control character that is used when there is a need to call for attention; it may control alarm or attention devices.

8.3   BS Backspace

A format effector which causes the active position to move one character position backwards.

8.4   CAN Cancel

A character, or the first character of a sequence, indicating that the data preceding it is in error. As a result, this data shall be ignored. The specific meaning of this character shall be defined for each application and/or between sender and recipient.

8.5   CR Carriage Return

A format effector which causes the active position to move to the first character position on the same line.

8.6   DC1 Device Control One

A device control character which is primarily intended for turning on or starting an ancillary device. If it is not required for this purpose, it may be used to restore a device to the basic mode of operation (see also DC2 and DC3), or for any other device control function not provided by other DCs.

8.7   DC2 Device Control Two

A device control character which is primarily intended for turning on or starting an ancillary device. If it is not required for this purpose, it may be used to set a device to a special mode of operation (in

which case DC1 is used to restore the device to the basic mode), or for any other device control function not provided by other DCs.

8.8   DC3 Device Control Three

A device control character which is primarily intended for turning off or stopping an ancillary device. This function may be a secondary level stop, for example wait, pause, stand-by or halt (in which case DC1 is used to restore normal operation). If it is not required for this purpose, it may be used for any other ancillary device control function not provided by other DCs.

Table 10/T.50 – Basic 7-bit code table

b7					0	0	0	0	1	1	1	1
b6					0	0	1	1	0	0	1	1
b5					0	1	0	1	0	1	0	1
b4	b3	b2	b1		0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	③	P	③	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#/£ ②	3	C	S	c	s
0	1	0	0	4	EOT	DC4	¤/$ ②	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF ①	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT ①	ESC	+	;	K	③	k	③
1	1	0	0	12	FF ①	IS4	,	<	L	③	l	③
1	1	0	1	13	CR ①	IS3	–	=	M	③	m	③
1	1	1	0	14	SO	IS2	.	>	N	③	n	③
1	1	1	1	15	SI	IS1	/	?	O	_	o	DEL

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①   See paragraph 4.1.2.2 above

②   See paragraph 4.3.2 above

③   See paragraphs 4.3.3 and 6.2.3 above

Table 11/T.50 – International Reference Version (IRV)

b7						0	0	0	0	1	1	1	1
b6						0	0	1	1	0	0	1	1
b5						0	1	0	1	0	1	0	1
						0	1	2	3	4	5	6	7
b4	b3	b2	b1										
0	0	0	0	0		NUL	DLE	SP	0	@	P		p
0	0	0	1	1		SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2		STX	DC2	"	2	B	R	b	r
0	0	1	1	3		ETX	DC3	#	3	C	S	c	s
0	1	0	0	4		EOT	DC4	¤	4	D	T	d	t
0	1	0	1	5		ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6		ACK	SYN	&	6	F	V	f	v
0	1	1	1	7		BEL	ETB	'	7	G	W	g	w
1	0	0	0	8		BS	CAN	(	8	H	X	h	x
1	0	0	1	9		HT	EM	)	9	I	Y	i	y
1	0	1	0	10		LF	SUB	*	:	J	Z	j	z
1	0	1	1	11		VT	ESC	+	;	K	[	k	{
1	1	0	0	12		FF	IS4	,	<	L	\	l		
1	1	0	1	13		CR	IS3	–	=	M	]	m	}
1	1	1	0	14		SO	IS2	.	>	N	^	n	–
1	1	1	1	15		SI	IS1	/	?	O	_	o	DEL

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8.9   DC4 Device Control Four

A device control character which is primarily intended for turning off, stopping or interrupting an ancillary device. If it is not required for this purpose, it may be used for any other device control function not provided by other DCs.

8.10   DEL Delete

A character used primarily to erase or obliterate an erroneous or unwanted character in punched tape. DEL characters may also serve to accomplish media-fill or time-fill. They may be inserted into, or removed from, a stream of data without affecting the information content of that stream, but such action may affect the information layout and/or the control equipment.

8.11   DLE Data Link Escape

A transmission control character which will change the meaning of a limited number of contiguously following bit combinations. It is used exclusively to provide supplementary transmission control functions. Only graphic characters and transmission control characters can be used in DLE sequences.

8.12   EM End of Medium

A control character that may be used to identify the physical end of a medium, or the end of the used portion of a medium, or the end of the wanted portion of data recorded on a medium. The portion of this character does not necessarily correspond to the physical end of the medium.

8.13   ENQ Enquiry

A transmission control character used as a request for a response from a remote station – the response may include station identification and/or station status. When a "Who are you" function is required on the general switched transmission network, the first use of ENQ after the connection is established shall have the meaning "Who are you" (station identification). Subsequent use of ENQ may, or may not, include the function "Who are you", as determined by agreement.

8.14   EOT End of Transmission

A transmission control character used to indicate the conclusion of the transmission of one or more texts.

8.15   ESC Escape

A control character which is used to provide additional characters. It alters the meaning of a limited number of contiguously following bit combinations. The use of this character is specified in ISO Standard 2022.

8.16   ETB End of Transmission Block

A transmission control character used to indicate the end of a transmission block of data where data is divided into such blocks for transmission purposes.

8.17   EXT End of Text

A transmission control character which terminates a text.

8.18   FF Form Feed

A format effector which causes the active position to advance to the corresponding character position on a pre-determined line of the next form or page.

8.19   HT Horizontal Tabulation

A format effector which causes the active position to advance to the next pre-determined character position.

8.20   IS1 (US) Information Separator One (Unit Separator)

A control character used to separate and qualify data logically; its specific meaning has to be defined for each application. If this character is used in hierarchical order as specified in the general definition of IS, it delimits a data item called a unit.

8.21   IS2 (RS) Information Separator Two (Record Separator)

A control character used to separate and qualify data logically; its specific meaning has to be defined for each application. If this character is used in hierarchical order as specified in the general definition of IS, it delimits a data item called a record.

8.22   IS3 (GS) Information Separator Three (Group Separator)

A control character used to separate and qualify data logically; its specific meaning has to be defined for each application. If this character is used in hierarchical order as specified in the general definition of IS, it delimits a data item called a group.

8.23   IS4 (FS) Information Separator Four (File Separator)

A control character used to separate and qualify data logically; its specific meaning has to be defined for each application. If this character is used in hierarchical order as specified in the general definition of IS, it delimits a data item called a file.

8.24   LF Line Feed

A format effector which causes the active position to advance to the corresponding character position of the next line.

8.25   NAK Negative Acknowledge

A transmission control character transmitted by a receiver as a negative response to the sender.

8.26   NUL Null

A control character used to accomplish media-fill or time-fill. NUL characters may be inserted into, or removed from, a stream of data without affecting the information content of that stream, but such action may affect the information layout and/or the control of equipment.

8.27   SI Shift-In

A control character which is used in conjunction with SO and ESC to extend the graphic character set of the code. It may reinstate the standard meanings of the bit combinations which follow it. The effect of this character when using code extension techniques is described in ISO Standard 2022.

8.28   SO Shift-Out

A control character which is used in conjunction with SI and ESC to extend the graphic character set of the code. It may alter the meaning of the bit combinations 2/1 to 7/14 which follow it until an SI character is reached. The effect of this character when using code extension techniques is described in ISO 2022.

8.29   SOH Start Of Heading

A transmission control character used as the first character of a heading of an information message.

8.30   STX Start of Text

A transmission control character which precedes a text and which is used to terminate a heading.

8.31   SUB Substitute character

A control character used in the place of a character that has been found to be invalid or in error. SUB is intended to be introduced by automatic means.

8.32   SYN Synchronous idle

A transmission control character used by a synchronous transmission system in the absence of any other character (idle condition) to provide a signal from which synchronism may be achieved or retained between data terminal equipment.

8.33   VT Vertical Tabulation

A format effector which causes the active position to advance to the corresponding character position on the next pre-determined line.

APPENDIX I – (to Recommendation T.50)

Guidelines for standards derived from Recommendation T.50 (ISO Standard 646)

I.1   GENERAL

When national or application-oriented standards based on Recommendation T.50/ISO 646 are drafted, it is recommended to take account of the following considerations.

I.2   STRUCTURE OF A STANDARD

It is recommended to adopt the same structure and editorial style as implemented for Recommendation T.50/ISO 646. All facilities, restrictions and specifications of the standard should be stated clearly in sentences using plain language, rather than be summarized by tables with notes.

I.2.1   Control functions

The standard should contain explicit descriptions of the control functions. Even where those descriptions are identical to the descriptions in paragraph 8 above, they should be explicit descriptions, not just referenced to Recommendation T.50/ISO 646. For application-oriented standards specific meanings of the Information Separators and of the Device Controls should be defined.

I.2.2   Graphic characters (see paragraph 6.2.3 above)

Where there is no need for particular characters, the graphic characters of the International Reference Version (IRV) should be allocated to the same positions and with the same name as in Recommendation T.50/ISO 646.

I.2.3   Composite graphic characters and repertoire (see paragraph 5 above)

Recommendation T.50/ISO 646 permits the construction of composite graphic characters by using the control characters BACKSPACE and CARRIAGE RETURN so as to image two or more graphic characters at the same character position.

The total number of graphic characters which can be obtained from any version of the character set, with or without using this facility, is called the repertoire. Recommendation T.50/ISO 646 does not define a particular repertoire. However, as the interpretation and/or the imaging of composite characters may cause difficulties, agreement between sender and recipient of the data may be required. In order to avoid the necessity of such agreement and to facilitate interchange, national or application-oriented standards may specify a standard repertoire of graphic characters and thus recognize only a limited number of composite graphic characters. Such limitations are considered fully compatible with Recommendation T.50/ISO 646.

I.2.4   Versions

In a standard one or more versions can be specified. It should be noted that a version is not a standard but only part of a standard. The standard itself consists of the well defined version or versions and a set of clauses as mentioned above. The definition of a version requires that the options mentioned in paragraph 6.1 above be accurately exercised.

CONVERSION TABLE BETWEEN INTERNATIONAL ALPHABETS No. 2 AND No. 5 AND CONTROL CHARACTERS OF ALPHABET No. 5, NOT CONTAINED IN THE FIRST PART OF THE TABLE, USED FOR METEOROLOGICAL TRANSMISSIONS

Part I – Conversion table between International Alphabets No. 2 and No. 5

Symbols or commands	Alphabet No. 2		Alphabet No. 5	
	Letter case	Figure case	Column	Row
A	1		4	1
B	2		4	2
C	3		4	3
D	4		4	4
E	5		4	5
F	6		4	6
G	7		4	7
H	8		4	8
I	9		4	9
J	10		4	10
K	11		4	11
L	12		4	12
M	13		4	13
N	14		4	14
O	15		4	15
P	16		5	0
Q	17		5	1
R	18		5	2
S	19		5	3
T	20		5	4
U	21		5	5
V	22		5	6
W	23		5	7
X	24		5	8
Y	25		5	9
Z	26		5	10
Carriage return	27	27	0	13
Line feed	28	28	0	10
Letters	29	29		
Figures	30	30		
Space	31	31	2	0
–		1	2	13
?		2	3	15
:		3	3	10
ENQ - WRU		4	0	5
3		5	3	3
8		9	3	8
Bell		10	0	7
(		11	2	8
)		12	2	9
.		13	2	14

Conversion table (*continued*)

Symbols or commands	Alphabet No. 2		Alphabet No. 5	
	Letter case	Figure case	Column	Row
,		14	2	12
9		15	3	9
0		16	3	0
1		17	3	1
4		18	3	4
'		19	2	7
5		20	3	5
7		21	3	7
=		22	3	13
2		23	3	2
/		24	2	15
6		25	3	6
+		26	2	11

Note: Signal No. 32 of Alphabet No. 2 has been omitted because it is not used.

Part II – Control characters of Alphabet No. 5, not contained in the first part of the table, used for meteorological transmissions

Symbols	Code of Alphabet No. 5	
	Column	Line
NUL	0	0
SOH	0	1
STX	0	2
ETX	0	3
EOT	0	4
ACK	0	6
DLE	1	0
DC1	1	1
DC2	1	2
NAK	1	5
SYN	1	6
ETB	1	7
ESC	1	11
FS	1	12
GS	1	13
RS	1	14
DEL	7	15

FORMAT OF METEOROLOGICAL MESSAGES

1.   EXAMPLE OF SURFACE OBSERVATIONS (SYNOP)

(a) Use of International Telegraph Alphabet No. 2

Starting line	←←≡↓ZCZC→↑345→→→→→
Abbreviated heading	←←≡↓SMYG↑10→↓LYBM→↑280000
Text	←←≡↓AAXX→↑28001
	←←≡↑13131→.....→.....→.....→.....→ etc.*.....=
	←←≡↑13272→.....→.....→.....→.....→ etc.*.....=
	←←≡↑13333→.....→.....→.....→.....→ etc.*.....=
	←←≡↑13462→.....→.....→.....→.....→ etc.*.....=
	←←≡↑13586→↓NIL↑=

End-of-message signals   ↓←←≡≡≡≡≡≡≡NNNN↓↓↓↓↓↓↓↓↓↓↓↓

>   *Legend:*   ← Carriage return (Signal No. 27)   ↓ Letter shift (Signal No. 29)
>
>   ≡ Line feed (Signal No. 28)   ↑ Figure shift (Signal No. 30)
>
>   → Space (Signal No. 31)   = Signal No. 22 (figure case position)

(b) Use of International Alphabet No. 5

Starting line   [SOH] [CR] [CR] [LF] 345

Abbreviated heading [CR] [CR] [LF] SMYG 10 [SP] LYBM [SP] 280000

Text   [CR] [CR] [LF] AAXX [SP] 28001

                     [CR] [CR] [LF] 13131 [SP] ..... [SP] ..... [SP] ..... [SP] ..... [SP] etc.*.....=

                     [CR] [CR] [LF] 13272 [SP] ..... [SP] ..... [SP] ..... [SP] ..... [SP] etc.*.....=

                     [CR] [CR] [LF] 13333 [SP] ..... [SP] ..... [SP] ..... [SP] ..... [SP] etc.*.....=

                     [CR] [CR] [LF] 13462 [SP] ..... [SP] ..... [SP] ..... [SP] ..... [SP] etc.*.....=

                     [CR] [CR] [LF] 13586 [SP] NIL=

End-of-message
signals   [CR] [CR] [LF] [ETX]

* Full use should be made of the teleprinter line (69 characters per line). See also paragraph 2.3.3.2.6, Part II.

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Legend:

[SOH]   Start of heading (Signal 0/1)

[CR]   Carriage return (Signal 0/13)

[LF]   Line feed (Signal 0/10)

[SP]   Space (Signal 2/0)

[ETX]   End of text (Signal 3/13)

=   Separator (Signal 3/13)

2.   EXAMPLE OF SURFACE OBSERVATIONS (SHIP)

(a) Use of International Telegraph Alphabet No. 2

Starting line   ←←≡↓ZCZC→↑234→→→→→

Abbreviated heading   ←←≡↓SMVD↑01→↓KWBC→↑280000

Text   ←←≡↓BBXX**

                         ←←≡↓WLGT**→↓28004→99510→70428→41595

                         ←←≡↑.....→.....→.....→.....→.....etc*

                         ←←≡↑.....→.....=

End-of-message signals   ↓←←≡≡≡≡≡≡≡≡NNNN↓↓↓↓↓↓↓↓↓↓↓↓

(b) Use of International Alphabet No. 5

Starting line   [SOH] [CR] [CR] [LF] 234

Abbreviated heading   [CR] [CR] [LF] SMVD 01 [SP] KWBC [SP] 280000

Text   [CR] [CR] [LF] BBXX**

                       [CR] [CR] [LF] WLGT** [SP] 28004 [SP] 99510 [SP] 70428 [SP] 41595 [SP] etc.*.....=

                       [CR] [CR] [LF] ..... [SP] ..... [SP] .....=

End-of-message signals   [CR] [CR] [LF] [ETX]

---

*   Full use should be made of the teleprinter line (69 characters per line). See also paragraph 2.3.3.2.6, Part II.

**   In a bulletin of SHIP reports from sea stations, the group $M_iM_iM_jM_j$ shall be included only as the first line of the text, and the ship call sign or buoy identification and the group $YYGGi_w$ shall be included in every individual report.

3.   EXAMPLE OF UPPER-AIR OBSERVATIONS (TEMP)

(a) Use of International Telegraph Alphabet No. 2

Starting line   ←←≡↓ZCZC→↑248→→→→→

Abbreviated heading   ←←≡↓USSN↑01→↓ESWI→↑011200

Text   ←←≡↓TTAA→↑51111→02185→99...→......→.....etc*

                             ←←≡↑.....→.....→.....→.....→.....=

                             ←←≡

                             ←←≡↓TTAA→↑51111→↓NIL↑=

End-of-message signals   ↓←←≡≡≡≡≡≡≡NNNN↓↓↓↓↓↓↓↓↓↓↓

(b) Use of International Alphabet No. 5

Starting line | SOH | CR | CR | LF | 248

Abbreviated heading | CR | CR | LF | USSN 01 | SP | ESWI | SP | 011200

Text | CR | CR | LF | TTAA | SP | 51111 | SP | 02185 | SP | 99... | SP | ..... | SP | etc.*.....=

         | CR | CR | LF | ..... | SP | ..... | SP | ..... | SP | ..... | SP | .....=

         | CR | CR | LF |

         | CR | CR | LF | TTAA | SP | 51111 | SP | NIL=

End-of-message signals | CR | CR | LF | ETX |

* Full use should be made of the teleprinter line (69 characters per line). See also paragraph 2.3.3.2.6, Part II.

4.   EXAMPLES OF PRESENTATION OF FORMATS FOR SYNOP BULLETINS

(a) All Sections 1, 2, 3 and 4 shall be consecutively transmitted without any insertion of spaces and solidi
     in the identifier groups of Sections 3 and 4.

Example:

```
ZCZC  007
SMRS  10  RUMS  220600
AAXX  22061
26298  21/50  82503  11054  21058  40333  57010  71022  8807/  333  21068  69902 =
26477  21335  82503  11049  21052  40247  57004  77777  886//  333  21049  69902  88706 =
26781  31296  82301  11050  21060  40248  52004  71022  887//  333  21057  88706 =
26997  21450  80000  11068  21/86  40310  52009  72070  886//  333  21146  60002  88712 =
27595  22997  93008  11077  21196  40158  52010  333  21191  69932 =
27612  31950  20000  11132  21145  40233  52002  71000  80001  333  21141 =
27731  22998  62902  11119  21154  40234  52013  80002  333  21117  69902 =
27947  32998  23602  11148  21178  40217  52020  80002 =
27962  22997  03404  11136  21171  40197  52027  333  21126  69992 =
NNNN
```

(b) Sections 1, 2, 3 and 4 shall start at the beginning of a line but identifiers of Sections 3 and 4 shall start with two spaces at the beginning.

Example:

ZCZC 055

SMDD 01 ETPD 110600

AAXX 11061

09393 32996 31704 10015 21027 40244 57005 83030

   333 20015 34101 =

09543 32950 11401 11018 21034 40274 53002 81030

   333 21018 3/103 41999 =

09184 32960 71905 10038 21006 40215 56003 8707/

   333 20038 31003 =

09385 32960 51704 10018 21018 40243 5/005 83046

   333 20017 34000 =

NNNN

5.   EXAMPLES OF PRESENTATION OF NIL TEXTS

(a) SYNOP bulletin

   SMRS10 RUMS 220600
   NIL

(b) TEMP bulletin

   USSN01 ESW1 011200
   NIL

(c) CREX bulletin

   KOMS10 FAPR 220600
   NIL

(d) BUFR bulletin

   IUKN01 EGRR 221200
   NIL

DATA DESIGNATORS $T_1T_2A_1A_2$ii IN ABBREVIATED HEADINGS

*

*   *

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Table A

Data type designator T_1 Matrix Table for $T_2A_1A_2$ii definitions

T_1	Data type	T_2	A_1	A_2	ii	Priority
A	Analyses	B1	C1	C1	**	3
B	Addressed message	***	***	***	***	1/2/4*
C	Climatic data	B1	C1	C1	**	4
D	Grid point information (GRID)	B2	C3	C4	D2	3
E	Satellite imagery	B5	C1	C1	**	3
F	Forecasts	B1	C1	C1	**	3
G	Grid point information (GRID)	B2	C3	C4	D2	3
H	Grid point information (GRIB)	B2	C3	C4	D2	3
I	Observational data (Binary coded) – BUFR	B3	C6	C3	**	2
J	Forecast information (Binary coded) – BUFR	B3	C6	C4	D2	3
K	CREX	B3	C7	C3	**	2
L	–					
M	–					
N	Notices	B1	C1	C1	**	4
O	Oceanographic information (GRIB)	B4	C3	C4	D1	3
P	Pictorial information (Binary coded)	B2	C3	C4	D2	3
Q	Pictorial information regional (Binary coded)	B2	C3	C5	D2	3
R	–					
S	Surface data	B1	C1/C2	C1/C2	**	2/4*
T	Satellite data	B1	C3	C4	**	2
U	Upper-air data	B1	C1/C2	C1/C2	**	2
V	National data	(2)	C1	C1	**	(1)
W	Warnings	B1	C1	C1	**	1
X	GRID regional use	B2	C3	C5	D2	3
Y	GRIB regional use	B2	C3	C5	D2	3
Z	–					

*   Priority level: 1 is allocated to service messages.
                        2 is allocated to data and request messages.
                        3 is allocated to seismic waveform data (T_1T_2 = SY).
                        4 is allocated to administrative messages.
**   See paragraph 2.3.2.2 for definition and use.
*** See paragraph 2.4.2 for definition and use.
(1) To be determined.
(2) Table B2 or national table.

Table B1

Data type designator T$_2$ (when T$_1$ = A, C, F, N, S, T, U or W)

Instructions for the proper application of the data type designators

1.   The designators specified in this table should be used to the greatest extent possible to indicate the type of data contained within the body of the bulletin.

2.   When the tables does not contain a suitable designator for the data type, an alphabetic designator which is not assigned in the table should be introduced and the WMO Secretariat notified.

3.   This table includes only the FM number and code name for an individual code form. The Roman numeral identifying the latest version has been omitted to reduce clutter. In all cases the latest version of a code is implied. Refer to *Manual on Codes* (WMO-No. 306) for the complete code name (including the version) of any numbered code. In those few instances where a numbered code does not exist, a reference and the common name is given: e.g. [ICAO] (AIREP). An explanatory note may be appended to an individual table if necessary.

4.   In the event that no standard format has been established for a particular data type, and where there is a recommended format, that format is given in square brackets under the column labeled Code form (e.g. [TEXT]). This is a character code in free form – International Alphabet No. 2 (Attachment II-1) or International Alphabet No. 5 (Attachment II-2) will be used.

T$_1$ = A Analyses

T$_2$ Designator	Data type	Code form (name)
C	Cyclone	[TEXT]
G	Hydrological/marine	[TEXT]
H	Thickness	[TEXT]
I	Ice	FM 44 (ICEAN)
O	Ozone layer	[TEXT]
R	Radar	[TEXT]
S	Surface	FM 45 (IAC)/FM 46 (IAC FLEET)
U	Upper air	FM 45 (IAC)
W	Weather summary	[TEXT]
X	Miscellaneous	[TEXT]

T$_1$ = C Climatic data

T$_2$ Designator	Data type	Code form (name)
A	Climatic anomalies	[TEXT]
E	Monthly means (upper air)	FM 76 (CLIMAT TEMP SHIP)
H	Monthly means (surface)	FM 72 (CLIMAT SHIP)
O	Monthly means (ocean areas)	FM 73 (NACLI, CLINP, SPCLI, CLISA, INCLI)
S	Monthly means (surface)	FM 71 (CLIMAT)
U	Monthly means (upper air)	FM 75 (CLIMAT TEMP)

T$_1$ = F Forecasts

T$_2$ Designator	Data type	Code form (name)
A	Aviation area/GAMET/advisories	FM 53 (ARFOR)/[TEXT]
B	Upper winds and temperatures	FM 50 (WINTEM)
C	Aerodrome (VT < 12 hours)	FM 51 (TAF)
D	Radiological trajectory dose	FM 57 (RADOF)
E	Extended	[TEXT]
F	Shipping	FM 46 (IAC FLEET)
G	Hydrological	FM 68 (HYFOR)
H	Upper-air thickness	[TEXT]
I	Iceberg	[TEXT]
J	Radio warning service (including IUWDS data)	[TEXT]
K	Tropical cyclone advisories	[TEXT]
L	Local/area	[TEXT]
M	Temperature extremes	[TEXT]
O	Guidance	[TEXT]
P	Public	[TEXT]
Q	Other shipping	[TEXT]
R	Aviation route	FM 54 (ROFOR)
S	Surface	FM 45 (IAC)/FM 46 (IAC FLEET)
T	Aerodrome (VT ≥ 12 hours)	FM 51 (TAF)
U	Upper air	FM 45 (IAC)
V	Volcanic ash advisories	[TEXT]
W	Winter sports	[TEXT]
X	Miscellaneous	[TEXT]
Z	Shipping area	FM 61 (MAFOR)

T$_1$ = N Notices

T$_2$ Designator	Data type	Code form (name)
G	Hydrological	[TEXT]
H	Marine	[TEXT]
N	Nuclear emergency response	[TEXT]
O	METNO/WIFMA	[TEXT]
P	Product generation delay	[TEXT]
T	TEST MSG [System related]	[TEXT]
W	Warning related and/or cancellation	[TEXT]

T$_1$ = S Surface data

T$_2$ Designator	Data type	Code form (name)
A	Aviation routine reports	FM 15 (METAR)
B	Radar reports (Part A)	FM 20 (RADOB)
C	Radar reports (Part B)	FM 20 (RADOB)
D	Radar reports (Parts A & B)	FM 20 (RADOB)
E	Seismic data	* (SEISMIC)
F	Atmospherics reports	FM 81 (SFAZI)/FM 82 (SFLOC)/FM 83 (SFAZU)
G	Radiological data report	FM 22 (RADREP)
I	Intermediate synoptic hour	FM 12 (SYNOP)/FM 13 (SHIP)
L	–	–
M	Main synoptic hour	FM 12 (SYNOP)/FM 13 (SHIP)
N	Non-standard synoptic hour	FM 12 (SYNOP)/FM 13 (SHIP)
O	Oceanographic data	FM 63 (BATHY)/FM 64 (TESAC)/FM 62 (TRACKOB)
P	Special aviation weather reports	FM 16 (SPECI)

T$_1$ = S Surface data (*continued*)

T$_2$ Designator	Data type	Code form (name)
R	Hydrological (river) reports	FM 67 (HYDRA)
S	Drifting buoy reports	FM 18 (DRIFTER)
T	Sea ice	[TEXT]
U	Snow depth	[TEXT]
V	Lake ice	[TEXT]
W	Wave information	FM 65 (WAVEOB)
X	Miscellaneous	[TEXT]
Y	Seismic waveform data	(any format)
Z	Sea-level data and deep-ocean tsunami data	(any alphanumeric format)

———————

*   The international seismic code is documented in the *Manual on Codes* (WMO-No. 306), Volume I, Attachment I.

T$_1$ = T Satellite data

T$_2$ Designator	Data type	Code form (name)
B	Satellite orbit parameters	[TEXT]
C	Satellite cloud interpretations	FM 85 (SAREP)
H	Satellite remote upper-air soundings	FM 86 (SATEM)
R	Clear radiance observations	FM 87 (SARAD)
T	Sea surface temperatures	FM 88 (SATOB)
W	Winds and cloud temperatures	FM 88 (SATOB)
X	Miscellaneous	[TEXT]

T$_1$ = U Upper-air data

T$_2$ Designator	Data type	Code form (name)
A	Aircraft reports	FM 41 (CODAR), ICAO (AIREP)
D	Aircraft reports	FM 42 (AMDAR)
E	Upper-level pressure, temperature, humidity and wind (Part D)	FM 35 (TEMP)/FM 36 (TEMP SHIP)/ FM 38 (TEMP MOBIL)
F	Upper-level pressure, temperature, humidity and wind (Parts C and D) [National and bilateral option]	FM 35 (TEMP)/FM 36 (TEMP SHIP)/ FM 38 (TEMP MOBIL)
G	Upper wind (Part B)	FM 32 (PILOT)/FM 33 (PILOT SHIP)/ FM 34 (TEMP MOBIL)
H	Upper wind (Part C)	FM 32 (PILOT)/FM 33 (PILOT SHIP)/ FM 34 (TEMP MOBIL)
I	Upper wind (Parts A and B) [National and bilateral option]	FM 32 (PILOT)/FM 33 (PILOT SHIP)/ FM 34 (TEMP MOBIL)
K	Upper-level pressure, temperature, humidity and wind (Part B)	FM 35 (TEMP)/FM 36 (TEMP SHIP)/ FM 38 (TEMP MOBIL)
L	Upper-level pressure, temperature, humidity and wind (Part C)	FM 35 (TEMP)/FM 36 (TEMP SHIP)/ FM 38 (TEMP MOBIL)
M	Upper-level pressure, temperature, humidity and wind (Parts A and B) [National and bilateral option]	FM 35 (TEMP)/FM 36 (TEMP SHIP)/ FM 38 (TEMP MOBIL)
N	Rocketsonde reports	FM 39 (ROCOB)/FM 40 (ROCOB SHIP)
P	Upper wind (Part A)	FM 32 (PILOT)/FM 33 (PILOT SHIP)/ FM 34 (PILOT MOBIL)
Q	Upper wind (Part D)	FM 32 (PILOT)/FM 33 (PILOT SHIP)/ FM 34 (PILOT MOBIL)

T_1 = U Upper-air data (*continued*)

T_2

Designator	Data type	Code form (name)
R	Aircraft report	[NATIONAL*] (RECCO)
S	Upper-level pressure, temperature, humidity and wind (Part A)	FM 35 (TEMP)/FM 36 (PILOT SHIP)/ FM 38 (TEMP MOBIL)
T	Aircraft report	FM 41 (CODAR)
X	Miscellaneous	[TEXT]
Y	Upper wind (Parts C and D) [National and bilateral option]	FM 32 (PILOT)/FM 33 (PILOT SHIP)/ FM 34 (PILOT MOBIL)
Z	Upper-level pressure, temperature, humidity and wind from a sonde released by carrier balloon or aircraft (Parts A, B, C, D)	FM 37 (TEMP DROP)

————

* For example, United States national code form for reports from a meteorological reconnaissance flight (RECCO), is documented in the *Manual on Codes* (WMO-No. 306), Volume II, Chapter IV, Part F.

T_1 = W Warnings

T_2

Designator	Data type	Code form (name)
A	AIRMET	[TEXT]
C	Tropical cyclone (SIGMET)	[TEXT]
E	Tsunami	[TEXT]
F	Tornado	[TEXT]
G	Hydrological/river flood	[TEXT]
H	Marine/coastal flood	[TEXT]
O	Other	[TEXT]
S	SIGMET	[TEXT]
T	Tropical cyclone (Typhoon/hurricane)	[TEXT]
U	Severe thunderstorm	[TEXT]
V	Volcanic ash clouds (SIGMET)	[TEXT]
W	Warnings and weather summary	[TEXT]

Table B2

Data type designator T_2 (when T_1 = D, G, H, X or Y)

Instructions for the proper application of the data type designators

1.   The designator specified in this table should be used to the greatest extent possible to indicate the type of data contained within the text of the bulletin.

2.   Where more than one type is contained in the text, the designator for one of the data types should be used.

3.   When the table does not contain a suitable designator for the data type, an alphabetic designator which is not assigned in the table should be introduced and the WMO Secretariat notified.

Designator	Data type	Designator	Data type
A	Radar data	K	Swell height + combinations
B	Cloud	L	–
C	Vorticity	M	For national use
D	Thickness (relative topography)	N	Radiation
E	Precipitation	O	Vertical velocity
F	–	P	Pressure
G	Divergence	Q	Wet bulb potential temperature
H	Height	R	Relative humidity
I	–	S	–
J	Wave height + combinations	T	Temperature

Table B2 (*continued*)

Designator	Data type	Designator	Data type
U	Eastward wind component	X	–
V	Northward wind component	Y	–
W	Wind	Z	Not assigned

Table B3

Data type designator T_2 (when T_1 = I or J)

Instructions for the proper application of the data type designators

1.   The designators specified in this table should be used to the greatest extent possible to indicate the type of data contained within the body of the BUFR bulletin.

2.   Where more than one data type is contained in the bulletin, the designators for only one of the data types should be used.

3.   When the table does not contain a suitable designator for the data type, an alphabetic designator which is not assigned in the table should be introduced and the WMO secretariat notified.

Designator	Data type
N	Satellite data
O	Oceanographic/limnographic (water property)
P	Pictorial
S	Surface/sea level
T	Text (plain language information)
U	Upper-air data
X	Other data types

Table B4

Data type designator T_2 (when T_1 = O)

Instructions for the proper application of the data type designators

1.   The designators specified in this table should be used to the greatest extent possible to indicate the type of data contained within the body of the GRIB bulletin for oceanographic products.

2.   Where more than one data type is contained in the bulletin, the designators for only one of the data types should be used.

3.   When the table does not contain a suitable designator for the data type, an alphabetic designator which is not assigned in the table should be introduced and the WMO secretariat notified.

Designator	Data type
D	Depth
E	Ice concentration
F	Ice thickness
G	Ice drift
H	Ice growth
I	Ice convergence/divergence
Q	Temperature anomaly
R	Depth anomaly
S	Salinity
T	Temperature
U	Current component
V	Current component
W	Temperature warming
X	Mixed data

Table B5

Data type designator T_2 (when T_1 = E)

Designator	*Data type*
C	Cloud top temperature
F	Fog
I	Infrared
S	Surface temperature
V	Visible
W	Water vapour
Y	User specified
Z	Unspecified

Table B6

Data type designator T_2 (when T_1 = P, Q)

Instructions for the proper application of the data type designators

1.   The designator specified in this table should be used to the greatest extent possible to indicate the type of data contained within the text of the bulletin.

2.   Where more than one type is contained in the text, the designator for one of the data types should be used.

3.   When the table does not contain a suitable designator for the data type, an alphabetic designator which is not assigned in the table should be introduced and the WMO Secretariat notified.

Designator	*Data type*
A	Radar data
B	Cloud
C	Clear air turbulence
D	Thickness (relative topography)
E	Precipitation
F	Aerological diagrams (Ash cloud)
G	Significant weather
H	Height
I	Ice flow
J	Wave height + combinations
K	Swell height + combinations
L	Plain language
M	For national use
N	Radiation
O	Vertical velocity
P	Pressure
Q	Wet bulb potential temperature
R	Relative humidity
S	Snow cover
T	Temperature
U	Eastward wind component
V	Northward wind component
W	Wind
X	Lifted index
Y	Observational plotted chart
Z	Not assigned

Table C1

Geographical designators A₁A₂ for use in abbreviated headings T₁T₂A₁A₂ii CCCC YYGGgg for bulletins containing meteorological information, excluding ships' weather reports and oceanographic data

Instructions for the proper application of the geographical designators

1.   This table is subdivided into two parts: Part I contains geographical designators related to countries or territories in each RTH zone of responsibility for the collection of observational reports (surface and upper-air); Part II contains those for vast areas such as continents, hemispheres, etc.

2.   In the case of bulletins containing observational reports (surface and upper-air) from land stations, geographical designators contained in Part II of the table should be used only when no suitable designators are available in Part I of the table.

3.   In the case of bulletins containing meteorological information related to aircraft reports, analyses, prognoses, warnings, climatological data, satellite data and also analogue facsimile information, all the geographical designators contained in this table can be used. However, as far as possible, the geographical designator XX should not be used.

4.   For the geographical designator in the abbreviated heading of the METNO and WIFMA messages, XX should be used.

5.   Geographical designators contained in this table should not be used in the abbreviated heading of bulletins containing ships' weather reports and oceanographic data.

Notes:
1. The designations employed and the presentation of the material in this table do not imply the expression of any opinion whatsoever on the part of the Secretariat of the World Meteorological Organization concerning the legal status of any country, territory, city or area, or of its authorities, or concerning the delimitation of its frontiers or boundaries.
2. For T₁T₂ = SZ, A₁A₂ area designator from Table C1 should be used.

Part I – Country or territory designators

A_1A_2	Country	A_1A_2	Country
AB	Albania	BY	Belarus
AG	Argentina	BZ	Brazil
AH	Afghanistan		
AI	Ascension Island	CD	Chad
AJ	Azerbaijan	CE	Central African Republic
AK	Alaska	CG	Congo
AL	Algeria	CH	Chile
AN	Angola	CI	China
AT	Antigua and Barbuda, Saint Kitts and Nevis, and other British islands in the vicinity	CM	Cameroon
		CN	Canada
AU	Australia	CO	Colombia
AY	Armenia	CR	Canary Islands (Spain)
AZ	Azores	CS	Costa Rica
		CT	Canton Island
BA	Bahamas	CU	Cuba
BC	Botswana	CV	Cape Verde
BD	Brunei Darussalam	CY	Cyprus
BE	Bermuda	CZ	Czech Republic
BH	Belize		
BI	Burundi	DJ	Djibouti
BJ	Benin	DL	Germany
BK	Banks Islands	DN	Denmark
BM	Myanmar	DO	Dominica
BN	Bahrain	DR	Dominican Republic
BO	Bolivia		
BR	Barbados	EG	Egypt
BU	Bulgaria	EO	Estonia
BV	Bouvet Island	EQ	Ecuador
BW	Bangladesh	ER	United Arab Emirates
BX	Belgium, Luxembourg	ES	El Salvador

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Table C1 – Part I (*continued*)

A_1A_2	Country	A_1A_2	Country
ET	Ethiopia	LA	Lao People's Democratic Republic
		LB	Lebanon
FA	Faroe Islands	LC	Saint Lucia
FG	French Guiana	LI	Liberia
FI	Finland	LJ	Slovenia
FJ	Fiji	LN	Southern Line Islands
FK	Falkland Islands (Malvinas)	LS	Lesotho
FP	Saint Pierre and Miquelon	LT	Lithuania
FR	France	LV	Latvia
FW	Wallis and Futuna	LY	Libyan Arab Jamahiriya
GB	Gambia	MA	Mauritius
GC	Cayman Islands	MB	Marion Island
GD	Grenada	MC	Morocco
GE	Gough Island	MD	Madeira
GG	Georgia	MF	Saint-Martin, Saint-Barthélemy, Guadeloupe and other French islands in the vicinity
GH	Ghana		
GI	Gibraltar	MG	Madagascar
GL	Greenland	MH	Marshall Islands
GM	Guam	MI	Mali
GN	Guinea	MJ	The former Yugoslav Republic of Macedonia
GO	Gabon	MK	Montenegro
GQ	Equatorial Guinea	ML	Malta
GR	Greece	MN	St Maarten, St Eustatius and Saba
GU	Guatemala	MO	Mongolia
GW	Guinea-Bissau	MR	Martinique
GY	Guyana	MS	Malaysia
		MT	Mauritania
HA	Haiti	MU	Macao, China
HE	Saint Helena	MV	Maldives
HK	Hong Kong, China	MW	Malawi
HO	Honduras	MX	Mexico
HU	Hungary	MY	Mariana Islands
HV	Burkina Faso	MZ	Mozambique
HW	Hawaiian Islands		
		NC	New Caledonia
IC	Comoros	NG	Papua New Guinea
ID	Indonesia	NI	Nigeria
IE	Ireland	NK	Nicaragua
IL	Iceland	NL	Netherlands
IN	India	NM	Namibia
IQ	Iraq	NO	Norway
IR	Islamic Republic of Iran	NP	Nepal
IS	Israel	NR	Niger
IV	Côte d'Ivoire	NU	Netherlands Antilles (Bonaire, Curaçao) and Aruba
IY	Italy	NV	Vanuatu
		NW	Nauru
JD	Jordan	NZ	New Zealand
JM	Jamaica		
JP	Japan	OM	Oman
		OR	South Orkney Islands
KA	Caroline Islands	OS	Austria
KB	Kiribati		
KI	Christmas Island	PF	French Polynesia
KK	Cocos Islands	PH	Philippines
KN	Kenya	PI	Phoenix Islands
KO	Republic of Korea	PK	Pakistan
KP	Cambodia	PL	Poland
KR	Democratic People's Republic of Korea	PM	Panama
KU	Cook Islands	PO	Portugal
KW	Kuwait	PR	Peru
KY	Kyrgyzstan	PT	Pitcairn
KZ	Kazakhstan	PU	Puerto Rico

Table C1 – Part I (*continued*)

A_1A_2	Country	A_1A_2	Country
PY	Paraguay	TD	Trinidad and Tobago
		TG	Togo
QB	Bosnia and Herzegovina	TH	Thailand
QT	Qatar	TI	Turks and Caicos Islands
		TK	Tokelau
RA	Russian Federation (East)	TM	Timor-Leste
RE	Réunion and associated islands	TN	United Republic of Tanzania
RH	Croatia	TO	Tonga
RM	Republic of Moldova	TP	Sao Tome and Principe
RO	Romania	TR	Turkmenistan
RS	Russian Federation (West)	TS	Tunisia
RW	Rwanda	TU	Turkey
		TV	Tuvalu
SB	Sri Lanka		
SC	Seychelles	UG	Uganda
SD	Saudi Arabia	UK	United Kingdom of Great Britain and Northern Ireland
SG	Senegal		
SI	Somalia	UR	Ukraine
SK	Sarawak	US	United States of America
SL	Sierra Leone	UY	Uruguay
SM	Suriname	UZ	Uzbekistan
SN	Sweden		
SO	Solomon Islands	VG	Saint Vincent and the Grenadines
SP	Spain	VI	Virgin Islands
SQ	Slovakia	VN	Venezuela
SR	Singapore	VS	Viet Nam
SU	Sudan		
SV	Swaziland	YE	Yemen
SW	Switzerland	YG	Serbia
SX	Santa Cruz Islands		
SY	Syrian Arab Republic	ZA	South Africa
SZ	Spitzbergen Islands	ZB	Zambia
		ZM	Samoa
TA	Tajikistan	ZR	Democratic Republic of the Congo
TC	Tristan da Cunha	ZW	Zimbabwe

Part II – Area designators

A_1A_2	*Geographical area*	A_1A_2	*Geographical area*
AA	Antarctic	MP	Central Mediterranean area
AC	Arctic	MQ	Western Mediterranean area
AE	South-East Asia		
AF	Africa	NA	North America
AM	Central Africa	NT	North Atlantic area
AO	West Africa		
AP	Southern Africa	OC	Oceania
AS	Asia	OH	Sea of Okhotsk
AW	Near East		
AX	Arabian Sea area	PA	Pacific area
		PE	Persian Gulf area
BQ	Baltic Sea area	PN	North Pacific area
		PQ	Western North Pacific
CA	Caribbean and Central America	PS	South Pacific area
		PW	Western Pacific area
EA	East Africa	PZ	Eastern Pacific area
EC	East China Sea area		
EE	Eastern Europe	SA	South America
EM	Middle Europe	SE	Southern Ocean area
EN	Northern Europe	SJ	Sea of Japan area
EU	Europe	SS	South China Sea area
EW	Western Europe	ST	South Atlantic area
FE	Far East	XE	Eastern hemisphere
		XN	Northern hemisphere
GA	Gulf of Alaska area	XS	Southern hemisphere
GX	Gulf of Mexico area	XT	Tropical belt
		XW	Western hemisphere
IO	Indian Ocean area	XX	For use when other designators are not appropriate
ME	Eastern Mediterranean area		
MM	Mediterranean area		

Table C2

Geographical designators A_1A_2 for use in abbreviated headings $T_1T_2A_1A_2$ii CCCC YYGGgg for bulletins containing ships' weather reports and oceanographic data including reports from automatic marine stations

Instructions for the proper application of the geographical designators

1.   The first letter A_1 will denote the nature of the ship or automatic marine station:

   For ocean weather stations: W
   For mobile ships and other marine stations: V
   For floats (T_1T_2 = SO):   F

2.   The second letter A_2 will denote the area from which the reports contained in the bulletins originate.

3.   Whenever practicable, separate bulletins should be prepared to avoid the use of the letter X.

Note: For T_1T_2 = SZ, A_1A_2 area designators from Table C1 should be used.

Designator	*Geographical area*			
A	Area between 30°N–60°S,	35°W	–	70°E
B	Area between 90°N–05°N,	70°E	–	180°E
C	Area between 05°N–60°S,	120°W	–	35°W
D	Area between 90°N–05°N,	180°W	–	35°W
E	Area between 05°N–60°S,	70°E	–	120°W

Table C2 (*continued*)

Designator	Geographical area
F	Area between 90°N–30°N, 35°W – 70°E
J	Area south of 60°S
X	More than one area

Table C3

Geographical area designator A$_1$ (when T$_1$ = D, G, H, O, P, Q, T, X or Y) and geographical area designator A$_2$ (when T$_1$ = I or J)

Instructions for the proper application of the geographical area designator

1.   The designator specified in this table should be used to the greatest extent possible to indicate the geographical area of the data contained within the text of the bulletin.

2.   Where the geographical area of the data does not correspond exactly with the designator, the designator for the area most approximating that of the data may be used.

3.   When the table does not contain a suitable designator for the geographical area, an alphabetic designator which is not assigned in the table should be introduced and the WMO Secretariat notified.

Designator	Geographical area
A	0° – 90°W northern hemisphere
B	90°W –180° northern hemisphere
C	180° – 90°E northern hemisphere
D	90°E – 0° northern hemisphere
E	0° – 90°W tropical belt
F	90°W –180° tropical belt
G	180° – 90°E tropical belt
H	90°E – 0° tropical belt
I	0° – 90°W southern hemisphere
J	90°W –180° southern hemisphere
K	180° – 90°E southern hemisphere
L	90°E – 0° southern hemisphere
N	Northern hemisphere
S	Southern hemisphere
T	45°W –180° northern hemisphere
X	Global area (area not definable)

Table C4

Reference time designator A$_2$ (when T$_1$ = D, G, H, J, O, P, or T)

Instructions for the proper application of the reference time designators

1.   The designators specified in this table should be used to the greatest extent possible to indicate the reference time of data contained within the text of the bulletin.

2.   Where the table does not contain a suitable designator for the reference time, an alphabetic designator which is not assigned in the table should be used.

Designator	Reference time	Designator	Reference time
A	Analysis (00 hour)	L	84 hours forecast
B	6 hours forecast	M	96 hours forecast
C	12 hours forecast	N	108 hours forecast
D	18 hours forecast	O	120 hours forecast (5 days)
E	24 hours forecast	P	132 hours forecast
F	30 hours forecast	Q	144 hours forecast
G	36 hours forecast	R	156 hours forecast (7 days)
H	42 hours forecast	S	168 hours forecast
I	48 hours forecast	T	10 days forecast
J	60 hours forecast	U	15 days forecast
K	72 hours forecast	V	30 days forecast
		W. . .Z	Not assigned

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Table C5

Reference time designator A$_2$ (when T$_1$ = Q, X or Y)

Table C5

Designator	Reference time	Designator	Reference time
A	Analysis (00 hour)	J	27 hours forecast
B	3 hours forecast	K	30 hours forecast
C	6 hours forecast	L	33 hours forecast
D	9 hours forecast	M	36 hours forecast
E	12 hours forecast	N	39 hours forecast
F	15 hours forecast	O	42 hours forecast
G	18 hours forecast	P	45 hours forecast
H	21 hours forecast	Q	48 hours forecast
I	24 hours forecast		

Table C6

Data type designator A$_1$ (when T$_1$ = I or J)

Instructions for the proper application of the data type designators

1.   The designators specified in this table should be used to the greatest extent possible to indicate the type of data contained within the body of the BUFR bulletin.

2.   Where more than one data type is contained in the bulletin, the designators for only one of the data types should be used.

3.   When the table does not contain a suitable designator for the data types, an alphabetic designator which is not assigned in the table should be introduced and the WMO Secretariat notified.

T$_1$T$_2$	A$_1$	ii	Data type	TAC correspondence	Data category subcategory (Common Table C13)
IN	A		Satellite data (AMSUA)		003/003
IN	B		Satellite data (AMSUB)		003/004
IN	H		Satellite data (HIRS)		003/005
IN	M		Satellite data (MHS)		003/006
IO	B		Buoy observations	BUOY	001/025
IO	I		Sea ice		
IO	P		Sub-surface profiling floats	TESAC	031/004
IO	R		Sea surface observations	TRACKOB	031/001
IO	S		Sea surface and below soundings	BATHY, TESAC	031/005
IO	T		Sea surface temperature		
IO	W		Sea surface waves	WAVEOB	031/002
IO	X		Other sea environmental		
IP	C		Radar composite imagery data		
IP	I		Satellite imagery data		
IP	R		Radar imagery data		
IP	X		Not defined		
IS	A	01–29	Routinely scheduled observations for distribution from automatic (fixed or mobile) land stations (e.g. 0000, 0100, … or 0220, 0240, 0300, …, or 0715, 0745, ... UTC)	n/a	000/006
IS	A	30–59	N-minute observations from automatic (fixed or mobile) land stations	n/a	000/007
IS	B		Radar reports (parts A and B)	RADOB	006/003
IS	C	01–45	Climatic observations from land stations	CLIMAT	000/020
IS	C	46–59	Climatic observations from marine stations	CLIMAT SHIP	001/020

Table C6 (*continued*)

T_1T_2	A_1	ii	Data type	TAC correspondence	Data category subcategory (Common Table C13)
IS	D		Radiological observation	RADREP	010/001
IS	E		Ozone measurement at surface	n/a	008/000
IS	F		Source of atmospherics	SFAZI, SFLOC, SFAZU	000/030
IS	I	01–45	Intermediate synoptic observations from fixed land stations	SYNOP (SIxx)	000/001 000/051
IS	I	46–59	Intermediate synoptic observations from mobile land stations	SYNOP MOBIL	000/004
IS	M	01–45	Main synoptic observations from fixed land stations	SYNOP (SMxx)	000/002 000/052
IS	M	46–59	Main synoptic observations from mobile land stations	SYNOP MOBIL	000/005
IS	N	01–45	Synoptic observations from fixed land stations at non-standard time (i.e. 0100, 0200, 0400, 0500, ... UTC)	SYNOP (SNxx)	000/000 000/050
IS	N	46–59	Synoptic observations from mobile land stations at non-standard time (i.e. 0100, 0200, 0400, 0500, ... UTC)	SYNOP MOBIL	000/003
IS	R		Hydrologic reports	HYDRA	000/040
IS	S	01–19	Synoptic observations from marine stations	SHIP	001/000
IS	S	20–39	One-hour observations from automatic marine stations	n/a	001/006
IS	S	40–59	N-minute observations from automatic marine stations	n/a	001/007
IS	T	01–19	Tide gauge observations	n/a	001/030
IS	T	20–39	Observed water level time series	n/a	001/031
IS	V		Special aeronautical observations (SPECI)	SPECI	000/011
IS	W		Aviation routine weather observations (METAR)	METAR	000/010
IS	X		Other surface data	IAC, IAC FLEET	
IT	A		Administrative message		
IT	B		Service message		
IT	R		Request for data (inclusive of type)		
IT	X		Other text messages or information		
IU	A		Single level aircraft reports (automatic)	AMDAR	004/000
IU	A		Single level aircraft reports (manual)	AIREP/PIREP	004/001
IU	B		Single level balloon reports	n/a	
IU	C		(used for single level satellite-derived reports – see Note 3)	SAREP/SATOB	005/000
IU	D		Dropsonde/Dropwindsondes	TEMP DROP	002/007
IU	E		Ozone vertical sounding	n/a	008/001
IU	I		Dispersal and transport analysis	n/a	009/000
IU	J	01–19	Upper wind from fixed land stations (entire sounding)	PILOT (parts A, B, C, D)	002/001
IU	J	20–39	Upper wind from mobile land stations (entire sounding)	PILOT MOBIL (parts A, B, C, D)	002/003
IU	J	40–59	Upper wind from marine stations (entire sounding)	PILOT SHIP (parts A, B, C, D)	002/002
IU	K	01–19	Radio soundings from fixed land stations (up to 100 hPa)	TEMP (parts A, B)	002/004
IU	K	20–39	Radio soundings from mobile land stations (up to 100 hPa)	TEMP MOBIL (parts A, B)	002/006
IU	K	40–59	Radio soundings from marine stations (up to 100 hPa)	TEMP SHIP (parts A, B)	002/005
IU	M		Model derived sondes		
IU	N		Rocketsondes		
IU	O		Profiles of aircraft observations in ascending/ descending	AMDAR	002/020

Table C6 (*continued*)

T_1T_2	A_1	ii	Data type	TAC correspondence	Data category subcategory (Common Table C13)
IU	P		Profilers	PILOT	002/010
IU	Q		RASS temperature profilers	TEMP	002/011
IU	R		(used for radiance data – see Note 3)		
IU	S	01–19	Radiosondes/pibal reports from fixed land stations (entire sounding)	TEMP (parts A, B, C, D)	002/004
IU	S	20–39	Radio soundings from mobile land stations (entire sounding)	TEMP MOBIL (parts A, B, C, D)	002/006
IU	S	40–59	Radio soundings from marine stations (entire sounding)	TEMP SHIP (parts A, B, C, D)	002/005
IU	T		(used for satellite-derived sondes – see Note 3)	SATEM, SARAD, SATOB	
IU	U	01–45	Monthly statistics of data from upper-air stations	CLIMAT TEMP	002/025
IU	U	46–59	Monthly statistics of data from marine stations	CLIMAT TEMP, SHIP	002/026
IU	W	01–19	Upper wind from fixed land stations (up to 100 hPa)	PILOT (parts A, B)	002/001
IU	W	20–39	Upper wind from mobile land stations (up to 100 hPa)	PILOT MOBIL (parts A, B)	002/003
IU	W	40–59	Upper wind from marine stations (up to 100 hPa)	PILOT SHIP (parts A, B)	002/002
IU	X		Other upper-air reports		
JO	I		Sea ice		
JO	S		Sea surface and below soundings		
JO	T		Sea surface temperature		
JO	W		Sea surface waves		
JO	X		Other sea environmental data		
JS	A		Surface area forecast (e.g. airways)		
JS	D		Radiological forecast	RADOF	
JS	M		Surface forecasts (e.g. MOS)		
JS	O		Maritime forecast	MAFOR	
JS	P		Forecast amendments (airways)		
JS	R		Hydrologic forecast	HYFOR	
JS	S		Forecast amendments (TAF)		
JS	T		Aerodrome forecast (TAF)		
JS	X		Other surface forecasts		
JT	E		Tsunami		
JT	H		Hurricane, typhoon, tropical storm warning		
JT	S		Severe weather, SIGMET		
JT	T		Tornado warning		
JT	X		Other warnings		
JU	A		Forecast at single levels		
JU	B		Binary coded SIGWX, Embedded Cumulonimbus		
JU	C		Binary coded SIGWX, Clear-air turbulence		
JU	F		Binary coded SIGWX, Fronts		
JU	N		Binary coded SIGWX, Other SIGWX parameters		
JU	O		Binary coded SIGWX, Turbulence		
JU	S		Forecast soundings		
JU	T		Binary coded SIGWX, Icing/Tropopause		
JU	V		Binary coded SIGWX, Tropical storms, sandstorms, volcanoes		
JU	W		Binary coded SIGWX, High-level winds		
JU	X		Other upper-air forecasts		

Notes:

1. Content of ISMx, ISIx, ISNx messages corresponds to the content of traditional SYNOP messages SMxx, SIxx, SNxx.
2. Category/Subcategory = 000/000 identifies SYNOP data from 0100, 0200, 0300, 0400, 0500, 0700, 0800, 1000, 1100, 1300, ... UTC). Thus SNxx in traditional SYNOP corresponds to ISNx in BUFR.
3. Designators A_1 for T_1T_2 already used for satellite data (e.g. IUC, IUR, IUT) are not allocated and reserved for future allocations, pending the allocation of A_1 for T_1T_2 = IN (satellite data).

Table C7

Data type designator T_2 and A_1 (when T_1 = K)

T_1T_2	A_1	ii	Data type	TAC correspondence	Data category subcategory (Common Table C13)
KF	A		Surface area forecast (e.g. airways)		
KF	D		Radiological forecast	RADOF	
KF	M		Surface forecasts (e.g. MOS)		
KF	O		Maritime forecast	MAFOR	
KF	P		Forecast amendments (airways)		
KF	R		Hydrologic forecast	HYFOR	
KF	S		Forecast amendments (TAF)		
KF	T		Aerodrome forecast (TAF)		
KF	X		Other surface forecasts		
KO	B		Buoy observations	BUOY	001/025
KO	I		Sea ice		
KO	P		Sub-surface profiling floats	TESAC	031/004
KO	R		Sea surface observations	TRACKOB	031/001
KO	S		Sea surface and below soundings	BATHY, TESAC	031/005
KO	T		Sea surface temperature		
KO	W		Sea surface waves	WAVEOB	031/002
KO	X		Other sea environmental	WAVEOB	031/002
KP	I		Sea ice		
KP	S		Sea surface and below soundings		
KP	T		Sea surface temperature		
KP	W		Sea surface waves		
KP	X		Other sea environmental		
KS	A	01–29	Routinely scheduled observations for distribution from automatic (fixed or mobile) land stations (e.g. 0000, 0100, … or 0220, 0240, 0300, …, or 0715, 0745, … UTC)	n/a	000/006
KS	A	30–59	N-minute observations from automatic (fixed or mobile) land stations	n/a	000/007
KS	B		Radar reports (parts A and B)	RADOB	006/003
KS	C	01–45	Climatic observations from land stations	CLIMAT	000/020
KS	C	46–59	Climatic observations from marine stations	CLIMAT SHIP	001/020
KS	D		Radiological observation	RADREP	010/001
KS	E		Ozone measurement at surface	n/a	008/000
KS	F		Source of atmospherics	SFAZI, SFLOC, SFAZU	000/030
KS	I	01–45	Intermediate synoptic observations from fixed land stations	SYNOP (SIxx)	000/001 000/051
KS	I	46–59	Intermediate synoptic observations from mobile land stations	SYNOP MOBIL	000/004
KS	M	01–45	Main synoptic observations from fixed land stations	SYNOP (SMxx)	000/002 000/052
KS	M	46–59	Main synoptic observations from mobile land stations	SYNOP MOBIL	000/005

Table C7 (*continued*)

T_1T_2	A_1	ii	Data type	TAC correspondence	Data category subcategory (Common Table C13)
KS	N	01–45	Synoptic observations from fixed land stations at non-standard time (i.e. 0100, 0200, 0400, 0500, ..., UTC)	SYNOP (SNxx)	000/000 000/050
KS	N	46–59	Synoptic observations from mobile land stations at non-standard time (i.e. 0100, 0200, 0400, 0500, 0700, 0800, 1000, 1100, 1300, ... UTC)	SYNOP MOBIL	000/003
KS	R		Hydrologic reports	HYDRA	000/040
KS	S	01–19	Synoptic observations from marine stations	SHIP	001/000
KS	S	20–39	One-hour observations from automatic marine stations	n/a	001/006
KS	S	40–59	N-minute observations from automatic marine stations	n/a	001/007
KS	V		Special aeronautical observations (SPECI)	SPECI	000/011
KS	W		Aviation routine weather observations (METAR)	METAR	000/010
KS	X		Other surface data	IAC, IAC FLEET	
KT	E		Tsunami		
KT	H		Hurricane, typhoon, tropical storm warning		
KT	S		Severe weather, SIGMET		
KT	T		Tornado warning		
KT	X		Other warnings		
KU	A		Single level aircraft reports (automatic)	AMDAR	004/000
KU	A		Single level aircraft reports (manual)	AIREP/PIREP	004/001
KU	B		Single level balloon reports	n/a	
KU	C		Single level satellite-derived reports	SAREP	005/000
KU	D		Dropsonde/dropwindsondes	TEMP DROP	002/007
KU	I		Dispersal and transport analysis	n/a	009/000
KU	J	01–19	Upper wind from fixed land stations	PILOT (parts A, B, C and D)	002/001
KU	J	20–39	Upper wind from mobile land stations	PILOT MOBIL (parts A, B, C and D)	002/003
KU	J	40–59	Upper wind from marine stations	PILOT SHIP (parts A, B, C and D)	002/002
KU	K	01–19	Radio soundings from fixed land stations	TEMP (parts A and B)	002/004
KU	K	20–39	Radio soundings from mobile land stations	TEMP MOBIL (parts A and B)	002/006
KU	K	40–59	Radio soundings from marine stations	TEMP SHIP (parts A and B)	002/005
KU	L		Ozone vertical profile	n/a	008/001
KU	M		Model derived sondes		
KU	N		Rocketsondes		
KU	O		Profiles of aircraft observations in ascending/descending	AMDAR	002/020
KU	P		Profilers	PILOT	002/010
KU	Q		RASS temperature profilers	TEMP	002/011
KU	S	01–19	Radiosondes/pibal reports from fixed land stations	TEMP (parts A, B, C and D)	002/004
KU	S	20–39	Radio soundings from mobile land stations	TEMP MOBIL (parts A, B, C and D)	002/006
KU	S	40–59	Radio soundings from marine stations	TEMP SHIP (parts A, B, C and D)	002/005
KU	T		Satellite derived sondes		
KU	U	01–45	Monthly statistics of data from upper-air stations	CLIMAT TEMP	002/025
KU	U	46–59	Monthly statistics of data from marine stations	CLIMAT TEMP, SHIP	002/026

Table C7 (*continued*)

T_1T_2 A_1 ii	Data type	TAC correspondence	Data category subcategory (Common Table C13)
KU W 01–19	Upper wind from fixed land stations	PILOT (parts A and B)	002/001
KU W 20–39	Upper wind from mobile land stations	PILOT MOBIL (parts A and B)	002/003
KU W 40–59	Upper wind from marine stations	PILOT SHIP	002/002
KU X	Other upper-air reports	(parts A and B)	
KV A	Forecast at single levels		
KV B	Coded SIGWX, Embedded Cumulonimbus		
KV C	CREX coded SIGWX, Clear air turbulence		
KV F	CREX coded SIGWX, Fronts		
KV N	CREX coded SIGWX, Other SIGWX parameters		
KV O	CREX coded SIGWX, Turbulence		
KV S	Forecast soundings		
KV T	CREX coded SIGWX, Icing/Tropopause		
KV V	CREX coded SIGWX, Tropical storms, sandstorms, volcanoes		
KV W	CREX coded SIGWX, High-level winds		
KV X	Other upper-air forecasts		

Note: T_1T_2 = SZ is allocated to sea-level data and deep-ocean tsunami data in any alphanumerical form including CREX.

Table D1

Level designator ii (when T_1 = O)

Instructions for the proper application of level designators for ocean depths

The designators specified in this table should be used to the greatest extent possible to indicate the levels below the ocean surface in the body of the GRIB bulletin for oceanographic products.

Designator	Depth (in metres)	Designator	Depth (in metres)
98	Surface	62	500
96	2.5	60	600
94	5.0	58	700
92	7.5	56	800
90	12.5	54	900
88	17.5	52	1000
86	25.0	50	1100
84	32.5	48	1200
82	40.0	46	1300
80	50.0	44	1400
78	62.5	42	1500
76	75.0	40	1750
74	100	38	2000
72	125	36	2500
70	150	34	3000
68	200	32	4000
66	300	30	5000
64	400	01	Primary layer depth

Table D2

Level designator ii (when T$_1$ = D, G, H, J, P, Q, X or Y)

Instructions for the proper application of level designators

1.   The designator specified in this table should be used to the greatest extent possible to indicate the level of the data contained within the text of the bulletin.

2.   When data at more than one level are contained in the text, the designator for only one of the levels should be used.

3.   When the table does not contain a suitable designator for the level, a designator which is not assigned in the table should be used.

Designator	*Level*	*Designator*	*Level*
99	1000 hPa	54	540 hPa
98	Air properties for the Earth's surface	53	530 hPa
97	Level of the tropopause	52	520 hPa
96	Level of maximum wind	51	510 hPa
95	950 hPa	50	500 hPa
94	Level of 0°C isotherm	49	490 hPa
93	975 hPa	48	480 hPa
92	925 hPa	47	470 hPa
91	875 hPa	46	460 hPa
90	900 hPa	45	450 hPa
89	Any parameter reduced to sea level (e.g. MSLP)	44	440 hPa
		43	430 hPa
88	Ground or water properties for the Earth's surface (i.e. snow cover, wave and swell)	42	420 hPa
		41	410 hPa
		40	400 hPa
87	1000–500 hPa thickness	39	390 hPa
86	Boundary level	38	380 hPa
85	850 hPa	37	370 hPa
84	840 hPa	36	360 hPa
83	830 hPa	35	350 hPa
82	825 hPa	34	340 hPa
81	810 hPa	33	330 hPa
80	800 hPa	32	320 hPa
79	790 hPa	31	310 hPa
78	780 hPa	30	300 hPa
77	775 hPa	29	290 hPa
76	760 hPa	28	280 hPa
75	750 hPa	27	270 hPa
74	740 hPa	26	260 hPa
73	730 hPa	25	250 hPa
72	725 hPa	24	240 hPa
71	710 hPa	23	230 hPa
70	700 hPa	22	220 hPa
69	690 hPa	21	210 hPa
68	680 hPa	20	200 hPa
67	675 hPa	19	190 hPa
66	660 hPa	18	180 hPa
65	650 hPa	17	170 hPa
64	640 hPa	16	160 hPa
63	630 hPa	15	150 hPa
62	625 hPa	14	140 hPa
61	610 hPa	13	130 hPa
60	600 hPa	12	120 hPa
59	590 hPa	11	110 hPa
58	580 hPa	10	100 hPa
57	570 hPa	09	090 hPa
56	560 hPa	08	080 hPa
55	550 hPa	07	070 hPa

Table D2 (*continued*)

Designator	Level		Designator	Level
06	060 hPa		02	020 hPa
05	050 hPa		01	010 hPa
04	040 hPa		00	Entire atmosphere
03	030 hPa			(e.g. precipitable water)

Table D3
Level designator ii (when T$_1$T$_2$ = FA or UA)

T$_1$T$_2$	Designator ii	Data type	Code form (name)
FA	01–49	Aviation area/advisories	FM 53 (ARFOR) [text]
FA	50–59	GAMET	[TEXT]
FA	60–99	Not assigned	Not assigned
UA	01–59	Routine aircraft reports	ICAO AIREP
UA	60–69	Special aircraft reports, except for volcanic ash	ICAO AIREP
UA	70–79	Special aircraft reports, related to volcanic ash	ICAO AIREP
UA	80–99	Routine aircraft reports	ICAO AIREP

Note: Noting that there is no known use of the series 80–99, these series are allocated to routine aircraft reports up to 1 September 2008. After 1 September 2008, the series should be reserved for future use.

FORMAT FOR THE TEXT OF ADDRESSED MESSAGES AND A GENERAL EXAMPLE OF EACH TYPE

General format form

(only International Telegraph Alphabet No. 5 is shown)

The abbreviated heading format for addressed messages consists of two lines of information.

The form of the abbreviated heading:

T_1T_2 A_1A_2 ii $C_aC_aC_aC_a$ YYGGgg CCCC

where,

T_1T_2	=	BM designator for message in alphanumeric form
		BI designator for addressed message in binary form (use on binary links only)
A_1A_2	=	type of addressed message
		Options:
		AA – administrative message (to be passed to a person for information or action)
		BB – service message (to be passed to a person for action)
		RR – request for a GTS message by heading or sequence number
		RQ – request-to-database for data (request format TBD) intended for GDPFS action
		DA – the returned data response to the RR or RQ addressed message
ii	=	always 01 (no exceptions allowed)
$C_aC_aC_aC_a$	=	location indicator of the centre on the GTS to whom the message is addressed
YYGGgg	=	time of insertion on the GTS
CCCC	=	the international location indicator of the centre originating the message

TYPE 1

A_1A_2 = AA – Administrative message

The contents of this message type is a simple character free-flowing text, intended for human readability. This message type should be sent to a computer display or a printer. This type text message should be about general operational and/or administrative matters or discussions and GTS coordination topics. The T_1T_2 option to use is BM only, as the text is character data.

Example:
345
BMAA01 EDZW 261215
EGRR
ATTN OFFENBACH DATA MANAGER
THE BULLETINS YOU REQUESTED WILL BE RELAY TO YOUR CENTER
BEGINNING THE FIRST OF THE MONTH
SMVG01 TVSV
SMTD01 TTPP
REGARDS, BMO DATA MANAGER SUPERVISOR=

Note: EDZW is the centre the message is addressed to; EGRR is the originating centre of the message.

TYPE 2

A_1A_2 = BB – Service message

The contents of this message type is a simple character free-flowing text, intended for human readability. These message types should be sent to a display or printer. These are text messages about operational status and/or problem resolution matters. The T_1T_2 option to use is BM only, as the text is character data.

Example:
321
BMBB01 EGRR 281425
KWBC
ATTN EXETER COMMUNICATIONS SUPERVISOR
THE GTS LINK BETWEEN WASHINGTON AND BRASILIA IS DOWN FOR
6 HOURS DUE TO LINE RECONFIGURATION AT BRASILIA.
REGARDS, WASHINGTON COMMS SUPERVISOR=

Note: EGRR is the centre the message is addressed to; KWBC is the originating centre of the message.

TYPE 3

A_1A_2 = RR – Request/reply message

The structure of the text for this message type has two specific classes using two different formats in the request text. This addressed message type is for use between nodes of the GTS. To use the CLASS 1 formatted request form, the nodes of the GTS must be adjacent nodes. To use the CLASS 2 formatted request form, the nodes of the GTS do not have to be adjacent to each other. The request/reply type message is for the acquisition of data at the bulletin level and the bulletin is assumed to exist already. If it is sent on an X.25 virtual channel established for the exchange of alphanumeric data, then the T_1T_2 option of BM is recommended; and if, the X.25 virtual channel was established for binary data exchange, then the T_1T_2 option of BI is recommended. If there is only one virtual channel between nodes for both alphanumeric and binary data exchange, it is recommended to use the T_1T_2 option of BI as a default. The use of the T_1T_2 option of BM would be used on all GTS links using character protocols (i.e. BAUDOT or ERROR CONTROL PROCEDURES), as all addressed messages and request/reply responses are alphanumeric.

   CLASS 1. Request for repetition – to be sent between adjacent centres only. There can be three choices in the text of the request. The choices are:

1. For requesting only one message by its transmission sequence number;
2. For requesting a range of consecutive transmission sequence numbers; or
3. For requesting a group of specific messages by their transmission sequence numbers.

       There will be only one request line per message.

       The response to the request/reply CLASS 1 message will consist of two parts. The first part will be the construction and transmission of a status message using the TYPE 5 – data message format, indicating that action has been taken. This will be called a status of action message. The second part will be the transmission of the requested message(s). This will be a repeat of the originally sent message, including the original sequence number(s). The resulting transmission will most likely put the ongoing sequence numbers out of order. This should confirm, for the requesting center, the receipt of the needed message(s).

Choice 1 – Requesting only one (previously received) message

1. Format for an alphanumeric virtual channel or for any non-binary GTS link.
    (SOH)(CR)(CR)(LF) nnn
    (CR)(CR)(LF) BMRR01 $C_aC_aC_aC_a$ YYGGgg
    (CR)(CR)(LF) CCCC
    (CR)(CR)(LF) SQN nnn =   [one bulletin]
    (CR)(CR)(LF)(ETX)

2. Format for a binary virtual channel on X.25 GTS links.
    (SOH)(CR)(CR)(LF) nnn
    (CR)(CR)(LF) BIRR01 $C_aC_aC_aC_a$ YYGGgg
    (CR)(CR)(LF) CCCC
    (CR)(CR)(LF) SQN nnn =   [one bulletin]
    (CR)(CR)(LF)(ETX)

Choice 2 – Requesting a continuous series of (previously received) messages

1. Format for an alphanumeric virtual channel or for any non-binary link.
    (SOH)(CR)(CR)(LF) nnn
    (CR)(CR)(LF) BMRR01 $C_aC_aC_aC_a$ YYGGgg
    (CR)(CR)(LF) CCCC
    (CR)(CR)(LF) SQN nnn-nnn =   [a sequence of bulletins]
    (CR)(CR)(LF)(ETX)

2. Format for a binary virtual channel on X.25 GTS links.
    (SOH)(CR)(CR)(LF) nnn
    (CR)(CR)(LF) BIRR01 $C_aC_aC_aC_a$ YYGGgg
    (CR)(CR)(LF) CCCC
    (CR)(CR)(LF) SQN nnn-nnn =   [a sequence of bulletins]
    (CR)(CR)(LF)(ETX)

Choice 3 – Requesting specific (previously received) messages

1. Format for an alphanumeric virtual channel or for any non-binary link.
    (SOH)(CR)(CR)(LF) nnn
    (CR)(CR)(LF) BMRR01 $C_aC_aC_aC_a$ YYGGgg
    (CR)(CR)(LF) CCCC
    (CR)(CR)(LF) SQN nnn/nnn/nnn =   [a selected number of bulletins]
    (CR)(CR)(LF)(ETX)

2. Format for a binary virtual channel on X.25 GTS links.
    (SOH)(CR)(CR)(LF) nnn
    (CR)(CR)(LF) BIRR01 $C_aC_aC_aC_a$ YYGGgg
    (CR)(CR)(LF) CCCC
    (CR)(CR)(LF) SQN nnn/nnn/nnn =   [a selected number of bulletins]
    (CR)(CR)(LF)(ETX)

Note: Limit restriction: only one SQN line in a request.

Example – CLASS 1
788
BMRR01 LFPW 301215
DAMM
SQN 212-217=

Where LFPW is the centre the message is addressed to and DAMM is the originating centre of the message.

CLASS 2. Request for a bulletin – can be sent to any centre on the GTS. There is only one choice for the form of the text of the request. The form is always alphanumeric, however, the T_1T_2 option of BM is to be used for all requests for alphanumeric messages, and the T_1T_2 option of BI is to be used for all requests for binary messages, as all returned responses will use the same T_1T_2 for the heading type to facilitate proper routing when X.25 or equivalent links are required.

Format for the request:

Requests for messages (alphanumeric message request)

(SOH)(CR)(CR)(LF) nnn
(CR)(CR)(LF) BMRR01 $C_aC_aC_aC_a$ YYGGgg
(CR)(CR)(LF) CCCC
(CR)(CR)(LF) AHD $T_1T_2A_1A_2$ii CCCC YYGGgg =
(CR)(CR)(LF) AHD $T_1T_2A_1A_2$ii CCCC YYGGgg BBB =
(CR)(CR)(LF)(ETX)

Note 1: Limit restriction – no more than eight headings in a request beyond an adjacent centre.

Note 2: When the date-time group YYGGgg or the time group GGgg is not known, the following requests may be used:

AHD $T_1T_2A_1A_2$ii CCCCYY//// (BB/) (When BB=RR, CC or AA)
AHD $T_1T_2A_1A_2$ii CCCCYY//// (P//)
AHD $T_1T_2A_1A_2$ii CCCC //////
Where YY//// means for day YY, last occurrence in time.

Where ////// means last occurrence in day-time and the time is not older than 24 hours.

Examples – CLASS 2

•   Used for a non-binary X.25 virtual channel
051
BMRR01 AMMC 081220
KWBC
AHD SNAU55 AMMC 081100 RRA=
AHD SMID20 WIIX 081200=
Where AMMC is the centre the message is addressed to and KWBC is the originating centre of the message.

- Used for a binary X.25 virtual channel only

110
BIRR01 KWBC 081220
AMMC
AHD HTAC30 KWBC 081200 =
AHD HHBC85 KWBC 081200 =
Where KWBC is the centre the message is addressed to and AMMC is the originating centre of the message.

TYPE 4

A_1A_2 =   RQ – Request-to-database message

The format for this message type will be in a specific format. The intent is for automatic computer processing. There is one type of request message to a database (for GDPFS use).

Format for the request:
(SOH)(CR)(CR)(LF) nnn
(CR)(CR)(LF) BIRQ01 $C_aC_aC_aC_a$ YYGGgg
(CR)(CR)(LF) CCCC
(CR)(CR)(LF) [TBD]   [To be defined]
(CR)(CR)(LF)(ETX)

TYPE 5

A_1A_2 =   DA – Data message

This is the returned data message type. The purpose of this heading is to insure that if the requested data message is a bulletin containing a WMO abbreviated heading, the heading of the requested message heading is not used in the routing of the response back to the requesting centre. To insure proper routing the T_1T_2 for either BM or BI must reflect the code type in the returning data message. The data message has four different response forms. The response can be:
1. The requested message;
2. Message not found;
3. Message heading not recognized; or
4. Status message of action taken on RR CLASS 1 request.

       There is only one bulletin or meta-data file in a responding data message. In the examples below, assume the data message can either be BM or BI for CLASS 1 depending on the virtual channel used. If both the alphanumeric and binary messages are transmitted on only one virtual channel the use of BI will be the default.

Example of a requested message:
543
BMDA01 KWBC 081550
AMMC
SIID20 WIIX 081500
AAXX 08151
58424 42975 02203 10297 20251 40037 52008=
Where KWBC is the centre the message is addressed to and AMMC is the originating centre of the message.
Example of the message not found (NIL response):
189
BMDA01 KWBC 081250
AMMC
NIL SNAU55 AMMC 081100 RRB=
Where KWBC is the centre the message is addressed to and AMMC is the originating centre of the message.

Example of the message not recognized (ERR response):
154
BMDA01 KWBC 081250
AMMC
ERR SIID20 WIIX 081200=
Where KWBC is the centre the message is addressed to and AMMC is the originating centre of the message.
Example of the reply message to the RR type CLASS 1 request (STATUS response):
264
BMDA01 RJTD 101255
KWBC
RETRANSMISSION ACTIVATED FOR 212-218=
Where RJTD is the centre the message is addressed to and KWBC is the adjacent originating centre of the message.
Note: Limitation – circuits or virtual channels with priority queues must guard against confusion when selecting and responding to sequence number requests for transmission.

Where: (CR) = Carriage return
         (LF) = Line feed
         (SOH) = Start of header control character
         (ETX) = End of text control character

ATTACHMENT II-7

ROUTEING CATALOGUES

1.   FORMAT OF THE ROUTEING CATALOGUE

1.1   The routeing catalogue should be produced as an ASCII file, which could be imported into database applications. The information should therefore be presented in a database structure. The hereunder structure allows an easy display on a screen, e.g. using a "view" command.

1.2   The file containing the routeing catalogue of a GTS centre should be named: CCCCROCA.TXT, where CCCC is the location indicator of the centre. The date of the preparation of the catalogue should be inserted in the first line of the line as YYYYMMDD (where YYYY is the year, MM the month and DD the day).

1.3   For each abbreviated heading, a record should comprise the following fields

Field number	Content	Width
1	Abbreviated heading TTAAii CCCC	11
2	GTS circuit from which the bulletin is received (see paragraph 1.4)	4
3	GTS circuit to which the bulletin is sent (see paragraph 1.4)	4
As many additional fields in the format of field No. 3 as additional circuits to which the bulletin is sent.		

1.4   The following combination of four characters should be used to designate the GTS circuits and entered into fields No. 2, 3 and subsequent fields:

(a) When the GTS circuit is a the unique point-to-point circuit connecting the GTS centre to an adjacent centre, the location indicator CCCC of the relevant adjacent GTS centre should be used;

(b) In other cases, e.g. when the circuit is a point-to-multipoint circuit (e.g. a satellite distribution system), a specific CCCC combination should be used, for example using a combination of letters and figures to differentiate them from the usual location indicators CCCC; the description of the relevant GTS circuits may be given in the file CCCCRMKS.TXT (see paragraph 2).

In the combination of characters CCCC, wild cards "*" should only be used when the GTS centre cannot provide complete information. The use of wild cards is not recommended, since it limits the information.

1.5   The fields should be surrounded by quotes and separated by commas.

Sample of structure:

    "SMAA01 EGRR","RJTD","ANOU","DEMS","NFFN","NTAA","NZKL","PMBY"
    "SMAA01 EGRR","KWBC","NZKL"
    "SMAA10 KWBC","EGRR","DEMS","NFFN","NTAA","NZKL","WIIX"

2.   ADDITIONAL INFORMATION

Any additional information, such as the creation dates of the directory, details of any extra CCCCs included in the routeing catalogue, the means and procedures to access the routeing catalogue (e.g. FTP server) and any other information which may help users should be included in a file named: CCCCRMKS.TXT, where CCCC is the location indicator of the centre.

3.   ACCESS TO THE ROUTEING CATALOGUES OF RTHs

3.1   Each RTH should make available its own routeing catalogue on the FTP server, which it operates. The files from each centre should be found under GTS_routeing/CCCC subdirectories on all servers. When an

RTH does not have the capacity to make its routeing catalogue available on a local server, it should transfer its routeing catalogue CCCCROCA.TXT into the WMO FTP server under the sub-directory GTS_routeing/ CCCC, preferably by direct access to the WMO FTP server or by sending diskettes to the Secretariat.

3.2   RTHs should transfer their files CCCCRMKS.TXT into the WMO FTP server (www.wmo.ch) under the sub-directory GTS_routeing/CCCC, where CCCC is the location indicator of the RTH. Each sub-directory GTS_routeing/CCCC is reserved for each RTH, which may transfer and update the data as required. Each RTH should transfer its CCCCRMKS.TXT into the WMO FTP server, preferably by direct access to the WMO FTP server or by sending diskettes to the Secretariat. By accessing the information included in the files CCCCRMKS.TXT available in the WMO FTP server, the GTS centres should find information on the means and procedures to access the routeing directories of any RTHs.

3.3   RTH Offenbach operates on its own FTP server a mirror site of the part of the WMO FTP server related to the routeing catalogues.

ATTACHMENT II-8

WMO FASCIMILE TEST CHART

1.   The test chart is enclosed in a black frame 1.5 mm in width, the outer dimensions of which are:

length 449 mm; width 153 mm.

This frame is surrounded by a white margin 15 mm in width. The test chart is divided into sections marked on the transparency accompanying the test charts.

2.   Section   1(1):   Specimen of meteorological chart.

3.   Section   2(2):   Black and white lines for assessing the definition of the transmission according to different gradations.

2 mm	*1 mm*	*0.5 mm*	*0.33 mm*	*0.25 mm*	*0.20 mm*
0.5 line per mm	1 line per mm	2 lines per mm	3 lines per mm	4 lines per mm	5 lines per mm

4.   Section   3(2):   Abbreviation "WMO"

5.   Section   4(1):   Test chart identification number.

6.   Section   5(4):   Half-tone scales from black to white in eight density steps, according to a physiological scale.

7.   Section   6(4):   Black and white lines for assessing the definition of the transmission progressively from 2 mm to 0.20 mm (from 0.5 line per mm to 5 lines per mm).

8.   Section   7(2):   Tapering white line on a black background, opening out to 2 mm.

9.   Section   8(2):   white lines on a black background (thickness: 2 – 1 – 0.5 – 0.33 – 0.25 – 0.20 mm).

10.   Section   9(2):   Black lines of varying thickness (from 0.20 to 2 mm) on white background for assessing the reproduction quality of the separate lines.

11.   Section   10(2):   Black circle 0.5 mm thick with outer diameter of 39.5 mm and a square with diagonals inscribed in it.

12.   Section   11(1):   2 – 3 – 4 – 5 mm typographical signs.

Notes:
1. The accuracy is ± 0.015 mm (15/1000 of a millimetre) both as regards the thickness of the rectilinear or radial lines of the test chart, and as regards the length of the periodic element considered.
2. The position of the frames surrounding each element is to an accuracy of ± 0.15 mm (15/100 of a mm).
3. Taking into account the variations due to temperature changes (between 5 and 30°C) and humidity changes (from 25 to 85%) an accuracy of ± 0.2/1000 is achieved for lengths of 449 mm and 153 mm. All variations in length are regular and homogeneous whatever intermediate length is considered and remain within the limits of the above tolerance, all measurements being made on a flat surface.

Transparency

Test chart
(considerably reduced)

ATTACHMENT II-9

TRANSMISSION OF PICTORIAL INFORMATION BY CODED AND NON-CODED DIGITAL FACSIMILE

I. Coded or non-coded digital facsimile transmission procedures between centres on a channel equipped for X.25 procedures

1. The structure of the message, containing a bit-oriented product for transmission on links conforming to the provisions of ITU-T Recommendation X.25, should be as follows:

Start	Identification	Data description	Facsimile product	End

This message should be transmitted according to the procedures conforming to ITU-T Recommendation X.25, given in Part II, paragraph 2.12.

2. The starting line defined in Part II, paragraph 2.3.1.1 (b), should be the start of the transmission envelope; the end of message signal should consist of the characters [CR][CR][LF][ETX] as defined in Part II, paragraph 2.3.4 (b).

[SOH][CR][CR][LF] nnn   (identification + data descriptor + product) [CR][CR][LF][ETX]

(- - - - - - - - - - - start - - - - - - - - - - -)

(- WMO envelope -)
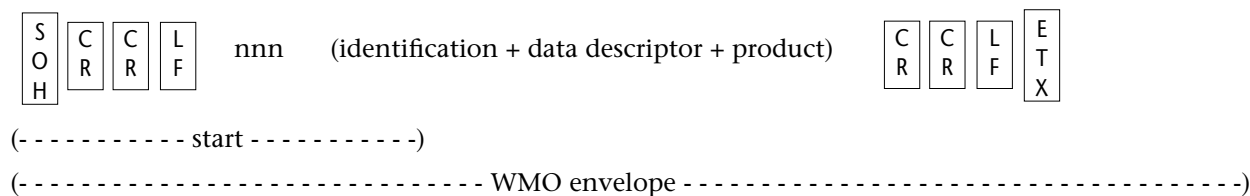
where   nnn is the transmission sequence number of the message.

3. The structure of the abbreviated heading defined in Part II, paragraph 2.3.2.1 (b), should be used to identify the product,

i.e. [CR][CR][LF] $T_1T_2A_1A_2ii$ [SP] CCCC [SP] YYGGgg ([SP] BBB)

in which T_1 = P – Pictorial information in digital form.

4. Attachment II-5 should be used to describe the products transmitted by facsimile. Table B2 defines T_2, while Tables C3 and C4 completely define A_1 and A_2. Table D describes the ii level indicators.

5. The series of binary data representing the product in digital facsimile should be preceded by the data descriptor groups coded in International Alphabet No. 5

[CR][CR][LF] DFAX $S_1S_2S_3S_4$

where   DFAX   indicates pictorial data which are coded or uncoded digital facsimile;

$S_1S_2S_3S_4$ are coded in accordance with Table A below to describe the characteristics of the product transmitted.

6. Example of identification and description of a product:

[CR][CR][LF] PEDA 98 [SP] KWBC [SP] 011200

[CR][CR][LF] DFAX 0122   - - - - - - - - - - binary data - - - - - - - - - -
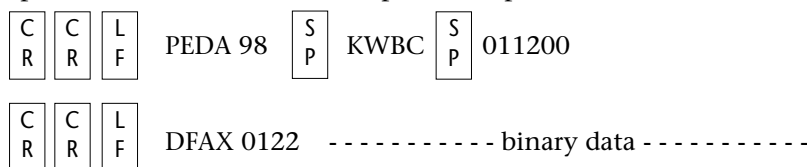
where P   indicates pictorial information in digital form;
       E   indicates precipitation;
       D   indicates northern hemisphere from 90°W to 0°;

A	indicates an analysis (00 hour);
98	indicates surface of Earth or ocean;
KWBC	indicates NMC Washington;
011200	indicates day one and time 1200 UTC;
DFAX	indicates coded or uncoded digital facsimile;
0	indicates uncoded digital facsimile;
1	indicates control signals (for IOC, phasing, etc.) are included;
2	indicates scanning frequency of 120 rpm;
2	indicates 3.85 lines/mm IOC vertical resolution.

Therefore the product would be formed as follows:

[SOH] [CR] [CR] [LF] 001

[CR] [CR] [LF] PEDA 98 [SP] KWBC [SP] 011200

[CR] [CR] [LF] DFAX 0122   bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb

bbbbbbbbbbbbbbbbbbbbbbbbbbbbbb/   /bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb

bbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbbb [CR] [CR] [LF] [ETX]

where   b represents binary data.

The length of the message is variable, depending on the product and data density.

Note: The envelope is used to recognize, store and retrieve data. The number of octets is only limited by the NMC transmitting of receiving the file (product). At present, the length of a chart transmitted by non-coded digital facsimile is less than 684 000 octets. NMCs should make sure that products of this length can in fact be transmitted by their systems. If products in digital facsimile were sent in coded form, the size of the file would be considerably reduced, enabling centres where the possibilities for processing are at present limited to implement more easily the new switching procedure for facsimile products.

Table A – Data descriptor $S_1S_2S_3S_4$ for identification of the characteristics of pictorial information in digital facsimile

S_1	S_2	S_3	S_4
Uncoded digital fax; 0	No control signals included: 0	Scanning frequency:	Vertical resolution:
Digital fax coded according to ITU-T Recommendation T.4 – one-dimensional: 1	Control signals included: 1	60 rpm 90 rpm 120 rpm: 2 240 rpm: 3 *or*	1.89 1/mm: 0 3.79 1/mm: 1 3.85 1/mm: 2 7.58 1/mm: 3 7.7 1/mm: 4
Digital fax coded according to ITU-T Recommendation T.4 – two-dimensional: 2		Horizontal resolution: 1728 picture elements/line: 6 3456 picture elements/line: 7	

Note: Procedures for transmission of coded digital facsimile according to the ITU-T group 4 standards are for further study.

II. Procedure for digital facsimile transmission between centres when separate channels are used for the transmission of the alphanumeric identifier and digital facsimile information respectively

1.   The coded or non-coded digital facsimile transmission procedure is intended for facsimile transmission on multiplexed channels by modems in conformity with ITU-T Recommendation V.29. The procedure can be used by automated centres (for facsimile transmission) as well as by non-automated centres. The procedure is based on the transmission of addressed messages for identification on the alphanumeric channel and facsimile products on the other channel.

2.   DESCRIPTION OF PROCEDURE

2.1   In the multiplexing mode, alphanumeric and facsimile products are transmitted separately over different channels of the multiplexer.

2.2   Channel B is used for the transmission of alphanumeric information while Channel A is used for the transmission of facsimile information.

2.3   For data transmission over Channel B, any WMO-recommended EDC procedure (WMO software, WMO hardware, X.25/LAPB) can be used.

Note: If WMO software or hardware procedures are used, the modem should have a backward channel.

2.4   The transmitting centre, after a facsimile document has been prepared for facsimile transmission, should send a message identifying the document over Channel B. The format of the identifier message is as follows:

| SOH | CR | CR | LF | nnn |

| CR | CR | LF | $T_1T_2A_1A_2ii$ | SP | CCCC | SP | YYGGgg | (SP BBB) |

| CR | CR | LF | FAX |

| CR | CR | LF | ETX |

where

T_1	designates the data type
T_2	designates the data type
A_1	is the geographical area designator
A_2	is the reference time designator
ii	is the level designator

} Attachment II-5, Tables A to D

CCCC is the identifier of the originating station;
YY   is the day of month;
GGgg is the standard time of observation;
FAX   is the inclination of transmission of facsimile information.

2.5   After receiving an identifier message, the receiving centre should send (over Channel B) a reply in the following form:

[SOH] [CR] [CR] [LF] nnn

[CR] [CR] [LF] $T_1T_2A_1A_2L_1L_2$ [SP] CCCC [SP] YYGGgg

[CR] [CR] [LF] DDD

[CR] [CR] [LF] [ETX]

The reply message should be compiled in conformity with the rules for addressed messages (Part II, paragraph 2.4) with the following changes:

(a) Adoption of a new type of addressed message: a service message for facsimile exchange control (specific designator TT = BF

(b) Service messages for facsimile exchange control should have first priority;

(c) Group DDD, which defines the control instruction (reply), is introduced into service messages for facsimile exchange control;

(d) Group DDD in a service message sent in reply to an identifier message may have one of the following meanings:

RDY   (ready)   –   Ready to receive document;

ABO   (abort)   –   Refusal to receive proposed document (this is sent if the receiving centre does not require this document);

RPT   (repeat)   –   Request to repeat identifier message (this is sent when an error is found in the identifier message by the receiving centre).

2.6   On receiving RDY, the transmitting centre starts sending the facsimile document over the multiplexed Channel A.

2.7   After reception of the document has been completed, or during the course of reception, the receiving centre sends a service message for facsimile exchange control. The format of the message is specified in paragraph 2.5 above. Group DDD may then have one of the following meanings:

ACK   (acknowledgement)   –   acknowledgement of reception of the facsimile document;

NAK   (negative acknowledgement) –   Notification of the rejection of the facsimile document (or poor quality of reception).

3.   ALGORITHM OF OPERATION OF THE TRANSMITTING CENTRE

3.1   Algorithm of operation of the transmitting centre is shown in Figure 1.

3.2   Description of the algorithm

Phase B–1   After a facsimile document has been prepared for transmission, the transmitting centre enters the "start" phase, then goes into Phase B–2.

Phase B–2   The transmitting centre sends an identifier message for the document, then waits for a reply (timer T01 is started).

Phases B–3, C–3, D–3, D–4   The transmitting centre is waiting for a reply to the identifier message. When timer T01 expires, the centre enters phase E–3.

On receiving one of the possible replies (RDY, RPT, ABO), the centre enters the receptive phase (B–4, E–3, E–4).

Phase E–3   The number of attempts to send an identifier message is stored in counter n.

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Phase E–2	When the number of attempts to send an identifier message becomes equal to N, the centre enters phase E–4.
	If the number of attempts is less than N, the centre enters phase B–2.
Phase B–4	The transmitting centre starts sending the facsimile document over Channel A, then waits for a reply (phases B–5, B–6).
Phase B–5	After receiving NAK during the course of sending a document, the transmitting centre goes into phase A–5.
Phase A–5	Automatic control signals of termination of facsimile transmission are sent and the number of attempts to send the document is stored in counter m.
Phase A–4	When the number of attempts to send the facsimile document becomes equal to M, the centre goes into phase E–4.
	The number of attempts to send a document is less than M, the centre enters phase A–5.
Phase B–6	After receiving ACK during the course of sending a document, the transmitting centre considers that the transmission may be completed and goes into phase A–6.
Phase A–6	Automatic control signals of termination of facsimile transmission are sent.
Phase B–7	When the transmission of the document is completed, the transmitting centre sends automatic control signals of termination of facsimile transmission, and waits for a replay (timer T02 is started).
Phase B–8, C–8, D–8	The transmitting centre is waiting for acknowledgement of reception of the document.
	When timer T02 expires, the centre enters phase E–4.
	On receiving one of the possible replies (ACK, NAK), the centre goes into the receptive phase (A–8, D–7).
Phase D–7	The number of attempts to retransmit the document is stored in counter k.
Phase D–5	When the number of attempts to retransmit the document becomes equal to K, the centre goes into phase E–4.
	If the number of attempts is less than K, the centre enters phase B–4.
Phase E–4	The operator of the system is notified of any abnormal situation.
Phase A–8	Transmission procedures have been completed.

3.3   The following values for the algorithm parameters are suggested:

$N = 3$

$M = 2$ ⎤
$K = 2$ ⎦ For channels operating in non/coded facsimile mode

$M = 5$ ⎤
$K = 5$ ⎦ For channels operating in coded facsimile

T01 is equal to 40 seconds.
T02 is equal to 120 seconds.

A   B   C   D   E

1   Start

2   Send an identifier message for document

    NO

    n = N ?   YES

3   Reply received RDY?   NO   Reply received RPT?   NO   Reply received ABO?   YES   Attempts counter n = :n + 1

   YES   NO   YES

   NO

4   m = M ?   Start document transmission   Timer T01   Call operator

5   Send "stop" signal counter m = :m + 1   YES   Reply received NAK?   NO   k = K ?   YES

6   Send "stop" signal   YES   Reply received ACK?

   NO

7   Stop document transmission – send "stop" signal   Attempts counter k = :k + 1

   YES

8   End   YES   Reply received ACK?   NO   Reply received NAK?   NO   Timer T02

Figure 1. Algorithm of operation of the transmitting centre

ATTACHMENT II-10

REPORTS OF RECEPTION CONDITIONS OF METEOROLOGICAL RADIO TRANSMISSIONS

Code form:

RECEP $Q_cL_aL_aL_a$ $L_oL_oL_oL_o$ YYG_1G_1g $G_2G_2gm_km_k$ CCC(n)(n)   SINPO   . . . . .

                                                      YYG_1G_1g $G_2G_2gm_km_k$ CCC(n)(n)   SINPO   . . . . .

Meaning of symbolic words and letters:

RECEP	–	Code form for reports of reception conditions of radio transmission.
Q_c	–	Quadrant of the globe (according to the *Manual on Codes*, Volume I).
$L_aL_aL_a$	–	Latitude of the radio receiving station in tenths of a degree.
$L_oL_oL_oL_o$	–	Longitude of the radio receiving station in tenths of a degree.
YY	–	Day of the month (UTC).
G_1G_1g	–	Time of observation in hours and tens of minutes (UTC) of the beginning of the period covered by the report.
G_2G_2g	–	Time of observation in hours and tens of minutes (UTC) of the ending of the period covered by the report.
m_km_k	–	Band in megahertz of the frequency to which the report refers, e.g.: 07 = 7 MHz or more, but under 8 MHz; 15 = 15 MHz or more, but under 16 MHz.
CCC(n)(n)	–	International call sign of the intercepted frequency (mostly three letters or three letters followed by one or two figures).
SINPO	–	Code indicator to be used and followed by a five-figure group referring to the SINPO code as defined by Recommendation No. 251-CCIR, published in Appendix 14 to ITU Radio Regulations, Geneva, 1968. The SINPO code is reproduced below.

SINPO signal reporting code

Rating scale	S	I	N	P	O
		Degrading effect			
	Signal strength	*Interference*	*Noise*	*Propagation disturbance*	*Overall rating*
5	Excellent	Nil	Nil	Nil	Excellent
4	Good	Slight	Slight	Slight	Good
3	Fair	Moderate	Moderate	Moderate	Fair
2	Poor	Severe	Severe	Severe	Poor
1	Barely audible	Extreme	Extreme	Extreme	Unusable

ATTACHMENT II-11

RE-ROUTEING PROCEDURES FOR THE MAIN TELECOMMUNICATION NETWORK

1. DEFINITIONS

Breakdown of a circuit means that a technical failure has occurred.

Outage of a centre or a circuit means that a centre or a circuit, because of a breakdown, or for any other reason, will be non-operational for a time period exceeding 30 minutes.

Back-up facilities means any equipment or circuits available for replacement of the equipment and/or circuits out of operation (the term "stand-by" should not be used in this connection).

Re-routeing of traffic means transmission and/or reception of meteorological information via other circuits or by means other than normal.

2. PRE-OUTAGE ARRANGEMENTS

The following arrangements should be made on bilateral or multilateral agreements:

(a) Appropriate transmission programmes of meteorological information, as required by the different centres, should be prepared at an early date;

(b) At the same time, necessary routeing tables should be prepared, taking into account the different routeing possibilities, if several possibilities exist;

(c) Arrangements should be made to ensure proper coordination between the operators of the different centres;

(d) Each centre should prepare instructions to be used by the operators, indicating what measures should be taken under various conditions.

3. DURING-OUTAGE ARRANGEMENTS

3.1   In case of a circuit outage, operators from both centres shall make every effort to resume normal traffic as soon as possible.

3.2   If a failure in operation is observed by a centre, the centre shall immediately inform all the centres concerned, if possible indicating the type of failure.

3.3   The centre shall then check its own equipment and circuits.

3.4   After determining the reason for the faulty operation, the centre shall immediately send a second message to all centres concerned. In any case, a second message shall be sent, not later than one hour after the first message has been sent, even in the case where the reason for the failure has not been found. In order that all centres concerned may be kept informed as regards further developments, additional messages shall be sent as required.

3.5   After one hour at the latest, of interruption of traffic, centres concerned shall decide whether and at what time eventual re-routeing procedures will commence. If centres concerned decide that re-routeing procedures are to commence, these procedures shall be in accordance with the already agreed bilateral and/or multilateral arrangements in this respect.

3.6   In case of interruption of the normal operation of a centre, measures shall be taken to try to ensure the collection of basic data from the zone of responsibility of that centre for onward transmission for regional and global distribution.

4. POST-OUTAGE ARRANGEMENTS

4.1   As soon as a centre which has been out of normal service is able to resume normal operation, it shall immediately inform all centres accordingly.

4.2   At that stage, centres concerned will decide when (after what delay) normal traffic will be resumed. In doing so, the technical requirements for such action shall be taken into account.

5.   SERVICE MESSAGES CONCERNING OUTAGES

5.1   Service messages may be transmitted on any available GTS circuits, taking into account the provisions, as defined in Part II, paragraph 2.4.

5.2   When no GTS circuit is available for the transmission of such service messages, they can be routed on the AFTN (in this case, service messages should conform to the format prescribed by ICAO), or on any other available telecommunication circuits.

ATTACHMENT II-12

INSTRUCTIONS FOR THE USE OF THE INDICATOR BBB

1.   The BBB indicator shall be included in the abbreviated heading lines of additional, subsequent, corrected or amended bulletins by those centres which are responsible for preparing or compiling the bulletins concerned.

2.   The BBB indicator shall be added when the abbreviated heading line defined by $T_1T_2A_1A_2ii$ CCCC YYGGgg has already been used for the transmission of a corresponding initial bulletin. Once the initial bulletin has been transmitted, the centre responsible for preparing or compiling the bulletin uses the BBB indicator to transmit additional, subsequent corrected or amended messages for the same $T_1T_2A_1A_2ii$ CCCC YYGGgg, but appended with the appropriate form of BBB indicator, following these guidelines:

(a) To transmit information or reports normally contained in an initial bulletin after the initial bulletin has been transmitted or for a subsequent or additional issuance of a bulletin whose $T_1T_2A_1A_2ii$ CCCC YYGGgg would not be unique without a BBB field and CCx or AAx does not apply. The BBB indicator to be used is RRx, where x =:
A, for the first bulletin after the issuance of the initial bulletin;
B, if another bulletin needs to be issued;
and so on up to and including x = X;
(b) To transmit a bulletin containing corrected information or reports that have already been issued in a previous bulletin. The BBB indicator to be used is CCx, where x =:
A, for the first bulletin containing corrected reports or information;
B, if a second bulletin containing corrected reports or information is issued;
and so on up to including x = X;
(c) To transmit a bulletin containing amendments to the information included in a previously issued bulletin. The BBB indicator to be used is AAx, where x = :
A, for the first bulletin containing amendments to information;
B, for a second bulletin containing amendments to information;
and so on up to and including x = X;
(d) If more than 24 BBB indicators have to be used for the sequences detailed in (a), (b) and (c) above, then x = X should continue to be used;
(e) For (a), (b) and (c) above, the characters x = Y and x = Z are to be used for special purposes indicated below:
(i)   x = Y should be used for the encoding of BBB when a system failure causes loss of the record of the sequence of character values assigned to x;
(ii) x = Z should be used for the encoding of BBB when bulletins are prepared or compiled more than 24 hours after the time of observation.

3.   An RTH on the GTS should ensure the relay of the bulletins received in accordance with its routeing directories even if the bulletins containing BBB indicators have not been received in the correct sequence.

ATTACHMENT II-13

ITU-T RECOMMENDATION X.25 (RELEVANT EXTRACTS)*

The extracts of ITU-T Recommendation X.25 describing the methods and elements of ITU-T Recommendation X.25 procedures to be used in the GTS are given in this attachment.

Recommendation X.25

Interface between data terminal equipment (DTE) and data circuit-terminating equipment (DCE) for terminals operating in the packet mode and connected to public data networks by dedicated circuit

(Geneva, 1976; amended at Geneva, 1980,
Malaga-Torremolinos, 1984 and Melbourne 1988)

[. . .]

CONTENTS

1.   DTE/DCE INTERFACE CHARACTERISTICS (PHYSICAL LAYER)

Administrations may offer one or more of the interfaces specified below. The exact use of the relevant points in these Recommendations is detailed below.

1.1   Recommendation X.21 interface

1.1.1   DTE/DCE physical interface elements

The DTE/DCE physical interface elements shall be according to §§ 2.1 through 2.5 of Recommendation X.21.

1.1.2   Procedures for entering operational phases

The procedures for entering operational phases shall be as described in § 5.2 of Recommendation X.21. The data exchanged on circuits T and R when the interface is in states 13S, 13R and 13 of Figure A-3/X.21 will be as described in subsequent sections of this Recommendation.

The not ready states given in § 2.5 of Recommendation X.21 are considered to be non-operational states and may be considered by the higher levels to be out of order states (see § 4.6 below).

1.1.3   Failure detection and test loops

The failure detection principles shall be according to § 2.6 of Recommendation X.21. In addition, i = OFF may be signalled due to momentary transmission failures. Higher levels may delay for several seconds before considering the interface to be out of order.

The definitions of test loops and the principles of maintenance testing using the test loops are provided in Recommendation X.150.

A description of the test loops and the procedures for their use is given in § 7 of Recommendation X.21.

Automatic activation by a DTE of a test loop 2 in the DCE at the remote terminal is not possible. However, some Administrations may permit the DTE to control the equivalent of a test loop 2, at the local DSE, to verify the operation of the leased line or subscriber line and all or part of the DCE or line terminating equipment. Control of the loop, if provided, may be either manual or automatic, as described in Recommendations X.150 and X.21 respectively.

1.1.4   Signal element timing

Signal element timing shall be in accordance with § 2.6.3 of Recommendation X.21.

1.2   Recommendation X.21 bis interface

1.2.1   DTE/DCE physical interface elements

The DTE/DCE physical interface elements shall be according to § 1.2 of Recommendation X.21 bis.

1.2.2   Operational phases

When circuit 107 is in the ON condition, and circuits 105, 108 and 109, if provided, are in the ON condition, data exchange on circuits 103 and 104 will be as described in subsequent sections of this Recommendation.

When circuit 107 is in the OFF condition, or any of circuits 105, 106, 108 or 109, if provided, are in the OFF condition, this is considered to be in a non-operational state, and may be considered by the higher levels to be in an out of order state (see § 4.6 below).

1.2.3   Failure detection and test loops

The failure detection principles, the description of test loops and the procedures for their use shall be according to §§ 3.1 through 3.3 of Recommendation X.21 bis. In addition, circuits 106 and 109 may enter the OFF condition due to momentary transmission failures. Higher levels may delay for several seconds before considering the interface to be out of order.

Automatic activation by a DTE of test loop 2 in the DCE at the remote terminal is not possible. However, some Administrations may permit the DTE to control the equivalent of a test loop 2, at the local DSE, to verify the operation of the leased line or subscriber line and all or part of the DCE or line terminating equipment. Control of the loop, if provided, may be either manual or automatic as described in Recommendations X.150 and X.21 bis respectively.

1.2.4   Signal element timing

Signal element timing shall be in accordance with § 3.4 of Recommendation X.21 bis.

1.3   V-series interface

General operation with V-series modems is as described in § 1.2 above. However, for specific details, particularly related to failure detection principles, loop testing, and the use of circuits 107, 109, 113 and 114, refer to the appropriate V-series Recommendations.

The delay between circuit 105-ON and circuit 106-ON (when these circuits are present) will be more than 10 ms and less than 1s. In addition, circuits 106 or 109 may enter the OFF condition due to momentary transmission failures or modem retraining. Higher levels may delay for several seconds before considering the interface to be out of order.

[. . .]

2.   LINK ACCESS PROCEDURES ACROSS THE DTE/DCE INTERFACE

2.1   Scope and field of applications

2.1.1   The Link Access Procedures (LAPB and LAP) are described as the Data Link Layer Element and are used for data interchange between a DCE and a DTE over a single physical circuit (LAPB and LAP), or optionally over multiple physical circuits (LAPB), operating in user classes of service 8 to 11 as indicated in Recommendation X.1. The optional, subscription-time selectable, multiple physical circuit operation with LAPB (known as multilink operation) is required if the effects of circuit failures are not to disrupt the Packet Level operation.

The single link procedures (SLPs) described in § 2.2, 2.3 and 2.4 (LAPB) and in §§ 2.2, 2.6 and 2.7 (LAP) are used for data interchange over a single physical circuit, conforming to the description given in § 1, between a DTE and a DCE. When the optional multilink operation is employed with LAPB, a single link procedure (SLP) is used independently on each physical circuit, and the multilink procedure (MLP) described in § 2.5 is used for data interchange over these multiple parallel LAPB data links. In addition, when only a single physical circuit is employed with LAPB, agreements may be made with the Administration to use this optional multilink procedure over the one LAPB data link.

2.1.2   The single link procedures (SLPs) use the principles and terminology of the High-level Data Link Control (HDLC) procedures specified by the International Organization for Standardization (ISO). The multilink procedure (MLP) is based on the principles and terminology of the Multilink Control Procedures specified by ISO.

2.1.3   Each transmission facility is duplex.

2.1.4   DCE compatibility of operation with the ISO balanced classes of procedure (Class BA with options 2, 8, and Class BA with options 2, 8, 10) is achieved using the LAPB procedure described in §§ 2.3 and 2.4. Of these classes, Class BA with options 2, 8 (LAPB modulo 8) is the basic service, and is available in all networks. Class BA with options 2, 8, 10 (LAPB modulo 128) is recognized as an optional, subscription-time selectable, extended sequence numbering service that may be available in those networks wishing to serve DTE applications having a need for modulo 128 sequence numbering.

DTE manufacturers and implementors must be aware that the procedure hereunder described as LAPB modulo 8 will be the only one available in all networks.

Likewise, a DTE may continue to use the LAP procedure described in §§ 2.2, 2.6 and 2.7 (in those networks supporting such a procedure), but for new DTE implementations, LAPB should be preferred. The LAP procedures are defined for modulo 8 basic service only.

Note: Other possible applications for further study are, for example:
        Two-way alternate, asynchronous response mode;
        Two-way simultaneous, normal response mode;
        Two-way alternate, normal response mode.

2.1.5   For those networks that choose to support both the basic and extended LAPB sequence numbering services, the choice of either basic mode (modulo 8) or extended mode (modulo 128) may be made at subscription time. The choice of the mode employed for each data link procedure is independent of all others and of the choice of mode for the corresponding Packet Layer procedures. All choices are matters for agreement for a period of time with the Administration.

2.1.6   In the case of those networks that support both the LAPB procedure and the LAP procedure, the DCE will maintain an internal mode variable B, which it will set as follows:

–   To 1, upon acceptance of an SABM/SABME (modulo 8/modulo 128) command from the DTE, or upon issuance of an SABM/SABME command by the DCE;
–   To 0, upon acceptance of an SARM command from the DTE.

        Whenever B is 1, the DCE will use the LAPB procedure described in §§ 2.2, 2.3 and 2.4 below, and is said to be in the LAPB (balanced) mode.

        Whenever B is 0, the DCE will use the LAP procedure described in §§ 2.2, 2.6 and 2.7 below, and is said to be in the LAP mode.

        Changes to the mode variable B by the DTE should occur only when the link has been disconnected as described in §§ 2.4.4.3 or 2.7.3.3 below.

        Should a DCE malfunction occur that negates the current setting of internal mode variable B, the DCE will, upon restoration of operation, not send either a SARM or SABM/SABME command. The DCE may send a DISC command or a DM response to notify the DTE that the DCE is in the disconnected phase. This will result in the DTE attempting to reinitialize the link with what the DTE considers to be the proper mode-setting command (SARM or SABM/SABME). The DCE will then be able to set the internal mode variable B to its proper value.

2.2   Frame structure

2.2.1   All transmissions on an SLP are in frames conforming to one of the formats of Table 1/X.25 for basic (modulo 8) operation, or alternatively one of the formats of Table 2/X.25 for extended (modulo 128) operation. The flag preceding the address field is defined as the opening flag. The flag following the FCS field is defined as the closing flag.

2.2.2   Flag sequence

        All frames shall start and end with the flag sequence consisting of one 0 bit followed by six contiguous 1 bits and one 0 bit. The DTE and DCE shall only send complete eight-bit flag sequences when sending multiple flag sequences (see § 2.2.11). A single flag may be used as both the closing flag for one frame and the opening flag for the next frame.

Table 1/X.25 – Frame formats – Basic (modulo 8) operation

Bit order of transmission   12345678   12345678   12345678   16 to 1   12345678

Flag	Address	Control	FCS	Flag
F	A	C	FCS	F
01111110	8-bits	8-bits	16-bits	01111110

FCS Frame check sequence

Bit order of transmission   12345678   12345678   12345678   16 to 1   12345678

Flag	Address	Control	Information	FCS	Flag
F	A	C	Info	FCS	F
01111110	8-bits	8-bits	N-bits	16-bits	01111110

FCS Frame check sequence

Table 2/X.25 – Frame formats – Extended (modulo 128) operation

Bit order of transmission   12345678   12345678   1 to *)   16 to 1   12345678

Flag	Address	Control	FCS	Flag
F	A	C	FCS	F
01111110	8-bits	*)-bits	16-bits	01111110

FCS Frame check sequence

Bit order of   12345678   12345678   1 to *)   16 to 1   12345678
transmission

Flag	Address	Control	Information	FCS	Flag
F	A	C	Info	FCS	F
01111110	8-bits	*)-bits	N-bits	16-bits	01111110

FCS Frame check sequence

*   16 for frame formats that contain sequence numbers; 8 for frame formats that do not contain sequence numbers.

2.2.3   Address field

The address field shall consist of one octet. The address field identifies the intended receiver of a command frame and the transmitter of a response frame. The coding of the address field is described in § 2.4.2 (LAPB) and in § 2.7.1 (LAP) below.

2.2.4   Control field

For modulo 8 (basic) operation the control field shall consist of one octet. For modulo 128 (extended) operation, the control field shall consist of two octets for frame formats that contain sequence numbers, and one octet for frame formats that do not contain sequence numbers. The content of this field is described in § 2.3.2 (LAPB) and in § 2.6.2 (LAP) below.

2.2.5   Information field

The information field of a frame, when present, follows the control field (see § 2.2.4 above) and precedes the frame check sequence (see § 2.2.7 below).

See §§ 2.3.4.9, 2.5.2, 2.6.4.8 and 5 for the various codings and groupings of bits in the information field as used in this Recommendation.

See §§ 2.3.4.9, 2.4.8.5, 2.6.4.8 and 2.7.7.5 below with regard to the maximum information field length.

2.2.6   Transparency

The DCE or DTE, when transmitting, shall examine the frame content between the two flag sequences including the address, control, information and FCS fields and shall insert a 0 bit after all sequences of 5 contiguous 1 bits (including the last 5 bits of the FCS) to ensure that a flag sequence is not simulated. The DCE or DTE, when receiving, shall examine the frame content and shall discard any 0 bit which directly follows 5 contiguous 1 bits.

2.2.7   Frame check sequence (FCS) field

The notation used to describe the FCS is based on the property of cyclic codes that a code vector such as 1000000100001 can be represented by a polynomial $P(x) = x^{12} + x^5 + 1$. The elements of an n-element code word are thus the coefficients of a polynomial of order $n - 1$. In this application, these coefficients can have the value 0 or 1 and the polynomial operations are performed modulo 2. The polynomial representing the content of a frame is generated using the first bit received after the frame opening flag as the coefficient of the highest order term.

The FCS field shall be a 16-bit sequence. It shall be the ones complement of the sum (modulo 2) of:

(1) The remainder of x^k $(x^{15} + x^{14} + x^{13} + x^{12} + x^{11} + x^{10} + x^9 + x^8 + x^7 + x^6 + x^5 + x^4 + x^3 + x^2 + x + 1)$ divided (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$, where k is the number of bits in the frame existing between, but not including, the final bit of the opening flag and the first bit of the ECS, excluding bits inserted for transparency; and

(2) The remainder of the division (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$ of the product of x^{16} by the content of the frame, existing between but not including, the final bit of the opening flag and the first bit of the FCS, excluding bits inserted for transparency.

As a typical implementation, at the transmitter, the initial content of the register of the device computing the remainder of the division is preset to all 1s and is then modified by division by the generator polynomial (as described above) on the address, control and information fields; the ones complement of the resulting remainder is transmitted as the 16-bit FCS.

At the receiver, the initial content of the register of the device computing the remainder is preset to all 1s. The final remainder, after multiplication by x^{16} and then division (modulo 2) by the generator polynomial $x^{16} + x^{12} + x^5 + 1$ of the serial incoming protected bits and the FCS, will be 0001110100001111 (x^{15} through x^0, respectively) in the absence of transmission errors.

Note: Examples of transmitted bit patterns by the DCE and the DTE illustrating application of the transparency mechanism and the frame check sequence to the SABM command and the UA response are given in Appendix I.

2.2.8   Order of bit transmission

Addresses, commands, responses and sequence numbers shall be transmitted with the low-order bit first (for example, the first bit of the sequence number that is transmitted shall have the weight 2^0). The order of transmitting bits within the information field is not specified under § 2 of this Recommendation. The FCS shall be transmitted to the line commencing with the coefficient of the highest term, which is found in bit position 16 of the FCS field (see Tables 1/X.25 and 2/X.25).

Note: In tables 1/X.25 to 13/X.25, bit 1 is defined as the low-order bit.

2.2.9   Invalid frames

The definition of an invalid frame is described in § 2.3.5.3 (LAPB) and in § 2.6.5.3 (LAP) below.

2.2.10   Frame abortion

Aborting a frame is performed by transmitted at least seven contiguous 1 bits (with no inserted 0 bits).

2.2.11   Interframe time fill

Interframe time fill is accomplished by transmitting contiguous flags between frames, i.e. multiple eight-bit flag sequences (see § 2.2.2).

2.2.12   Link channel states

A link channel as defined here is the means for transmission for one direction.

2.2.13   Active channel state

The DCE incoming or outgoing channel is defined to be in an active condition when it is receiving or transmitting, respectively, a frame, an abortion sequence or interframe time fill.

2.2.14   Idle channel state

The DCE incoming or outgoing channel is defined to be in an idle condition when it is receiving or transmitting, respectively, a continuous 1s state for a period of at least 15 bit times.

See § 2.3.5.5 for a description of DCE action when an idle condition exists on its incoming channel for an excessive period of time.

2.3   LAPB elements of procedures

2.3.1   The LAPB elements of procedures are defined in terms of actions that occur on receipt of frames at the DCE or DTE.

The elements of procedures specified below contain the selection of commands and responses relevant to the LAPB data link and system configurations described in § 2.1 above. Together, §§ 2.2 and 2.3 form the general requirements for the proper management of a LAOB access data link.

2.3.2 LAPB control field formats and parameters

2.3.2.1 Control field formats

The control field contains a command or a response, and sequence numbers where applicable.

Three types of control field formats are used to perform numbered information transfer (I format), numbered supervisory functions (S format) and unnumbered control functions (U format).

The control field formats for basic (modulo 8) operation are depicted in Table 3/X.25.

The control field formats for extended (modulo 128) operation are depicted in Table 4/X.25.

2.3.2.1.1 *Information transfer format – I*

The I format is used to perform an information transfer. The functions of N(S), N(R) and P are independent; i.e., each I frame has an N(S), an N(R) which may or may not acknowledge additional I frames received by the DCE or DTE, and a P bit that may be set to 0 or 1.

2.3.2.1.2 *Supervisory format – S*

The S format is used to perform data link supervisory control functions such as acknowledge I frames, request retransmission of I frames, and to request a temporary suspension of transmission of I frames. The functions of N(R) and P/F are independent; i.e., each supervisory frame has an N(R) which may or may not acknowledge additional I frames received by the DCE or DTE, and a P/F bit that may be set to 0 or 1.

2.3.2.1.3 *Unnumbered format – U*

The U format is used to provide additional data link control functions. This format contains no sequence numbers, but does include a P/F bit that may be set to 0 or 1. The unnumbered frames have the same control field length (one octet) in both basic (modulo 8) operation and extended (modulo 128) operation.

2.3.2.2 Control field parameters

The various parameters associated with the control field formats are described below.

2.3.2.2.1 *Modulus*

Each I frame is sequentially numbered and may have the value 0 through modulus minus 1 (where "modulus" is the modulus of the sequence numbers). The modulus equals either 8 or 128 and the sequence numbers cycle through the entire range.

2.3.2.2.2 *Send state variable V(S)*

The send state variable V(S) denotes the sequence number of the next in-sequence I frame to be transmitted. V(S) can take on the values 0 through modulus minus 1. The value of V(S) is incremented by 1 with each successive I frame transmission, but cannot exceed the N(R) of the last received I or supervisory frame by more than the maximum number of outstanding I frames (k). The value of k is defined in § 2.4.8.6 below.

Table 3/X.25 – LAPB control field format – Basic (modulo 8) operation

Control field	1	2	3	4	5	6	7	8
I format	0	N(S)			P	N(R)		
S format	1	0	S	S	P/F	N(R)		
U format	1	1	M	M	P/F	M	M	M

N(S)   Transmitter send sequence number (bit 2 = low-order bit)
N(R)   Transmitter receive sequence number (bit 6 = low-order bit)
S   Supervisory function bit
M   Modifier function bit
P/F   Poll bit when issued as a command, final bit when issued as a response (1 = Poll/Final)
P   Poll bit (1 = Poll)

Table 4/X.25 – LAPB control field format – Extended (modulo 128) operation

Control field	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
I format	0			N(S)					P	N(R)						
S format	1	0	S	S	X	X	X	X	P/F	N(R)						
U format	1	1	M	M	P/F	M	M	M								

N(S)   Transmitter send sequence number (bit 2 = low-order bit)

N(R)   Transmitter receive sequence number (bit 10 = low-order bit)

S   Supervisory function bit

M   Modifier function bit

X   Reserved and set to 0

P/F   Poll bit when issued as a command, final bit when issued as a response (1 = Poll/Final)

P   Poll bit (1 = Poll)

2.3.2.2.3   *Send sequence number N(S)*

Only I frames contain N(S), the send sequence number of transmitted I frames. At the time that an in-sequence I frame is designated for transmission, the value of N(S) is set equal to the value of the send state variable V(S).

2.3.2.2.4   *Receive state variable V(R)*

The receive state variable V(R) denotes the sequence number of the next in-sequence I frame expected to be received. V(R) can take on the values 0 through modulus minus 1. The value of V(R) is incremented by 1 by the receipt of an error-free, in – sequence I frame whose send sequence number N(S) equals the receive state variable V(R).

2.3.2.2.5   *Receive sequence number N(R)*

All I frames and supervisory frames contain N(R), the expected send sequence number of the next received I frame. At the time that a frame of the above types is designated for transmission, the value of N(R) is set equal to the current value of the receive state variable V(R), N(R) indicates that the DCE or DTE transmitting the N(R) has received correctly all I frames numbered up to and including N(R) – 1.

2.3.2.2.6   *Poll/Final bit P/F*

All frames contain P/F, the Poll/Final bit. In command frames, the P/F bit is referred to as the P bit. In response frames, it is referred to as the F bit.

2.3.3   Functions of the Poll/Final bit

The Poll bit set to 1 is used by the DCE or DTE to solicit (poll) a response from the DTE or DCE, respectively. The final bit set to 1 is used by the DCE or DTE to indicate the response frame transmitted by the DTE or DCE, respectively, as a result of the soliciting (poll) command.

The use of the P/F bit is described in § 2.4.3 below.

2.3.4   Commands and responses

For basic (modulo 8) operation, the commands and responses represented in Table 5/X.25 will be supported by the DCE and the DTE.

For extended (modulo 128) operation, the commands and responses represented in Table 6/X.25 will be supported by the DCE and the DTE.

For purposes of the LAPB procedures, the supervisory function bit encoding "11" and those encodings of the modifier function bits in Table 3/X.25 and 4/X.25 not identified in Table 5/X.25 or 6/X.25 are identified as "undefined or not implemented" command and response control fields.

The commands and responses in Tables 5/X.25 and 6/X.25 are defined as follows:

2.3.4.1   Information (I) command

The function of the information (I) command is to transfer across a data link a sequentially numbered frame containing an information field.

2.3.4.2   Receive ready (RR) command and response

The receive ready (RR) supervisory frame is used by the DCE or DTE to:

(1) Indicate it is ready to receive an I frame;
(2) Acknowledge previously received I frames numbered up to and including N(R)–1.

An RR frame may be used to indicate the clearance of a busy condition that was reported by the earlier transmission of an RNR frame by that same station (DCE or DTE). In addition to indicating the DCE or DTE status, the RR command with the P bit set to 1 may be used by the DCE or DTE to ask for the status of the DTE or DCE, respectively.

2.3.4.3   Receive not ready (RNR) command and response

The receive not ready (RNR) supervisory frame is used by the DCE or DTE to indicate a busy condition; i.e., temporary inability to accept additional incoming I frames. I frames numbered up to and including N(R) – 1 are acknowledged. I frame N(R) and any subsequent I frames received, if any, are not acknowledged; the acceptance status of these I frames will be indicated in subsequent exchanges.

In addition to indicating the DCE or DTE status, the RNR command with the P bit set to 1 may be used by a DCE or DTE to ask for the status of the DTE or DCE, respectively.

2.3.4.4   Reject (REJ) command and response

The reject (REJ) supervisory frame is used by the DCE or DTE to request transmission of I frames starting with the frame numbered N(R). I frames numbered N(R) – 1 and below are acknowledged. Additional I frames pending initial transmission may be transmitted following the retransmitted I frame(s).

Only one REJ exception condition for a given direction of information transfer may be established at any time. The REJ exception condition is cleared (reset) upon the receipt of an I frame with an N(S) equal to the N(R) of the REJ frame.

An REJ frame may be used to indicate the clearance of a busy condition that was reported by the earlier transmission of an RNR frame by that same station (DCE or DTE). In addition to indicating the DCE or DTE status, the REJ command with the P bit set to 1 may be used by the DCE or DTE to ask for the status of the DTE or DCE, respectively.

2.3.4.5   Set asynchronous balanced mode (SABM) command/Set asynchronous balanced mode extended (SABME) command (subscription time option)

The SABM unnumbered command is used to place the addressed DCE or DTE in an asynchronous balanced mode (ABM) information transfer phase where all command/response control fields will be one octet in length.

The SABME unnumbered command is used to place the addressed DCE or DTE in an asynchronous balanced mode (ABM) information transfer phase where numbered command/response control fields will be two octets in length, and unnumbered command/response control fields will be one octet in length.

No information field is permitted with the SABM or SABME command. The transmission of a SABM/SABME command indicates the clearance of a busy condition that was reported by the earlier transmission of an RNR frame by that same station (DCE or DTE). The DCE or DTE confirms acceptance of SABM/SABME [modulo 8 (basic) operation/modulo 128 (extended) operation] command by the transmission, at the first opportunity, of a UA response. Upon acceptance of this command, the DCE or DTE send state variable V(S) and receive state variable V(R) are set to 0.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged. It is the responsibility of a higher layer (e.g. Packet Layer or MLP) to recover from the possible loss of the contents (e.g. packets) of such I frames.

Note: The mode of operation of a data link [basic (modulo 8) extended (modulo 128)] is determined at subscription time and is only changed by going through a new subscription process.

2.3.4.6   Disconnect (DISC) command

The DISC unnumbered command is used to terminate the mode previously set. It is used to inform the DCE or DTE receiving the DISC command that the DTE or DCE sending the DISC command is suspending operation. No information field is permitted with the DISC command. Prior to actioning the DISC command, the DCE or DTE receiving the DISC command confirms the acceptance of the DISC command by the transmission of a UA response. The DTE or DCE sending the DISC command enters the disconnected phase when it receives the acknowledging UA response.

Previously transmitted I frames that are unacknowledged when this command is actioned remain unacknowledged. It is the responsibility of a higher layer (e.g. Packet Layer or MLP) to recover from the possible loss of the contents (e.g. packets) of such I frames.

2.3.4.7   Unnumbered acknowledgement (UA) response

The UA unnumbered response is used by the DCE or DTE to acknowledge the receipt and acceptance of the mode-setting commands. Received mode-setting commands are not actioned until the UA response is transmitted. The transmission of a UA response indicates the clearance of a busy condition that was reported by the earlier transmission of an RNR frame by that same station (DCE or DTE). No information field is permitted with the UA response.

2.3.4.8   Disconnected mode (DM) response

The DM unnumbered response is used to report a status where the DCE or DTE is logically disconnected from the data link, and is in the disconnected phase. The DM response may be sent to indicate that the DCE or DTE has entered the disconnected phase without benefit of having received a DISC command, or, if sent in response to the reception of a mode setting command, is sent to inform the DTE or DCE that the DCE or DTE, respectively, is still in the disconnected phase and cannot execute the set mode command. No information field is permitted with the DM response.

Table 5/X.25 – LAPB commands and responses – Basic (modulo 8) operation

Format	Command		Response		1	2	3	4	5	6	7	8
					Encoding							
Information transfer	I	Information			0	N(S)			P	N(R)		
Supervisory	RR	(receive ready)	RR	(receive ready)	1	0	0	0	P/F	N(R)		
	RNR	(receive not ready)	RNR	(receive not ready)	1	0	1	0	P/F	N(R)		
	REJ	(reject)	REJ	(reject)	1	0	0	1	P/F	N(R)		
Unnumbered	SABM	(set asynchronous balanced mode)			1	1	1	1	P	1	0	0
	DISC	(disconnect)			1	1	0	0	P	0	1	0
			DM	(disconnected mode)	1	1	1	1	F	0	0	0
			UA	(unnumbered acknowledgement)	1	1	0	0	F	1	1	0
			FRMR	(frame reject)	1	1	1	0	F	0	0	1

Table 6/X.25 – LAPB commands and responses – Extended (modulo 128) operation

Format	Command		Response		1	2	3	4	5	6	7	8	9	10-16
Information transfer	I	Information			0	N(S)							P	N(R)
Supervisory	RR	(receive ready)	RR	(receive ready)	1	0	0	0	0	0	0	0	P/F	N(R)
	RNR	(receive not ready)	RNR	(receive not ready)	1	0	1	0	0	0	0	0	P/F	N(R)
	REJ	(reject)	REJ	(reject)	1	0	0	1	0	0	0	0	P/F	N(R)
Unnumbered	SABM	(set asynchronous balanced mode)			1	1	1	1	P	1	1	0		
	DISC	(disconnect)			1	1	0	0	P	0	1	0		
			DM	(disconnected mode)	1	1	1	1	F	1	1	0		
			UA	(unnumbered acknowledgement)	1	1	0	0	F	1	1	0		
			FRMR	(frame reject)	1	1	1	0	F	0	0	1		

A DCE or DTE in a disconnected phase will monitor received commands and will react to an SABM/SABME command as outlined in § 2.4.4 below, and will respond with a DM response with the F bit set to 1 to any other command received with the P bit set to 1.

2.3.4.9   Frame reject (FRMR) response

The FRMR unnumbered response is used by the DCE or DTE to report an error condition not recoverable by retransmission of the identical frame; i.e. at least one of the following conditions, which results from the receipt of a valid frame:

(1) The receipt of a command or response control field that is undefined or not implemented;
(2) The receipt of an I frame with an information field which exceeds the maximum established length;
(3) The receipt of an invalid N(R); or
(4) The receipt of a frame with an information field which is not permitted or the receipt of a supervisory or unnumbered frame with incorrect length.

An undefined or not implemented control field is any of the control encodings that are not identified in Tables 5/X.25 or 6/X.25.

A valid N(R) must be within the range from the lowest send sequence number N(S) of the still unacknowledged frame(s) to the current DCE send state variable inclusive (or to the current internal variable x if the DCE is in the timer recovery condition as described in § 2.4.5.9).

An information field which immediately follows the control field, and consists of 3 or 5 octets [modulo 8 (basic) operation or modulo 128 (extended) operation, respectively], is returned with this response and provides the reason for the FRMR response. These formats are given in Tables 7/X.25 and 8/X.25.

2.3.5   Exception condition reporting and recovery

The error recovery procedures which are available to effect recovery following the detection/occurrence of an exception condition at the Data Link Layer are described below. Exception conditions described are those situations which may occur as the result of transmission errors, DCE or DTE malfunction, or operational situations.

Table 7/X.25 – LAPB FRMR information field format – Basic (modulo 8) operation

Information field bits

1 2 3 4 5 6 7 8	9	10 11 12	13	14 15 16	17	18	19	20	21	22	23	24
Rejected frame control field	0	V(S)	C/R	V(R)	W	X	Y	Z	0	0	0	0

–   Rejected frame control field is the control field of the received frame which caused the frame reject.
–   V(S) is the current send state variable value at the DCE or DTE reporting the rejection condition (bit 10 = low-order bit).
–   C/R set to 1 indicates the rejected frame was a response. C/R set to 0 indicates the rejected frame was a command.
–   V(R) is the current receive state variable value at the DCE or DTE reporting the rejection condition (bit 14 = low-order bit).
–   W set to 1 indicates that the control field received and returned in bits 1 through 8 was undefined or not implemented.
–   X set to 1 indicates that the control field received and returned in bits 1 through 8 was considered invalid because the frame contained an information field which is not permitted with this frame or is a supervisory or unnumbered frame with incorrect length. Bit W must be set to 1 in conjunction with this bit.
–   Y set to 1 indicates that the information field received exceeded the maximum established capacity.
–   Z set to 1 indicates the control field received and returned in bits 1 through 8 contained an invalid N(R).

Note: Bits 9 and 21 to 24 shall be set to 0.

Table 8/X.25 – LAPB FRMR information field format – Extended (modulo 88) operation

Information field bits

1 to 16	17	18 to 24	25	26 to 32	33	34	35	36	37	38	39	40
Rejected frame control field	0	V(S)	C/R	V(R)	W	X	Y	Z	0	0	0	0

–   Rejected frame control field is the control field of the received frame which caused the frame reject. When the rejected frame is an unnumbered frame, the control field of the rejected frame is positioned in bit positions 1-8, with 9-16 set to 0.
–   V(S) is the current send state variable value at the DCE or DTE reporting the rejection condition (bit 18 = low-order bit).
–   C/R set to 1 indicates the rejected frame was a response. C/R set to 0 indicates the rejected frame was a command.
–   V(R) is the current receive state variable value at the DCE or DTE reporting the rejection condition (bit 26 = low-order bit).
–   W set to 1 indicates that the control field received and returned in bits 1 through 16 was undefined or not implemented.
–   X set to 1 indicates that the control field received and returned in bits 1 through 16 was considered invalid because the frame contained an information field which is not permitted with this frame or is a supervisory or unnumbered frame with incorrect length. Bit W must be set to 1 in conjunction with this bit.
–   Y set to 1 indicates that the information field received exceeded the maximum established capacity.
–   Z set to 1 indicates the control field received and returned in bits 1 through 16 contained an invalid N(R).

Note: Bits 17 and 37 to 40 shall be set to 0.

2.3.5.1   Busy condition

The busy condition results when the DCE or DTE is temporarily unable to continue to receive I frames due to internal constraints, e.g. receive buffering limitations. In this case an RNR frame is transmitted from the busy DCE or DTE. I frames pending transmission may be transmitted from the busy DCE or DTE prior to or following the RNR frame.

An indication that the busy condition has cleared is communicated by the transmission of a UA (only in response to a SABM/SABME command), RR, REJ or SABM/SABME (modulo 8/modulo 128) frame.

2.3.5.2   N(S) sequence error condition

The information field of all I frames received whose N(S) does not equal the receive state variable V(R) will be discarded.

An N(S) sequence error exception condition occurs in the receiver when an I frame received contains an N(S) which is not equal to the receive state variable V(R) at the receiver. The receiver does not acknowledge (increment its receive state variable) the I frame causing the sequence error, or any I frame which may follow, until an I frame with the correct N(S) is received.

A DCE or DTE which receives one or more valid I frames having sequence errors or subsequent supervisory frames (RR, RNR and REJ) shall accept the control information contained in the N(R) field and the P or F bit to perform data link control functions; e.g. to receive acknowledgement of previously transmitted I frames and to cause the DCE or DTE to respond (P bit set to 1).

The means specified in §§ 2.3.5.2.1 and 2.3.5.2.2 shall be available for initiating the retransmission of lost or errored I frames following the occurrence of an N(S) sequence error condition.

2.3.5.2.1   *REJ recovery*

The REJ frame is used by a receiving DCE or DTE to initiate a recovery (retransmission) following the detection of an N(S) sequence error.

With respect to each direction of transmission on the data link, only one "sent REJ" exception condition from a DCE or DTE, to DTE or DCE, is established at a time. A "sent REJ" exception condition is cleared when the requested I frame is received.

A DCE or DTE receiving a REJ frame initiates sequential (re-)transmission of I frames starting with the I frame indicated by the N(R) contained in the REJ frame. The retransmitted frames may contain an N(R) and a P bit that are updated from, and therefore different from, the ones contained in the originally transmitted I frames.

2.3.5.2.2   *Time-out recovery*

If a DCE or DTE, due to a transmission error, does not receive (or receives and discards) a single I frame or the last I frame(s) in a sequence of I frames, it will not detect an N(S) sequence error condition and, therefore, will not transmit a REJ frame. The DTE or DCE which transmitted the unacknowledged I frame(s) shall, following the completion of a system specified time-out period (see §§ 2.4.5.1 and 2.4.5.9 below), take appropriate recovery action to determine at which I frame retransmission must begin. The retransmitted frame(s) may contain an N(R) and a P bit that is updated from, and therefore different from, the ones contained in the originally transmitted frame(s).

2.3.5.3   Invalid frame condition

Any frame which is invalid will be discarded, and no action is taken as the result of that frame. An invalid frame is defined as one which:

(a) Is not properly bounded by two flags;

(b) In basic (modulo 8) operation, contains fewer than 32 bits between flags; in extended (modulo 128) operation, contains fewer than 40 bits between flags of frames that contain sequence numbers or 32 bits between flags of frames that do not contain sequence numbers;

(c) Contains a Frame Check Sequence (FCS) error;

(d) Contains an address other than A or B (for single link operation) or other than C or D (for multilink operation).

For those networks that are octet aligned, a detection of non-octet alignment may be made at the Data Link Layer by adding a frame validity check that requires the number of bits between the opening flag and the closing flag, excluding bits inserted for transparency, to be an integral number of octets in length, or the frame is considered invalid.

2.3.5.4   Frame rejection condition

A frame rejection condition is established upon the receipt of an error-free frame with one of the conditions listed in § 2.3.4.9 above.

At the DCE or DTE, this frame rejection exception condition is reported by an FRMR response for appropriate DTE or DCE action, respectively. Once a DCE has established such an exception condition, no additional I frames are accepted until the condition is reset by the DTE, except for examination of the P bit. The FRMR response may be repeated at each opportunity, as specified in § 2.4.7.3, until recovery is effected by the DTE, or until the DCE initiates its own recovery in case the DTE does not respond.

2.3.5.5   Excessive idle channel state condition on incoming channel

Upon detection of an idle channel state condition (see § 2.2.1.2.1 above) on the incoming channel, the DCE shall wait for a period T3 (see § 2.4.8.3 below) without taking any specific action, waiting for detection of a return to the active channel state (i.e. detection of at least one flag sequence). After the period T3, the DCE shall notify the higher layer (e.g. the Packet Layer or the MLP) of the excessive idle channel state condition, but shall not take any action that would preclude the DTE from establishing the data link by normal data link set-up procedures.

Note: Other actions to be taken by the DCE at the Data Link Layer upon expiration of period T3 is a subject for further study.

2.4   Description of the LAPB procedure

2.4.1   LAPB basic and extended modes of operation

In accordance with the system choice made by the DTE at subscription time, the DCE will either support modulo 8 (basic) operation or will support modulo 128 (extended) operation. Changing from basic operation to extended operation, or vice versa, in the DCE requires resubscription by the DTE for the desired service, and is not supported dynamically.

Table 5/X.25 indicates the command and response control field formats used with the basic (modulo 8) service. The mode setting command employed to initialize (set up) or reset the basic mode is the SABM command. Table 6/X.25 indicates the command and response control field formats used with the extended (modulo 128) service. The mode setting command employed to initialize (set up) or reset the extended mode is the SABME command.

2.4.2   LAPB procedure for addressing

The address field identifies a frame as either a command or a response. A command frame contains the address of the DCE or DTE to which the command is being sent. A response frame contains the address of the DCE or DTE sending the frame.

In order to allow differentiation between single link operation and the optional multilink operation for diagnostic and/or maintenance reasons, different address pair encodings are assigned to data links operating with multilink procedure compared to data links operating with the single link procedure.

Frames containing commands transferred from the DCE to the DTE will contain the address A for the single link operation and address C for the multilink operation.

Frames containing responses transferred from the DCE to the DTE will contain the address B for the single link operation and address D for the multilink operation.

Frames containing commands transferred from the DTE to the DCE shall contain the address B for the single link operation and address D for the multilink operation.

Frames containing responses transferred from the DTE to the DCE shall contain the address A for the single link operation and address C for the multilink operation.

These addresses are coded as follows:

	Address	1	2	3	4	5	6	7	8
Single Link operation	A	1	1	0	0	0	0	0	0
	B	1	0	0	0	0	0	0	0
Multilink operation	C	1	1	1	1	0	0	0	0
	D	1	1	1	0	0	0	0	0

Note: The DCE will discard all frames received with an address other than A or B (single link operation), or C or D (multilink operation).

2.4.3   LAPB procedure for the use of the P/F bit

The DCE or DTE receiving an SABM/SABME, DISC, supervisory command or I frame with the P bit set to 1 will set the F bit to 1 in the next response frame it transmits.

The response frame returned by the DCE to an SABM/SABME or DISC command with the P bit set to 1 will be a UA or DM response with the F bit set to 1. The response frame returned by the DCE to an I frame with the P set to 1, received during the information transfer phase, will be an RR, REJ, RNR or FRMR response with the F bit set to 1. The response frame returned by the DCE to a supervisory command with the P bit set to 1, received during the information transfer phase, will be an RR, REJ, RNR or FRMR response with the F bit set to 1. The response frame returned by the DCE to an I frame or supervisory frame with the P bit set to 1, received during the disconnected phase, will be a DM response with the F bit set to 1.

The P bit may be used by the DCE in conjunction with the timer recovery condition (see § 2.4.5.9 below).

Note: Other use of the P bit by the DCE is a subject for further study.

2.4.4   LAPB procedure for link set-up and disconnection

2.4.4.1   Link set-up

The DCE will indicate that it is able to set up the data link by transmitting contiguous flags (active channel state).

Either the DTE or the DCE may initiate link set-up. Prior to initiation of link set-up, either the DCE or the DTE may initiate data link disconnection (see § 2.4.4.3) for the purpose of ensuring that the DCE and the DTE are in the same phase. The DCE may also transmit an unsolicited DM response to request the DTE to initiate link set-up.

The DTE shall initiate data link set-up by transmitting an SABM/SABME command to the DCE. If, upon receipt of the SABM/SABME command correctly, the DCE determines that it can enter the information transfer phase, it will return a UA response to the DTE, will reset its send and receive state variables V(S) and V(R) to zero, and will consider that the data link is set up. If, upon receipt of the SABM/SABME command correctly, the DCE determines that it cannot enter the information transfer phase, it will return a DM response to the DTE as a denial to the data link set-up initialization and will consider that the data link is not set up. In order to avoid misinterpretation of the DM response received, it is suggested that the DTE always sends its SABM/SABME command with the P bit set to 1. Otherwise, it is not possible to differentiate a DM response intended as a denial to link set-up from a DM response that is issued in a separate unsolicited sense as a request for a mode-setting command (as described in § 2.4.4.4.2).

The DCE will initiate data link set-up by transmitting an SABM/SABME command to the DTE and starting its Timer T1 in order to determine when too much time has elapsed waiting for a reply (see § 2.4.8.1 below). Upon reception of a UA response form the DTE, the DCE will reset its send and receive state variables V(S) and V(R) to zero, will stop its Timer T1, and will consider that the data link is set up. Upon reception of a DM response from the DTE as a denial to the link set-up initialization, the DCE will stop its Timer T1 and will consider that the data link is not set up.

The DCE, having sent the SABM/SAME command, will ignore and discard any frames except an SABM/SABME or DISC command, or a UA or DM response received from the DTE. The receipt of an SABM/SABME or DISC command from the DTE will result in a collision situation that is resolved per § 2.4.4.5 below. Frames other than the UA and DM responses sent in response to a received SABM/SABME or DISC command will be sent only after the data link is set up and if no outstanding SABM/SABME command exists.

After the DCE sends the SABM/SABME command, if a UA or DM response is not received correctly, Timer T1 will run out in the DCE. The DCE will then resend the SABM/SABME command and will restart Timer T1. After transmission of the SABM/SABME command N2 times by the DCE, appropriate higher layer recovery action will be initiated. The value of N2 is defined in § 2.4.8.4 below.

2.4.4.2 Information transfer phase

After having transmitted the UA response to the SABM/SABME command or having received the UA response to a transmitted SABM/SABME command, the DCE will accept and transmit I and supervisory frames according to the procedures described in § 2.4.5 below.

When receiving the SABM/SABME command while in the information transfer phase, the DCE will conform to the link resetting procedure described in § 2.4.7 below.

2.4.4.3 Link disconnection

The DCE shall initiate a disconnect of the data link by transmitting a DISC command to the DCE. On correctly receiving a DISC command in the information transfer phase, the DCE will send a UA response and enter the disconnected phase. On correctly receiving a DISC command in the disconnected phase, the DCE will send a DM response and remain in the disconnected phase. In order to avoid misinterpretation of the DM response received, it is suggested that the DTE always sends its DICS command with the P bit set to 1. Otherwise, it is not possible to differentiate a DM response intended as an indication that the DCE is already in the disconnected phase from a DM response that is issued in a separate unsolicited sense as a request for a mode-setting command (as described in § 2.4.4.4.2).

The DCE will initiate a disconnect of the data link by transmitting a DISC command to the DTE and starting its Timer T1 (see § 2.4.8.1 below). Upon reception of a UA response from the DTE, the DCE will stop its Timer T1 and will enter the disconnected phase. Upon reception of a DM response from the DTE as an indication that the DTE was already in the disconnected phase, the DCE will stop its Timer T1 and will enter the disconnected phase.

The DCE, having sent the DISC command, will ignore and discard any frames except an SABM/SABME or DISC command, or a UA or DM response received from the DTE. The receipt of an SABM/SABME or DISC command from the DTE will result in a collision situation that is resolved per § 2.4.4.5 below.

After the DCE sends the DISC command, if a UA or DM response is not received correctly, Timer T1 will run out in the DCE. The DCE will then resend the DISC command and will restart Timer T1. After transmission of the DISC command N2 times by the DCE, appropriate higher layer recovery action will be initiated. The value of N2 is defined in § 2.4.8.4 below.

2.4.4.4   Disconnected phase

2.4.4.4.1   After having receiving a DISC command from the DTE and returned a UA response to the DTE, or having received the UA response to a transmitted DISC command, the DCE will enter the disconnected phase.

In the disconnected phase, the DCE may initiate data link set-up. In the disconnected phase, the DCE will react to the receipt of an SABM/SABME command as described in § 2.4.4.1 above and will transmit a DM response in answer to a received DISC command. When receiving any other command (defined, or undefined or not implemented) with the P bit set to 1, the DCE will transmit a DM response with the F bit set to 1. Other frames received in the disconnected phase will be ignored by the DCE.

2.4.4.4.2   When the DCE enters the disconnected phase after detecting error conditions as listed in § 2.4.6 below, or after an internal malfunction, it may indicate this by sending a DM response rather than a DISC command. In these cases, the DCE will transmit a DM response and start its Timer T1 (see § 2.4.8.1 below).

If Timer T1 runs out before the reception of an SABM/SABME or DISC command from the DTE, the DCE will retransmit the DM response and restart Timer T1. After transmission of the DM response N2 times, the DCE will remain in the disconnected phase and appropriate recovery actions will be initiated. The value of N2 is defined in § 2.4.8.4 below.

Alternatively, after an internal malfunction, the DCE may either initiate a link resetting procedure (see § 2.4.7 below) or disconnect the data link (see § 2.4.4.3 above) prior to initiating a link set-up procedure (see § 2.4.4.1 above).

2.4.4.5   Collision of unnumbered commands

Collision situations shall be resolved in the following way:

2.4.4.5.1   If the sent and received unnumbered commands are the same, the DCE and the DTE shall each send the UA response at the earliest possible opportunity. The DCE shall enter the indicated phase either:

(1) After receiving the UA response;
(2) After sending the UA response; or
(3) After timing out waiting for the UA response having sent a UA response.

In the case of (2) above, the DCE will accept a subsequent UA response to the mode-setting command it issued without causing an exception condition if received within the time-out interval.

2.4.4.5.2   If the sent and received unnumbered commands are different, the DCE and the DTE shall each enter the disconnected phase and issue a DM response at the earliest possible opportunity.

2.4.4.6   Collision of DM response with SABM/SABME or DISC command

When a DM response is issued by the DCE or DTE as an unsolicited response to request the DTE or DCE, respectively, to issue a mode-setting command as described in § 2.4.4.4, a collision between an SABM/SABME or DISC command and the unsolicited DM response may occur. In order to avoid misinterpretation of the DM response received, the DTE always sends its SABM/SABME or DISC command with the P bit set to 1.

2.4.4.7   Collision of DM responses

A contention situation may occur when both the DCE and the DTE issue a DM response to request a mode-setting command. In this case, the DTE will issue an SABM/SABME command to resolve the contention situation.

2.4.5   LAPB procedures for information transfer

The procedures which apply to the transmission of I frames in each direction during the information transfer phase are described below.

In the following, "number one higher" is in reference to a continuously repeated sequence series, i.e., 7 is 1 higher than 6 and 0 is 1 higher than 7 for modulo 8 series, and 127 is 1 higher than 126 and 0 is 1 higher than 127 for modulo 128 series.

2.4.5.1   Sending I frames

When the DCE has an I frame to transmit (i.e. an I frame not already transmitted, or having to be retransmitted as described in § 2.4.5.6 below), it will transmit it with an N(S) equal to its current send state variable V(S), and an N(R) equal to its current receive state variable V(R). At the end of the transmission of the I frame, the DCE will increment its send state variable V(S) by 1.

If Timer T1 is not running at the time of transmission of an I frame, it will be started.

If the send state variable V(S) is equal to the last value of N (R) received plus k (where k is the maximum number of outstanding I frames – see § 2.4.8.6 below), the DCE will not transmit any new I frames, but may retransmit an I frame as described in §§ 2.4.5.6 or 2.4.5.9 below.

When the DCE is in the busy condition, it may still transmit I frames, provided that the DTE is not busy. When the DCE is in the frame rejection condition, it will stop transmitting I frames.

2.4.5.2   Receiving an I frame

2.4.5.2.1   When the DCE is not in a busy condition and receives a valid I frame whose send sequence number N(S) is equal to the DCE receive state variable V(R), the DCE will accept the information field of this frame, increment by one its receive state variable V(R), and act as follows:

(a) If the DCE is still not in a busy condition:
   (i) If an I frame is available for transmission by the DCE, it may act as in § 2.4.5.1 above and acknowledge the received I frame by setting N(R) in the control field of the next transmitted I frame to the value of the DCE receive state variable V(R). Alternatively, the DCE may acknowledge the received I frame by transmitting an RR frame with the N(R) equal to the value of the DCE receive state variable V(R).
   (ii) If no I frame is available for transmission by the DCE, it will transmit an RR frame with N(R) equal to the value of the DCE receive state variable V(R).
(b) If the DCE is now in a busy condition, it will transmit an RNR frame with N(R) equal to the value of the DCE receive state variable V(R) (see § 2.4.5.8).

2.4.5.2.2   When the DCE is in a busy condition, it may ignore the information field contained in any received I frame.

2.4.5.3   Reception of invalid frames

When the DCE receives an invalid frame (see § 2.3.5.3), this frame will be discarded.

2.4.5.4   Reception of out-of-sequence I frames

When the DCE receives a valid I frame whose send sequence number N(S) is incorrect, i.e. not equal to the current DCE receive state variable V(R), it will discard the information field of the I frame and transmit an REJ frame with the N(R) set to one higher than the N(S) of the last correctly received I frame. The REJ frame will be a command frame with the P bit set to 1 if an acknowledged transfer of the retransmission request is required; otherwise the REJ frame may be either a command or a response frame. The DCE will then discard the information field of all I frames received until the expected I frame is correctly received. When receiving the expected I frame, the DCE will then acknowledge the I frame as described in § 2.3.5.2 above. The DCE will use the N(R) and P bit information in the discarded I frames as described in § 2.3.5.2 above.

2.4.5.5   Receiving acknowledgement

When correctly receiving an I frame or a supervisory frame (RR, RNR or REJ), even in the busy condition, the DCE will consider the N(R) contained in this frame as an acknowledgement for all I frames it has transmitted with an N(S) up to and including the received N(R)–1. The DCE will stop Timer T1 when it correctly receives an I frame or a supervisory frame with the N(R) higher than the last received N(R) (actually acknowledging some I frames), or an REJ frame with an N(R) equal to the last received N(R).

If Timer T1 has been stopped by the receipt on an I, RR or RNR frame, and if there are outstanding I frames still unacknowledged, the DCE will restart Timer T1, if Timer T1 then runs out, the DCE will follow the recovery procedure (§ 2.4.5.9 below) with respect to the unacknowledged I frames. If Timer T1 has

been stopped by the receipt of an REJ frame, the DCE will follow the retransmission procedures in § 2.4.5.6 below.

2.4.5.6   Receiving an REJ frame

When receiving an REJ frame, the DCE will set its send state variable V(S) to the N(R) received in the REJ control field. It will transmit the corresponding I frame as soon as it is available or retransmit it in accordance with the procedures described in § 2.4.5.1 above. (Re)transmission will conform to the following procedure:

(i)   If the DCE is transmitting a supervisory command or response when it receives the REJ frame, it will complete that transmission before commencing transmission of the requested I frame;

(ii) If the DCE is transmitting an unnumbered command or response when it receives the REJ frame, it will ignore the request for retransmission;

(iii) If the DCE is transmitting an I frame when the REJ frame is received, it may abort the I frame and commence transmission of the requested I frame immediately after abortion;

(iv) If the DCE is not transmitting any frame when the REJ frame is received, it will commence transmission of the requested I frame immediately.

In all cases, if other unacknowledged I frames had already been transmitted following the one indicated in the REJ frame, then those I frames will be retransmitted by the DCE following the retransmission of the requested I frame. Other I frames not yet transmitted may be transmitted following the retransmitted I frames.

If the REJ frame was received from the DTE as a command with the P bit set to 1, the DCE will transmit an RR, RNR or REJ response with the F bit set to 1 before transmitting the corresponding I frame.

2.4.5.7   Receiving an RNR frame

After receiving an RNR frame whose N(R) acknowledges all frames previously transmitted, the DCE will stop Timer T1 and may then transmit an I frame, with the P bit set to 0, whose send sequence number is equal to the N(R) indicated in the RNR frame, restarting Timer T1 as it does. After receiving an RNR frame whose N(R) indicates a previously transmitted frame, the DCE will not transmit or retransmit any I frame, Timer T1 being already running. In either case, if the Timer T1 runs out before receipt of a busy clearance indication, the DCE will follow the procedures described in § 2.4.5.9 below. In any case, the DCE will not transmit any other I frames before receiving an RR of REJ frame or before the completion of a data link resetting procedure.

Alternatively, after receiving an RNR frame, the DCE may wait for a period of time (e.g. the length of the Timer T1) and then transmit a supervisory command frame (RR, RNR or REJ) with the P bit set to 1, and start Timer T1, in order to determine if there is any change in the receive status of the DTE. The DTE shall respond to the P bit set to 1 with a supervisory response frame (RR, RNR or REJ) with the F bit set to 1 indicating either continuance of the busy condition (RNR) or clearance of the busy condition (RR or REJ). Upon receipt of the DTE response, Timer T1 is stopped.

(1)   If the response is the RR or REJ response, the busy condition is cleared and the DCE may transmit I frames beginning with the I frame identified by the N(R) in the received response frame;

(2)   If the response is the RNR response, the busy condition still exists, and the DCE will after a period of time (e.g. the length of Timer T1) repeat the enquiry of the DTE receive status.

Timer T1 runs out before a status response is received, the enquiry process above is repeated. If N2 attempts to get a status response fail (i.e. Timer T1 runs out N2 times), the DCE will initiate a data link resetting procedure as described in § 2.4.7.2 below or will transmit a DM response to ask the DTE to initiate a data link set-up procedure as described in § 2.4.4.1 and enter the disconnected phase. The value of N2 is defined in § 2.4.8.4 below.

If, at any time during the enquiry process, an unsolicited RR or REJ frame is received form the DTE, it will be considered to be an indication of clearance of the busy condition. Should the unsolicited RR or REJ frame be a command frame with the P bit set to 1 the appropriate response frame with the F bit set to 1 must be transmitted before the DCE may resume transmission of I frames. If Timer T1 is running, the DCE will wait for the non-busy response with the F bit set to 1 or will wait for Timer T1 to run out and then may either reinitiate the enquiry process in order to realize a successful P/F bit exchange or resume transmission of I frames beginning with the I frame identified by the N(R) in the received RR or REJ frame.

2.4.5.8   DCE busy condition

When the DCE enters a busy condition, it will transmit an RNR frame at the earliest opportunity. The RNR frame will be a command frame with the P bit set to 1 if an acknowledged transfer of the busy condition indication is required; otherwise the RNR frame may be either a command or a response frame. While in the busy condition, the DCE will accept and process supervisory frames, will accept and process the contents of the N(R) fields of I frames, and will return an RNR response with the F bit set to 1 if it receives a supervisory command or I command frame with the P bit set to 1. To clear the busy condition, the DCE will transmit either an REJ frame or an RR frame, with N(R) set to the current receive state variable V(R), depending on whether or not it discarded information fields of correctly received I frames. The REJ frame or the RR frame will be a command frame with the P bit set to 1 an acknowledged transfer of the busy-to-non-busy transition is required, otherwise the REJ frame or the RR frame may be either a command or a response frame.

2.4.5.9   Waiting acknowledgement

The DCE maintains an internal transmission attempt variable which is set to 0 when the DCE sends a UA response, when the DCE receives a UA response or an RNR command or response, or when the DCE correctly receives an I frame or supervisory frame with the N(R) higher than the last received N(R) (actually acknowledging some outstanding I frames).

If Timer T1 runs out waiting for the acknowledgement from the DTE for an I frame transmitted, the DCE will enter the timer recovery condition, add one to its transmission attempt variable and set an internal variable x to the current value of its send state variable V(S). The DCE will then restart Timer T1, set its send state variable V(S) to the last value of N(R) received form the DTE and retransmit the corresponding I frame with the P bit set to 1, or transmit an appropriate supervisory command frame (RR, RNR or REJ) with the P bit set to 1.

The timer recovery condition is cleared when the DCE receives a valid supervisory frame with the F bit set to 1.

If, while in the timer recovery condition, the DCE correctly receives a supervisory frame with the F bit set to 1 and with the N(R) within the range from its current send state variable V(S) to x included, it will clear the timer recovery condition (including stopping Timer T1) and set its send state variable V(S) to the value of the received N(R), and may then resume with I frame transmission or retransmission, as appropriate.

If, while in the timer recovery condition, the DCE correctly receives an I or supervisory frame with the P/F bit set to 0 with a valid N(R) (see § 2.3.4.9), it will not clear the timer recovery condition. The value of the received N(R) may be used to update the send state variable V(S). However, the DCE may decide to keep the last transmitted I frame in store (even if it is acknowledged) in order to be able to retransmit it with the P bit set to 1 when Timer T1 runs out at a later time.

If the received supervisory frame with the P/F bit set to 0 is an REJ frame with a valid N(R), the DCE may either immediately initiate (re)transmission from the value of the send state variable V(S), or it may ignore the request for retransmission and wait until the supervisory frame with the F bit set to 1 is received before initiating (re)transmission of frames from the value identified in the N(R) field of the supervisory frame with the F bit set to 1. In the case of immediate retransmission, in order to prevent duplicate retransmissions following the clearance of the timer recovery condition, the DCE shall inhibit retransmission of a specific I frame [same N(R) in the same numbering cycle] if the DCE has retransmitted that I frame as the result of a received REJ frame with the P/F bit set to 0.

If, while in the timer recovery condition, the DCE receives a REJ command with the P bit set to 1, the DCE will respond immediately with an appropriate supervisory response with the F bit set to 1. The DCE may then use the value of the N(R) in the REJ command to update the send state variable V(S), and may either immediately begin (re)transmission from the value N(R) indicated in the REJ frame or ignore the request for retransmission and wait until the supervisory frame with the F bit set to 1 is received before initiating (re)transmission of I frames form the value identified in the N(R) field of the supervisory frame with the F bit set to 1. In the case of immediate retransmission, in order to prevent duplicate retransmissions following the clearance of the timer recovery condition, the DCE shall inhibit retransmission of a specific I frame [same N(R) in the same numbering cycle] if the DCE has retransmitted that I frame as the result of the received REJ command with the P bit set to 1.

If Timer T1 runs out in the timer recovery condition, and no I or supervisory frame with the P/F bit set to 0 and with a valid N(R) has been received, or no REJ command with the P bit set to 1 and

with a valid N(R) has been received, the DCE will add one to its transmission attempt variable, restart Timer T1, and either retransmit the I frame sent with the P bit set to 1 or transmit an appropriate supervisory command with the P bit set to 1.

If the transmission attempt variable is equal to N2, the DCE will initiate a data link resetting procedure as described in § 2.4.7.2 below, or will transmit a DM response to ask the DTE to initiate a data link set-up procedure as described in § 2.4.4.1 above and enter the disconnected phase. N2 is a system parameter (see § 2.4.8.4 below).

Note: Although the DCE may implement the internal variable x, other mechanisms do exist that achieve the identical function.

2.4.6   LAPB conditions for link resetting or link-re-initialization (link set-up)

2.4.6.1   When the DCE receives, during the information transfer phase, a frame which is not invalid (see § 2.3.5.3) with one of the conditions listed in § 2.3.4.9 above, the DCE will request the DTE to initiate a link resetting procedure by transmitting an FRMR response to the DTE as described in § 2.4.7.3.

2.4.6.2   When the DCE receives, during the information transfer phase, an FRMR response from the DTE, the DCE will either initiate the link resetting procedures itself as described in § 2.4.7.2 or return a DM response to ask the DTE to initiate the link set-up (initialization) procedure as described in § 2.4.4.1. After transmitting a DM response, the DCE will enter the disconnected phase as described in § 2.4.4.4.2.

2.4.6.3   When the DCE receives, during the information transfer phase, a UA response, or an unsolicited response with the F bit set to 1, the DCE may either initiate the link resetting procedures itself as described in § 2.4.7.2, or return a DM response to ask the DTE to initiate the link set-up (initialization) procedure as described in § 2.4.4.1. After transmitting a DM response, the DCE will enter the disconnected phase as described in § 2.4.4.4.2.

2.4.6.4   When the DCE receives, during the information transfer phase, a DM response from the DTE, the DCE will either initiate the link set-up (initialization) procedures itself as described in § 2.4.4.1, or return a DM response to ask the DTE to initiate the link set-up (initialization) procedures as described in § 2.4.4.1. After transmitting a DM response, the DCE will enter the disconnected phase as described in § 2.4.4.4.2.

2.4.7   LAPB procedure for data link resetting

2.4.7.1   The data link resetting procedure is used to initialize both directions of information transfer according to the procedure described below. The link resetting procedure only applies during the information transfer phase.

2.4.7.2   Either the DTE or the DCE may initiate the link resetting procedure. The data link resetting procedure indicates a clearance of a DCE and/or DTE busy condition, if present.

The DTE shall initiate a data link resetting by transmitting an SABM/SABME command to the DCE. If, upon correct receipt of the SABM/SABME command, the DCE determines that it can continue in the information transfer phase, it will return a UA response to the DTE, will reset its send and receive state variables V(S) and V(R) to zero, and will remain in the information transfer phase. If, upon correct receipt of the SABM/SABME command, the DCE determines that it cannot remain in the information transfer phase, it will return a DM response as a denial to the resetting request and will enter the disconnected phase.

The DCE will initiate a data link resetting by transmitting an SABM/SABME command to the DTE and starting its Timer T1 (see § 2.4.8.1 below). Upon reception of a UA response from the DTE, the DCE will reset its send and receive state variables V(S) and V(R) to zero, will stop its Timer T1, and will remain in the information transfer phase. Upon reception of a DM response from the DTE as a denial to the data link resetting request, the DCE will stop its Timer T1 and will enter the disconnected phase.

The DCE, having sent an SABM/SABME command, will ignore and discard any frames received from the DTE except an SABM/SABME or DISC command, or a UA or DM response. The receipt of an SABM/SABME or DISC command from the DTE will result in a collision situation that is resolved per § 2.4.4.5 above. Frames other than the UA or DM response sent in response to a received SABM/SABME or DISC command will be sent only after the data link is reset and if no outstanding SABM/SAMBE command exists.

After the DCE sends the SABM/SABME command, if a UA or DM response is not received correctly, Timer T1 will run out in the DCE. The DCE will then resend the SABM/SABME command and will restart Timer T1. After N2 attempts to reset the link, the DCE will initiate appropriate higher level recovery action and will enter the disconnected phase. The value of N2 is defined in § 2.4.8.4 below.

2.4.7.3   The DCE may ask the DTE to reset the data link by transmitting an FRMR response (see § 2.4.6.1 above). After transmitting an FRMR response, the DCE will enter the frame rejection condition.

The frame rejection condition is cleared when the DCE receives an SABM/SABME command, a DISC command, a FRMR response, or a DM response; or if the DCE transmits an SABM/SABME command, a DISC command, or a DM response. Other commands received while in the frame rejection condition will cause the DCE to retransmit the FRMR response with the same information field as originally transmitted.

The DCE may start Timer T1 on transmission of the FRMR response. If Timer T1 runs out before the frame rejection condition is cleared, the DCE may retransmit the FRMR response, and restart T1. After N2 attempts (time outs) to get the DTE to reset the data link, the DCE may reset the data link itself as described in § 2.4.7.2 above. The value of N2 is defined in § 2.4.8.4 below.

In the frame rejection condition, I frames and supervisory frames will not be transmitted by the DCE. Also, received I frames and supervisory frames will be discarded by the DCE except for the observance of a P bit set to 1. When an additional FRMR response must be transmitted by the DCE as a result of the receipt of a P bit set to 1 while Timer T1 is running, Timer T1 will continue to run. Upon reception of an FRMR response (even during a frame rejection condition), the DCE will initiate a resetting procedure by transmitting an SABM/SAMBE command as described in § 2.4.7.2 above, or will transmit a DM response to ask the DTE to initiate the data link set-up procedure as described in § 2.4.4.1 and enter the disconnected phase.

2.4.8   List of LAPB system parameters

The DCE and DTE system parameters are as follows:

2.4.8.1   Timer T1

The value of the DTE Timer T1 system parameter may be different to the DCE Timer T1 system parameter. These values shall be made known to both the DTE and the DCE, and agreed to for a period of time by both the DTE and the DCE.

The period of Timer T1, at the end of which retransmission of a frame may be initiated (see § 2.4.4 and § 2.4.5 above for the DCE), shall take into account whether T1 is started at the beginning or the end of the transmission of a frame.

The proper operation of the procedure requires that the transmitter's (DCE or DTE) Timer T1 be greater than the maximum time between transmission of a frame (SABM/SABME, DISC, I or supervisory command, or DM or FRMR response) and the reception of the corresponding frame returned as an answer to that frame (UA, DM or acknowledging frame). Therefore, the receiver (DCE or DTE) should not delay the response or acknowledging frame returned to one of the above frames by more than a value T2, where T2 is a system parameter (see § 2.4.8.2).

The DCE will not delay the response or acknowledging frame returned to one of the above DTE frames by more than a period T2.

2.4.8.2   Parameter T2

The value of the DTE parameter T2 may be different to the value of the DCE parameter T2. These values shall be made known to both the DTE and the DCE, and agreed to for a period of time by both the DTE and the DCE.

The period of parameter T2 shall indicate the amount of time available at the DCE or DTE before the acknowledging frame must be initiated in order to ensure its receipt by the DTE or DCE, respectively, prior to Timer T1 running out at the DTE or DCE (parameter T2 < Timer T1).

Note: The period of parameter T2 shall take into account the following timing factors: the transmission time of the acknowledging frame, the propagation time over the access link, the stated processing times at the DCE and the DTE, and the time to complete the transmission of the frame(s) in the DCE or DTE transmit queue that are neither displaceable or modifiable in an orderly manner.

Given a value for Timer T1 for the DTE or DCE, the value of parameter T2 at the DCE or DTE, respectively, must be no larger than T1 minus 2 times the propagation time over the access data link, minus the frame processing time at the DCE, minus the frame processing time at the DTE, and minus the transmission time of the acknowledging frame by the DCE or DTE, respectively.

2.4.8.3   Timer T3

The DCE shall support a Timer T3 system parameter, the value of which shall be made known to the DTE.

The period of Timer T3, at the end of which an indication of an observed excessively long idle channel state is passed to the Packet Layer shall be sufficiently greater than the period of the DCE Timer T1 (i.e T3 > T1) so that the expiration of T3 provides the desired level of assurance that the data link channel is in a non-active, non-operational state, and is in need of link set-up before normal data link operation can resume.

2.4.8.4   Maximum number of attempts to complete a transmission N2

The value of the DTE N2 system parameter may be different to the value of the DCE N2 system parameter. These values shall be made known to both the DTE and the DCE, and agreed to for a period of time by both the DTE and the DCE.

The value of N2 shall indicate the maximum number of attempts made by the DCE or DTE to complete the successful transmission of a frame to the DTE or DCE, respectively.

2.4.8.5   Maximum number of bits in an I frame N1

The value of the DTE N1 system parameter may be different to the value of the DCE N1 system parameter. These values shall be made known to both the DTE and the DCE.

The values of N1 shall indicate the maximum number of bits in an I frame (excluding flags and 0 bits inserted for transparency) that the DCE or DTE is willing to accept from the DTE or DCE, respectively.

In order to allow for universal operation, a DTE should support a value of DTE N1 which is not less than 1080 bits (135 octets). DTEs should be aware that the network may transmit longer packets (see § 5.2), that may result in a link level problem.

All networks shall offer to a DTE which requires it, a value of DCE N1 which is greater than or equal to 2072 bits (259 octets) plus the length of the address, control and FCS fields at the DTE/DCE interface, and greater than or equal to the maximum length of the data packets which may cross the DTE/DCE interface plus the length of the address, control and FCS fields at the DTE/DCE interface.

Appendix II provides a description of how the values stated above are derived.

2.4.8.6   Maximum number of outstanding I frames k

The value of the DTE k system parameter shall be the same as the value of the DCE k system parameter. This value shall be agreed to for a period of time by both the DTE and the DCE.

The value of k shall indicate the maximum number of sequentially numbered I frames that the DTE or DCE may have outstanding (i.e. unacknowledged) at any given time. The value of k shall never exceed seven for modulo 8 operation, or one hundred and twenty-seven for modulo 128 operation. All networks (DCEs) shall support a value of seven. Other values of k (less than and greater than seven) may also be supported by networks (DCEs).

[. . .]

3.   DESCRIPTION OF THE PACKET LAYER DTE/DCE INTERFACE

This and subsequent sections of the Recommendation relate to the transfer of packets at the DTE/DCE interface. The procedures apply to packets which are successfully transferred across the DTE/DCE interface.

Each packet to be transferred across the DTE/DCE interface shall be contained within the data link layer information field which will delimit its length, and only one packet shall be contained in the information field.

Note: Some networks require the data fields of packets to contain an integral number of octets. The transmission by the DTE of data fields not containing an integral number of octets to the network may cause a loss of data integrity. DTEs wishing universal operation on all networks should transmit all packets with data

fields containing only an integral number of octets. Full data integrity can only be assured by exchange of octet-oriented data fields in both directions of transmission.

This section covers a description of the packet layer interface for virtual call and permanent virtual circuit services.

Procedures for the virtual circuit service (i.e., virtual call and permanent virtual circuit services) are specified in § 4. Packet formats are specified in § 5. Procedures and formats for optional user facilities are specified in §§ 6 and 7.

3.1   Logical channels

To enable simultaneous virtual calls and/or permanent virtual circuits, logical channels are used. Each virtual call or permanent virtual circuit is assigned a logical channel group number (less than or equal to 15) and a logical channel number (less than or equal to 255). For virtual calls, a logical channel group number and a logical channel number are assigned during the call set-up phase. The range of logical channels used for virtual calls is agreed with the Administration at the time of subscription to the service (see Annex A). For permanent virtual circuits, logical channel group numbers and logical channel numbers are assigned in agreement with the Administration at the time of subscription to the service (see Annex A).

3.2   Basic structure of packets

Every packet transferred across the DTE/DCE interface consists of at least three octets. These three octets contain a general format identifier, a logical channel identifier and a packet type identifier. Other packet fields are appended as required (see § 5).

Packet types and their use in association with various services are given in Table 14/X.25.

3.3   Procedure for restart

The restart procedure is used to initialize or re-initialize the packet layer DTE/DCE interface. The restart procedure simultaneously clears all the virtual calls and resets all the permanent virtual circuits at the DTE/DCE interface (see § 4.5).

Figure B-1/X.25 gives the state diagram which defines the logical relationships from the DTE for the restart procedure.

3.3.1   Restart by the DTE

The DTE may at any time request a restart by transferring across the DTC/DCE interface a restart request packet. The interface for each logical channel is then in the DTE restart request state (r2).

The DCE will confirm the restart by transferring a DCE restart confirmation packet and placing the logical channels used for virtual calls in the ready state (p1), and the logical channels used for permanent virtual circuits in the flow control ready state (d1).

Note: States p1 and d1 are specified in § 4.

The DCE restart confirmation packet can only be interpreted universally as having local significance. The time spent in the DTE restart request state (r2) will not exceed time-limit T20 (see Annex D).

3.3.2   Restart by the DCE

The DCE may indicate a restart by transferring across the DTE/DCE interface a restart indication packet. The interface for each logical channel is then in the DCE restart indication state (r3). In this state of the DTE/DCE interface, the DCE will ignore all packets except for restart request and DTE restart confirmation.

The DTE will confirm the restart by transferring a DTE restart confirmation packet and placing the logical channels used for virtual calls in the ready state (p1), and the logical channels used for permanent virtual circuits in the flow control ready state (d1).

The action taken by the DCE when the DTE does not confirm the restart within time-out T10 is given in Annex D.

3.3.3   Restart collision

Restart collision occurs when a DTE and a DCE simultaneously transfer a restart request and a restart indication packet. Under these circumstances, the DCE will consider that the restart is completed. The DCE will not expect a DTE restart confirmation packet and will not transfer a DCE restart confirmation packet. This places the logical channels used for virtual calls in the ready state (p1), and the logical channels used for permanent virtual circuits in the flow control ready state (d1).

3.4   Error handling

Table C-1/X.25 specifies the reaction of the DCE when special error conditions are encountered. Other error conditions are discussed in § 4.

3.4.1   Diagnostic packet

The diagnostic packet is used by some networks to indicate error conditions under circumstances where the usual methods of indication (i.e., reset, clear and restart with cause and diagnostic) are inappropriate (see Tables C-1/X.25 and D-1/X.25). The diagnostic packet from the DCE supplies information on error situations which are considered unrecoverable at the packet layer of Recommendation X.25; the information provided permits an analysis of the error and recovery by higher layers at the DTE if desired or possible.

A diagnostic packet is issued only once per particular instance of an error condition. No confirmation is required to be issued by the DTE on receipt of a diagnostic packet.

Table 14/X.25 – Packet types and their use in various services

Packet type		Service	
From DCE to DTE	*From DCE to DTE*	*VC*	*PVC*
Call set/up and clearing (see Note 1)			
Incoming call	Call request	X	
Call connected	Call accepted	X	
Clear indication	Clear request	X	
Data and interrupt (see Note 2)			
DCE data	DTE data	X	X
DCE interrupt	DTE interrupt	X	X
DCE interrupt confirmation	DTE interrupt confirmation	X	X
Flow control and reset (see Note 3)			
DCE RR	DTE RR	X	X
DCE RNR	DTE RNR	X	X
	DTE REJ[a]	X	X
Reset indication	Reset request	X	X
DCE reset confirmation	DTE reset confirmation	X	X
Restart (see Note 4)			
Restart indication	Restart request	X	X
DCE restart confirmation	DTE restart confirmation	X	X
Diagnostic (see Note 5)			
Diagnostic[a]		X	X
Registration[a] (see Note 6)			
Registration confirmation		X	X
	Registration request	X	X

[a] Not necessarily available on all networks.
VC   Virtual call
PVC   Permanent virtual circuit
Note 1 – See §§ 4.1 and 6.16 for procedures, § 5.2 for formats.
Note 2 – See § 4.3 for procedures and § 5.3 for formats
Note 3 – See §§ 4.4 and 6.4 for procedures, §§ 5.4 and 5.7.1 for formats.
Note 4 – See § 3.3 for procedures, § 5.5 for formats.
Note 5 – See § 3.4 for procedures and § 5.6 for formats
Note 6 – See § 6.1 for procedures, § 5.7.2 for formats.

4.   PROCEDURES FOR VIRTUAL CIRCUIT SERVICES

4.1   Procedures for virtual call service

Figure B-1/X.25, B-2/X.25 and B-3/X.25 show the state diagrams which define the events at the packet layer DTE/DCE interface for each logical channel used for virtual calls.

Annex C gives details of the action taken by the DCE on receipt of packets in each state shown in Annex B.

The call set-up and clearing procedures described in the following points apply independently to each logical channel assigned to the virtual call service at the DTE/DCE interface.

4.1.1   Ready state

If there is no call in existence, a logical channel is in the ready state (p1).

4.1.2   Call request packet

The calling DTE shall indicate a call request by transferring a call request packet across the DTE/DCE interface. The logical channel selected by the DTE is then in the DTE waiting state (p2). The call request packet includes the called DTE address.

Note 1: A DTE address may be a DTE network address or any other DTE identification agreed for a period of time between the DTE and the DCE.

Note 2: The call request packet should use the logical channel in the ready state with the highest number in the range which has been agreed with the Administration (see Annex A). Thus the risk of call collision is minimized.

4.1.3   Incoming call packet

The DCE will indicate that there is an incoming call by transferring across the DTE/DCE interface an incoming call packet. This places the logical channel in the DCE waiting state (p3).

The incoming call packet will use the logical channel in the ready state with the lowest number (see Annex A). The incoming call packet includes the calling DTE address.

Note: A DTE address may be a DTE network address or any other DTE identification agreed for a period of time between the DTE and the DCE.

4.1.4   Call accepted packet

The called DTE shall indicate its acceptance of the call by transferring across the DTE/DCE interface a call accepted packet specifying the same logical channel as that of the incoming call packet. This places the specified logical channel in the data transfer state (p4).

If the called DTE does not accept the call by a call accepted packet or does not reject it by a clear request packet as described in § 4.1.7 within time-out T11 (see Annex D), the DCE will consider it as a procedure error from the called DTE and will clear the virtual call according to the procedure described in § 4.1.8.

4.1.5   Call connected packet

The receipt of a call connected packet by the calling DTE specifying the same logical channel as that specified in the call request packet indicates that the call has been accepted by the called DTE by means of a call accepted packet. This places the specified logical channel in the data transfer state (p4).

The time spent in the DTE waiting state (p2) will not exceed time-limit T21 (see Annex D).

4.1.6   Call collision

Call collision occurs when a DTE and DCE simultaneously transfer a call request packet and an incoming call packet specifying the same logical channel. The DCE will proceed with the call request and cancel the incoming call.

4.1.7   Clearing by the DTE

At any time, the DTE may indicate clearing by transferring across the DTE/DCE interface a clear request packet (see § 4.5). The logical channel is then in the DTE clear request state (p6). When the DCE is prepared to free the logical channel, the DCE will transfer across the DTE/DCE interface a DCE clear confirmation packet specifying the logical channel. The logical channel is then in the ready state (p1).

The DCE clear confirmation packet can only be interpreted universally as having local significance; however, within some Administrations' networks, clear confirmation may have end-to-end significance. In all cases, the time spent in the DTE clear request state (p6) will not exceed time-limit T23 (see Annex D).

It is possible that subsequent to transferring a clear request packet the DTE will receive other types of packets, depending upon the state of the logical channel, before receiving a DCE clear confirmation packet.

Note: The calling DTE may abort a call by clearing it before it has received a call connected or clear indication packet.

The call DTE may refuse an incoming call by clearing it as described in this point rather than transmitting a call accepted packet as described in § 4.1.4.

4.1.8 Clearing by the DCE

The DCE will indicate clearing by transferring across the DTE/DCE interface a clear indication packet (see § 4.5). The logical channel is then in the DCE clear indication state (p7). The DTE shall respond by transferring across the DTE/DCE interface a DTE clear confirmation packet. The logical channel is then in the ready state (p1).

The action taken by the DCE when the DTE does not confirm clearing within time-out T13 is given in Annex D.

4.1.9 Clear collision

Clear collision occurs when a DTE and DCE simultaneously transfer a clear request packet and a clear indication packet specifying the same logical channel. Under these circumstances, the DCE will consider that the clearing is completed. The DCE will not expect a DTE clear confirmation packet and will not transfer a DCE clear confirmation packet. This places the logical channel in the ready state (p1).

4.1.10 Unsuccessful call

If a call cannot be established, the DCE will transfer a clear indication packet specifying the logical channel indicated in the call request packet.

4.1.11 Call progress signals

The DCE will be capable of transferring to the DTE clearing call progress signals as specified in Recommendation X.96.

Clearing call progress signals will be carried in clear indication packets which will terminate the call to which the packet refers. The method of coding clear indication packets containing call progress signals is detailed in § 5.2.4.

4.1.12 Data transfer state

The procedures for the control of packets between DTE and DCE while in the data transfer state are contained in § 4.3.

4.2 Procedures for permanent virtual circuit service

Figures B-1/X.25 and B-3/X.25 show the state diagrams which give a definition of events at the packet layer DTE/DCE interface for logical channels assigned for permanent virtual circuits.

Annex C gives details of the action taken by the DCE on receipt of packets in each state shown in Annex B.

For permanent virtual circuits, there is no call set-up or clearing. The procedures for the control of packets between DTE and DCE while in the data transfer state are contained in § 4.3.

If a momentary failure occurs within the network, the DCE will reset the permanent virtual circuit as described in § 4.3.3, with the cause "Network congestion", and then will continue to handle data traffic.

If the network has a temporary inability to handle data traffic, the DCE will reset the permanent virtual circuit with the cause "Network out of order". When the network is again able to handle data traffic, the DCE should reset the permanent virtual circuit with the cause "Network operational".

4.3   Procedures for data and interrupt transfer

The data transfer and interrupt procedures described in this section apply independently to each logical channel assigned for virtual calls or permanent virtual circuits existing at the DTE/DCE interface.

Normal network operation dictates that user data in data and interrupt packets are all passed transparently, unaltered through the network in the case of packet DTE to packet DTE communications. The order of bits in data and interrupt packets is preserved. Packet sequences are delivered as complete packet sequences. DTE diagnostic codes are treated as described in §§ 5.2.4, 5.4.3 and 5.5.1.

4.3.1   States for data transfer

A virtual call logical channel is in the data transfer state (p4) after completion of call establishment and prior to a clearing or a restart procedure. A permanent virtual circuit logical channel is continually in the data transfer state (p4) except during the restart procedure. Data, interrupt, flow control and reset packets may be transmitted and received by a DTE in the data transfer state of a logical channel at the DTE/DCE interface. In this state, the flow control and reset procedures described in § 4.4 apply to data transmission on that logical channel to and from the DTE.

When a virtual call is cleared, data and interrupt packets may be discarded by the network (see § 4.5). In addition, data, interrupt, flow control and reset packets transmitted by a DTE will be ignored by the DCE when the logical channel is in the DCE clear indication state (p7). Hence it is left to the DTE to define DTE to DTE protocols able to cope with the various possible situations that may occur.

4.3.2   User data field length of data packets

The standard maximum user data field length is 128 octets.

In addition, other maximum user data field lengths may be offered by Administrations from the following list: 16, 32, 64, 256, 512, 1024, 2048 and 4096 octets. An optional maximum user data field length may be selected for a period of time as the default maximum user data field length common to all virtual calls at the DTE/DCE interface (see § 6.9). A value other than the default may be selected for a period of time for each permanent virtual circuit (see § 6.9). Negotiation of maximum user data field lengths on a per call basis may be made with the flow control parameter negotiation facility (see § 6.12).

The user data field of data packets transmitted by a DTE or DCE may contain any number of bits up to the agreed maximum.

Note: Some networks require the user data field to contain an integral number of octets (see the note in § 3).

If the user data field in a data packet exceeds the locally permitted maximum user data field length, then the DCE will reset the virtual call or permanent virtual circuit with the resetting cause "Local procedure error".

4.3.3   Delivery confirmation bit

The setting of the Delivery Confirmation bit (D bit) is used to indicate whether or not the DTE wishes to receive an end-to-end acknowledgement of delivery, for data it is transmitting, by means of the packet receive sequence number P(R) (see § 4.4).

Note: The use of the D bit procedure does not obviate the need for a higher layer protocol agreed between the communicating DTEs which may be used with or without the D bit procedure to recover from user or network generated resets and clearings.

The calling DTE may, during call establishment, ascertain that the D bit procedure can be used for the call by setting bit 7 in the General Format Identifier of the call request packet to 1 (see § 5.1.1). Every network or part of the international network will pass this bit transparently. If the remote DTE is able to handle the D bit procedure, it should not regard this bit being set to 1 in the incoming call packet as invalid.

Similarly, the called DTE can set bit 7 in the General Format Identifier of the call accepted packet to 1. Every network or part of the international network will pass this bit transparently. If the calling DTE is able to handle the D bit procedure, it should not regard this bit being set to 1 in the call connected packet as invalid.

The use by DTEs of the above mechanism in the call request and call accepted packets is recommended but is not mandatory for using the D bit procedure during the virtual call.

4.3.4   More data mark

If a DTE or DCE wishes to indicate a sequence of more than one packet, it uses a more data mark (M bit) as defined below.

The M bit can be set to 1 in any data packet. When it is set to 1 in a full data packet or in a partially full data packet also carrying the D bit set to 1, it indicates that more data is to follow. Recombination with the following data packet may only be performed within the network when the M bit is set to 1 in a full data packet which also has the D bit set to 0.

A sequence of data packets with every M bit set to 1 except for the last one will be delivered as a sequence of data packets with the M bit set to 1 except for the last one when the original packets having the M bit set to 1 are either full (irrespective of the setting of the D bit) or partially full but have the D bit set to 1.

Two categories of data packets, A and B, have been defined as shown in Table 15/X.25. Table 15/X.25 also illustrates the network's treatment of the M and D bits at both ends of a virtual call or permanent virtual circuit.

Table 15/X.25 – Definition of two categories of data packets and network
treatment of the M and D bits

Data packet sent by source DTE				Combining with subsequent packet(s) is performed by the network when possible	Data packet[a] received by destination DTE	
Category	M	D	Full		M	D
B	0 or 1	0	No	No	0 (see Note 1)	0
B	0	1	No	No	0	1
B	1	1	No	No	1	1
B	0	0	Yes	No	0	0
B	0	1	Yes	No	0	1
A	1	0	Yes	Yes (see Note 2)	1	0
B	1	1	Yes	No	1	1

[a] Refers to the delivered data packet whose last bit of user data corresponds to the last bit of user data, if any, that was present in the data packet sent by the source DTE.

Note 1:   The originating network will force the M bit to 0.

Note 2:   If the data packet sent by the source DTE is combined with other packets, up to and including a category B packet, the M and D bit settings in the data packet received by the destination DTE will be according to that given in the two right hand columns for the last data packet sent by the source DTE that was part of the combination.

4.3.5   Complete packet sequence

A complete packet sequence is defined as being composed of a single category B packet and all contiguous preceding category A packets (if any). Category A packets have the exact maximum user data field length with the M bit set to 1 and the D bit set to 0. All other data packets are category B packets.

When transmitted by a source DTE, a complete packet sequence is always delivered to the destination DTE as a single complete packet sequence.

Thus, if the receiving end has a larger maximum user data field length than the transmitting end, then packets within a complete packet sequence will be combined within the network. They will be delivered in a complete packet sequence where each packet, except the last one, has the exact maximum user data field length, the M bit set to 1, and the D bit set to 0. The user data field of the last packet of the sequence may have less than the maximum length and the M and D bits are set as described in Table 15 X.25.

If the maximum user data field length is the same at both ends, then user data fields of data packets are delivered to the receiving DTE exactly as they have been received by the network, except as

follows. If a full packet with the M bit set to 1 and D bit set to 0 is followed by an empty packet, then the two packets may be merged so as to become a single category B full packet. If the last packet of a complete packet sequence transmitted by the source DTE has user data field less than the maximum length, the M bit set to 1 and the D bit set to 0, then the last packet of the complete packet sequence delivered to the receiving DTE will have the M bit set to 0.

If the receiving end has a smaller maximum user data field length than the transmitting end, the packets will be segmented within the network, and the M and d bits will be set by the network as described to maintain complete packet sequences.

4.3.6   Qualifier bit

In some cases, an indicator may be needed with the user data field to distinguish between two types of information. It may be necessary to differentiate, for example, between user data and control information. An example of such a case is contained in Recommendation X.29.

If such a mechanism is needed, an indicator in the data packet header called the Qualifier bit (Q bit) may be used.

The use of the Q bit is optional. If this mechanism is not needed, the Q bit is always set to 0. If the Q bit mechanism is used, the transmitting DTE should set the Q bit so as to have the same value (i.e. 0 or 1) in all data packets of the same complete packet sequence. A complete packet sequence transferred by the DTE to the DCE in this fashion will be delivered to the distant DTE as a complete packet sequence having the Q bit set in all packets to the value assigned by the transmitting DTE.

If the Q bit is not set by the DTE to the same value in all the data packets of a complete packet sequence, the value of the Q bit in any of the data packets of the corresponding packet sequence transferred to the distant DTE is not guaranteed by the network. Moreover, some networks may reset the virtual call or permanent virtual circuit as described in Annex C/X.25.

Successive data packets are numbered consecutively (see § 4.4.1.1) regardless of the value of the Q bit.

4.3.7   Interrupt procedure

The interrupt procedure allows a DTE transmit data to the remote DTE, without following the flow control procedure applying to data packets (see § 4.4). The interrupt procedure can only apply in the flow control ready state (d1) within the data transfer state (p4).

The interrupt procedure has no effect on the transfer and flow control procedures applying to the data packets on the virtual call or permanent virtual circuit.

To transmit an interrupt, a DTE transfers across the DTE/DCE interface a DTE interrupt packet. The DTE should not transmit a second DTE interrupt packet until the first one is confirmed with a DCE interrupt confirmation packet (see Table C-4/X.25). The DCE, after the interrupt procedure is completed at the remote end, will confirm the receipt of the interrupt by transferring a DCE interrupt confirmation packet. The receipt of a DCE interrupt confirmation packet indicates that the interrupt has been confirmed by the remote DTE by means of a DTE interrupt confirmation packet.

The DCE indicates an interrupt from the remote DTE by transferring across the DTE/DCE interface a DCE interrupt packet containing the same data field as in the DTE interrupt packet transmitted by the remote DTE. A DCE interrupt packet is delivered at or before the point in the stream of data packets at which the DTE interrupt packet was generated. The DTE will confirm the receipt of the DCE interrupt packet by transferring a DTE interrupt confirmation packet.

4.3.8   Transit delay of data packets

Transit delay is an inherent characteristic of a virtual call or a permanent virtual circuit, common to the two directions of transmission.

This transit delay is the data packet transfer delay as defined in § 3.1/X.135, measured between boundaries B_2 and B_{n-1}, as defined in Figure 2/X.135 (that means, excluding the access lines), with the conditions given in § 3.2/X.135, and is expressed in terms of a mean value.

Selection of transit delay on a per call basis, and indication to both the calling and called DTEs of the value of transit delay applying for a given virtual call, may be made by the mean of the transit delay selection and indication facility (see § 6.27).

4.4   Procedures for flow control

§ 4.4 only applies to the data transfer state (p4) and specifies the procedures covering flow control of data packets and reset on each logical channel used for a virtual call circuit.

4.4.1   Flow control

At the DTE/DCE interface of a logical channel used for a virtual call or permanent virtual circuit, the transmission of data packets is controlled separately for each direction and is based on authorizations from the receiver.

On a virtual call or permanent virtual circuit, flow control also allows a DTE to limit the rate at which it accepts packets across the DTE/DCE interface, noting that there is a network-dependent limit on the number of data packets which may be in the network on the virtual call or permanent virtual circuit.

4.4.1.1   Numbering of data packets

Each data packet transmitted at the DTE/DCE interface for each direction of transmission in a virtual call or permanent virtual circuit is sequentially numbered.

The sequence numbering scheme of the packets is performed modulo 8. The packet sequence numbers cycle through the entire range 0 to 7. Some Administrations will provide the extended packet sequence numbering facility (see § 6.2) which, if selected, provides a sequence numbering scheme for packets being performed modulo 128. In this case, packet sequence numbers cycle through the entire range 0 to 127. The packet sequence numbering scheme, modulo 8 or 128, is the same for both directions of transmission and is common for all logical channels at the DTE/DCE interface.

Only data packets contain this sequence number called the packet send sequence number P(S).

The first data packet to be transmitted across the DTE/DCE interface for a given direction of data transmission, when the logical channel has just entered the flow control ready state (d1), has a packet send sequence number equal to 0.

4.4.1.2   Window description

At the DTE/DCE interface, a window is defined for each direction of data transmission of a logical channel used for a virtual call or permanent virtual circuit. The window is the ordered set of W consecutive packet send sequence numbers of the data packets authorized to cross the interface.

The lowest sequence number in the window is referred to as the lower window edge. When a virtual call or permanent virtual circuit at the DTE/DCE interface has just entered the flow control ready state (d1), the window related to each direction of data transmission has a lower window edge equal to 0.

The packet send sequence number of the first data packet not authorized to cross the interface is the value of the lower window edge plus W (modulo 8, or 128 when extended).

The standard window size W is 2 for each direction of data transmission at the DTE/DCE interface. In addition, other window sizes may be offered by Administrations. An optional window size may be selected for a period of time as the default window size common to all virtual calls at the DTE/DCE interface (see § 6.10). A value other than the default may be selected for a period of time for each permanent virtual circuit (see § 6.10). Negotiation of window sizes on a per call basis may be made with the flow control parameter negotiation facility (see § 6.12).

4.4.1.3   Flow control principles

When the sequence number P(S) of the next data packet to be transmitted by the DCE is within the window, the DCE is authorized to transmit this data packet to the DTE. When the sequence number P(S) of the next data packet to be transmitted by the DCE is outside of the window, the DCE will not transmit a data packet to the DTE. The DTE should follow the same procedure.

When the sequence number P(S) of the data packet received by the DCE is the next in sequence and is within the window, the DCE will accept this data packet. A received data packet containing a P(S) that is out of sequence (i.e., there is a duplicate or a gap in the P(S) numbering), outside the window, or not equal to 0 for the first data packet after entering the flow control ready state (d1) is considered by the DCE as a local procedure error. The DCE will reset the virtual call or permanent virtual circuit (see § 4.4.3). The DTE should follow the same procedure.

A number (modulo 8, or 128 when extended), referred to as a packet receive sequence number P(R), conveys across the DTE/DCE interface information from the receiver for the transmission of data packets. When transmitted across the DTE/DCE interface, a P(R) becomes the lower window edge. In this way, additional data packets may be authorized by the receiver to cross the DTE/DCE interface.

The packet receive sequence number, P(R), is conveyed in data, receive ready (RR) and receive not ready (RNR) packets.

The value of a P(R) received by the DCE must be within the range from the last P(R) received by the DCE up to and including the packet send sequence number of the next data packet to be transmitted by the DCE. Otherwise, the DCE will consider the receipt of this P(R) as a procedure error and will reset the virtual call or permanent virtual circuit. The DTE should follow the same procedure.

The receive sequence number P(R) is less than or equal to the sequence number of the next expected data packet and implies that the DTE or DCE transmitting P(R) has accepted at least all data packets numbered up to and including P(R)-1.

4.4.1.4   Delivery confirmation

When the D bit is set to 0 in a data packet having P(S) = p, the significance of the returned P(R) corresponding to that data packet (i.e., P(R) ≥ p + 1) is a local updating of the window across the packet layer interface so that the achievable throughput is not constrained by the DTE to DTE round trip delay across the network(s).

When the D bit is set to 0 in a data packet, the returned P(R) corresponding to that data packet does not signify that a P(R) has been received from the remote DTE.

When the D bit is set to 1 in a data packet having P(S) = p, the significance of the returned P(R) corresponding to that data packet (i.e., P(R) ≥ + 1) is an indication that a P(R) has been received from the remote DTE for all data bits in the data packet in which the D bit had originally been set to 1.

Note 1:   A DTE, on receiving a data packet with the D bit set to 1, should transmit the corresponding P(R) as soon as possible in order to avoid the possibility of deadlocks (e.g., without waiting for further data packets). A data, RR or RNR packet may be used to convey the P(R) (see Note to § 4.4.1.6). Likewise, the DCE is required to send P(R) to the DTE as soon as possible from when the P(R) is received from the remote DTE. When the DTE is not currently operating the D bit procedure, the receipt of a data packet with the D bit set to 1 may be treated by the DTE as an error condition.

Note 2:   If a P(R) for a data packet with the D bit set to 1 is outstanding, local updating of the window will be deferred for subsequent data packets with D bit set to 0. Some networks may also defer updating the window for previous data packets (within the window) with the D bit set to 0 until the corresponding P(R) for the packet with the outstanding D bit set to 1 is transmitted to the DTE.

Note 3:   P(R) values corresponding to the data contained in data packets with the D bit set to 1 need not be the same at the DTE/DCE interfaces at each end of a virtual call or a permanent virtual circuit.

Note 4:   If the DTE has sent data packets with the D bit set to 0, the DTE does not have to wait for local updating of the window by the DCE before initiating a resetting or clearing procedure.

4.4.1.5   DTE and DCE receive ready (RR) packets

RR packets are used by the DTE or DCE to indicate that it is ready to receive the W data packets within the window starting with P(R), where P(R) is indicated in the RR packet.

4.4.1.6   DTE and DCE receive not ready (RNR) packets

RNR packets are used by the DTE or DCE to indicate a temporary inability to accept additional data packets for a given virtual call or permanent virtual circuit. A DTE or DCE receiving an RNR packet shall stop transmitting data packets on the indicated logical channel, but the window is updated by the P(R) value of the RNR packet. The receive not ready situation indicated by the transmission of an RNR packet is cleared by the transmission in the same direction of an RR packet or by the initiation of a reset procedure.

The transmission of an RR packet after an RNR packet at the packet layer is not to be taken as a demand for retransmission of packets which have already been transmitted.

Note: The RNR packet may be used to convey across the DTE/DCE interface the P(R) value corresponding to a data packet which had the D bit set to 1 in the case that additional data packets cannot be accepted.

4.4.2   Throughput characteristics and throughput classes

The definitions of throughput and steady state throughput are given in § 4. of Recommendation X.135.

A throughput class for one direction of transmission is an inherent characteristic of the virtual call or permanent virtual circuit related to the amount of resources allocated to this virtual call or permanent virtual circuit. It is a measure of the steady state throughput that can be provided under optimal conditions on a virtual call or permanent virtual circuit. However, due to the statistical sharing of transmission and switching resources, it is not guaranteed that the throughput class can be reached 100% of the time.

The relations between throughput class and the throughput parameters and objectives described in Recommendation X.135 require further study. The complete definition of the optimal conditions where the measure of the steady state throughput in relation to throughput class is meaningful also requires further study. Pending the results of these further studies, it cannot be guaranteed or verified that network supporting a given throughput class value (64 kbit/s for instance) offers better performance to its users than a network not supporting that throughput class. However, a network may offer a guarantee to its users on a contractual basis.

The optimal conditions for measurement include the following:

(1)   The access line characteristics of the local and remote DTEs do not constrain the throughput class;

Note: In particular, because of the overhead due to the frame and packet headers, when the throughput class corresponding to the user class of service of the DTE is applicable to a virtual call or permanent virtual circuit, a steady state throughput equal to that throughput class can never be reached.

(2)   The window sizes at the local and remote DTE/DCE interfaces do not constrain the throughput;

(3)   The traffic characteristics of other logical channels at local and remote DTE/DCE interfaces do not constrain the throughput;

(4)   The receiving DTE is not flow controlling the DCE such that the throughput class is not attainable;

(5)   The transmitting DTE sends only data packets which have the maximum data field length;

(6)   The D bit is not set to 1.

The throughput class is expressed in bits per second. The maximum data field length is specified for a virtual call or permanent virtual circuit, and thus the throughput class can be interpreted by the DTE as the number of full data packets/second at the DTE/DCE interface.

In the absence of the default throughput classes assignment facility (see § 6.11), the default throughput classes for both directions of transmission correspond to the user class of service of the DTE (see § 7.2.2.2) but do not exceed the maximum throughput class supported by the network. Negotiation of throughput classes on a per call basis may be made with the throughput class negotiation facility (see § 6.13).

Note: The sum of the throughput classes of all virtual calls and permanent virtual circuits supported at a DTE/DCE interface may be greater than the data transmission rate of the access line.

4.4.3   Procedure for reset

The reset procedure is used to re-initialize the virtual call or permanent virtual circuit and in so doing removes in each direction all data and interrupt packets which may be in the network (see s.4.5). When a virtual call or permanent virtual circuit at the DTE/DCE interface has just been reset, the window related to each direction of data transmission has a lower window edge equal to 0, and the numbering of subsequent data packets to cross the DTE/DCE interface for each direction of data transmission shall start from 0.

The reset procedure can only apply in the data transfer state (p4) of the DTE/DCE interface. In any other state of the DTE/DCE interface, the reset procedure is abandoned. For example, when a clearing or restarting procedure is initiated, reset request and reset indication packets can be left unconfirmed.

For flow control, there are three states d1, d2 and d3 within the data transfer state (p4). They are flow control ready (d1), DTE reset request (d2), and DCE reset indication (d3) as shown in the state diagram in Figure B-3/X.25. When entering state p4, the logical channel is placed in state d1. Table C-4/X.25 specifies actions taken by the DCE on the receipt of packets from the DTE.

4.4.3.1   Reset request packet

The DTE shall indicate a request for reset by transmitting a reset request packet specifying the logical channel to be reset. This places the logical channel in the DTE reset request state (d2).

4.4.3.2   Reset indication packet

The DCE will indicate a reset by transmitting to the DTE a reset indication packet specifying the logical channel being reset and the reason for the resetting. This places the logical channel in the DCE reset indication state (d3). In this state, the DCE will ignore data, interrupt, RR and RNR packets.

4.4.3.3   Reset collision

Reset collision occurs when a DTE and a DCE simultaneously transmit a reset request packet and a reset indication packet specifying the same logical channel. Under these circumstances, the DCE will consider that the reset is completed. The DCE will not expect a DTE reset confirmation packet and will not transfer a DCE reset confirmation packet. This places the logical channel in the flow control ready state (d1).

4.4.3.4   Reset confirmation packets

When the logical channel is in the DTE reset request state (d2), the DCE will confirm reset by transmitting to the DTE a DCE reset confirmation packet. This places the logical channel in the flow control ready state (d1).

The DCE reset confirmation packet can only be interpreted universally as having local significance; however, within some Administrations' networks, reset confirmation may have end-to-end significance. In all cases the time spent in the DTE reset request state (d2) will not exceed time-limit T22 (see Annex D).

When the logical channel is in the DCE reset indication state (d3), the DTE will confirm reset by transmitting to the DCE a DTE reset confirmation packet. This places the logical channel in the flow control ready state (d1). The action taken by the DCE when the DTE does not confirm the reset within time-out T12 is given in Annex D.

4.5   Effects of clear, reset and restart procedures on the transfer of packets

All data and interrupt packets generated by a DTE (or the network) before initiation by the DTE or the DCE of a clear, reset or restart procedure at the local interface will be either delivered to the remote DTE before the DCE transmits the corresponding indication on the remote interface, or discarded by the network.

No data or interrupt packets generated by a DTE (or the network) after the completion of a reset (or for permanent virtual circuits also a restart) procedure at the local interface will be delivered to the remote DTE before the completion of the corresponding reset procedure at the remote interface.

When a DTE initiates a clear, reset or restart procedure at its local interface, all data and interrupt packets which were generated by the remote DTE (or the network) before the corresponding indication is transmitted to the remote DTE will be either delivered to the initiating DTE before DCE confirmation of the initial clear, reset or restart request, or discarded by the network.

Note: The maximum number of packets which may be discarded is a function of network end-to-end delay and throughput characteristics and, in general, has no relation to the local window size. For virtual calls and permanent virtual circuits on which all data packets are transferred with the D bit set to 1, the maximum number of packets which may be discarded in one direction of transmission is not larger than the window size of the direction of transmission.

4.6   EFFECTS OF THE PHYSICAL LAYER AND THE DATA LINK LAYER ON THE PACKET LAYER

4.6.1   General principles

In general, if a problem is detected in one layer (physical, data link or packet layer) and can be solved in this layer according to the DCE error recovery procedures provided in this Recommendation without loss or duplication of data, the adjacent layers are not involved in the error recovery.

If an error recovery by the DCE implies a possible loss or duplication of data, then the higher layer is informed.

The reinitialization of one layer by the DCE is only performed if a problem cannot be solved in this layer.

Changes of operational states of the physical layer and the data link layer of the DTE/DCE do not implicitly change the state of each logical channel at the packet layer. Such changes when they occur are explicitly indicated at the packet layer by the use of restart, clear or reset procedures as appropriate.

4.6.2   Definition of an out of order condition

In the case of a single link procedure, there is an out of order condition when:

- A failure on the physical and/or data link layer is detected: such a failure is defined as a condition in which the DCE cannot transmit or cannot receive any frame because of abnormal conditions caused by, for instance, a line default between DTE and DCE;

Note: Short physical layer outages (e.g., loss of carrier) are not considered as physical layer failures by the DCE and the data link layer and packet layer are not informed.

- The DCE has received or transmitted a DISC command.

There may be other out of order network-dependent conditions such as: reset of the data link layer, expiration of T3 timer (see § 2.4.5.3), receipt or transmission of a DM response, etc.

In the case of the Multilink procedure, an out of order condition is considered as having occurred when it is present at the same time for every single link procedure of the DTE/DCE interface. There may be other out of order network-dependent conditions such as the performance by DTE or DCE of the multilink resetting procedure (see § 2.5.4.2), loss of multilink frame(s) (see § 2.5.4.4), etc.

4.6.3   Actions on the packet layer when an out of order condition is detected

When an out of order condition is detected, the DCE will transmit to the remote end:

(1) A reset with the cause "Out of order" for each permanent virtual circuit; and
(2) A clear with the cause "Out of order" for each existing virtual call.

4.6.4   Actions on the packet layer during an out of order condition

During an out of order condition:
(1) The DCE will clear any incoming virtual call with the cause "Out of order";
(2) For any data or interrupt packet received from the remote DTE on a permanent virtual circuit, the DCE will reset the permanent virtual circuit with the cause "Out of order";
(3) A reset packet received from the remote DTE on a permanent virtual circuit will be confirmed to the remote DTE by either reset confirmation or reset indication packet.

4.6.5   Actions on the packet layer when the out of order condition is recovered

When the out of order condition is recovered:

(1) The DCE will send a restart indication packet with the cause "Network operational" to the local DTE;
(2) A reset with the cause "Remote DTE operational" will be transmitted to the remote end of each permanent virtual circuit.

5.   PACKET FORMATS

5.1   General

The possible extension of packet formats by the addition of new fields is for further study.

Note: Any such field:
(a) Would only be provided as an addition following all previously defined fields, and not as an insertion between any of the previously defined fields;
(b) Would be transmitted to a DTE only when either the DCE has been informed that the DTE is able to interpret this field and act upon it, or when the DTE can ignore the field without adversely affecting the operation of the DTE/DCE interface (including charging);
(c) Would not contain any information pertaining to a user facility to which the DTE has not subscribed, unless the DTE can ignore the facility without adversely affecting the operation of the DTE/DCE interface (including charging).

Bits of an octet are numbered 8 to 1 where bit 1 is the low order bit and is transmitted first. Octets of a packet are consecutively numbered starting from 1 and are transmitted in this order.

5.1.1 General format identifier

The general format identifier field is a four bit binary coded field which is provided to indicate the general format of the reset of the header. The general format identifier field is located in bit positions 8, 7, 6 and 5 of octet 1, and bit 5 is the low order bit (see Table 16/X.25).

Bit 8 of the general format identifier is used for the Qualifier bit in data packets, for the Address bit in call set-up and clearing packets and is set to 0 in all other packets.

Bit 7 of the general format identifier is used for the delivery confirmation procedure in data and call set-up packets and is set to 0 in all other packets.

Bits 6 and 5 are encoded for four possible indications. Two of the codes are used to distinguish packets using modulo 8 sequence numbering from packets using modulo 128 sequence numbering. The third code is used to indicate an extension to an expanded format for a family of general format identifier codes which are a subject to further study. The fourth code is reserved for other applications.

Note 1: The DTE must encode the GFI to be consistent with whether or not it has subscribed to the extended packet sequence numbering facility (see § 6.2).

Note 2: It is envisaged that other general format identifier codes could identify alternative packet formats.

Table 16/X.25 – General format identifier

General format identifier		Octet 1 bits			
		8	7	6	5
Call set/up packets	Sequence numbering scheme modulo 8	X	X	0	1
	Sequence numbering scheme modulo 128	X	X	1	0
Clearing packets	Sequence numbering scheme modulo 8	X	0	0	1
	Sequence numbering scheme modulo 128	X	0	1	0
Flow control, interrupt, reset, restart, registration and diagnostic packets	Sequence numbering scheme modulo 8	0	0	0	1
	Sequence numbering scheme modulo 128	0	0	1	0
Data packets	Sequence numbering scheme modulo 8	X	X	0	1
	Sequence numbering scheme modulo 128	X	X	1	0
General format identifierextension		0	0	1	1
Reserved for other applications		*	*	0	0

* Undefined

Note: A bit which is indicated as "X" may be set to either 0 or 1 as indicated in the text.

5.1.2 Logical channel group number

The logical channel group number appears in every packet except restart, diagnostic and registration packets in bit positions 4, 3, 2 and 1 of octet 1. For each logical channel, this number has local significance at the DTE/DCE interface.

This field is binary coded and bit 1 is the low order bit of the logical channel group number. In restart, diagnostic and registration packets, this field is coded all zeros.

5.1.3 Logical channel number

The logical channel number appears in every packet except restart, diagnostic and registration packets in all bit positions of octet 2. For each logical channel, this number has local significance at the DTE/DCE interface.

This field is binary coded and bit 1 is the low order bit of the logical channel number. In restart, diagnostic and registration packets, this field is coded all zeros.

5.1.4   Packet type identifier

Each packet shall be identified in octet 3 of the packet according to Table 17/X.25.

Table 17/X.25 – Packet type identifier

Packet type		Octet 3 bits							
From DCE to DTE	*From DTE to DCE*	*8*	*7*	*6*	*5*	*4*	*3*	*2*	*1*
Call set-up and clearing									
Incoming call	Call request	0	0	0	0	1	0	1	1
Call connected	Call accepted	0	0	0	0	1	1	1	1
Clear indication	Clear request	0	0	0	1	0	0	1	1
DCE clear confirmation	DTE clear confirmation	0	0	0	1	0	1	1	1
Data and interrupt									
DCE data	DTE data	X	X	X	X	X	X	X	0
DCE interrupt	DTE interrupt	0	0	1	0	0	0	1	1
DCE interrupt confirmation	DTE interrupt confirmation	0	0	1	0	0	1	1	1
Flow control, interrupt reset									
DCE RR (modulo 8)	DTE RR (modulo 8)	X	X	X	0	0	0	0	1
DCE RR (modulo 128)[a]	DTE RR (modulo 128)[a]	0	0	0	0	0	0	0	1
DCE RNR (modulo 8)	DTE RNR (modulo 8)	X	X	X	0	0	1	0	1
DCE RNR (modulo 128)[a]	DTE RNR (modulo 128)[a]	0	0	0	0	0	1	0	1
	DTE REJ (modulo 8) a)	X	X	X	0	1	0	0	1
	DTE REJ (modulo 128)[a]	0	0	0	0	1	0	0	1
Reset indication	Reset request	0	0	0	1	1	0	1	1
DCE reset confirmation	DTE reset confirmation	0	0	0	1	1	1	1	1
Restart									
Restart indication	Restart request	1	1	1	1	1	0	1	1
DCE restart confirmation	DTE restart confirmation	1	1	1	1	1	1	1	1
Diagnostic									
Diagnostic[a]		1	1	1	1	0	0	0	1
Registration[a]									
	Registration request	1	1	1	1	0	0	1	1
Registration confirmation		1	1	1	1	0	1	1	1

[a] Not necessarily available on every network

Note: A bit which is indicated as "X" may be set to either 0 or 1 as indicated in the text.

5.2   CALL SET-UP CLEARING PACKETS

5.2.1   Address block format

The call set-up and clearing packets contain an address block. This address block has two possible formats: a non-TOA/NPI address and a TOA/NPI address format. These two formats are distinguished by bit 8 of the general format identifier (A bit). When the A bit is set to 0, the non-TOA/NIP address format is used. When the A bit is set to 1, the TOA/NIP address format is used.

The non-TOA/NPI address format is supported by all networks. The NOA/NPI address format may be supported by some networks, in particular by those networks wishing to communicate with ISDNs for which the non-TOA/NPI address format provides insufficient addressing capacity.

Note: Prior to 1997, packet-mode DTEs operating according to case B of Recommendation X.31 (ISDN virtual circuit bearer service) will be addressed by a maximum 12 digit address from the E.164 numbering plan. After 1996, such a packet-mode DTE may have 15 digit E.164 address; TOA/NPI address procedures will be required to address these DTEs. Recommendations E.165 and E.166 provide further guidance.

When transmitting a call set-up or clearing packet, a DCE will use the TOA/NPI address format if the DTE has subscribed to the TOA/NPI address subscription facility (see § 6.28), the non-TOA/NPI address format if it has not.

Note: The TOA/NPI address subscription facility is designated in Recommendation X.2 for further study (FS). In addition, there are several technical items associated with this TOA/NPI address format which are for further study.

When transmitting a call set-up or clearing packet, a DTE will use the TOA/NPI address format if the DTE has subscribed to the TOA/NPI address subscription facility, the non-TOA/NPI address format if it has not.

When the address format used by one DTE in a call set-up or clearing packet is different from the address format used by the remote DTE, the network (if it supports the TOA/NPI address format) converts from one address format to the other (see § 6.28).

5.2.1.1   Format of the address block when the A bit is set to 0 (non-TOA/NPI address)
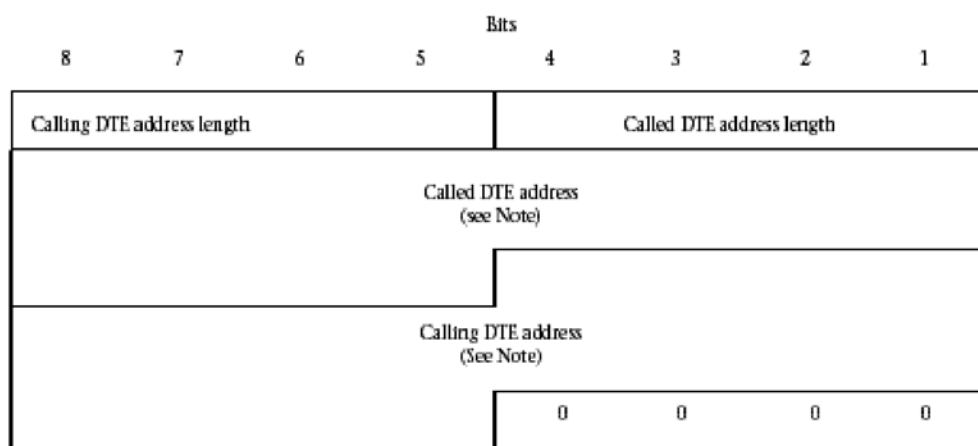
Figure 4/X.25 – Format of the address block when the A bit is set to 0

Note: The figure is drawn assuming the number of address digits present in the called DTE address field is odd and the number of address digits present in the calling DTE address field is even.

5.2.1.1.1   *Called and calling DTE address length fields*

These fields are four bits long each and consist of field length indicators for the called and calling DTE addresses. Bits 4, 3, 2 and 1 indicate the length of the called DTE address in semi-octets. Bits 8, 7, 6 and 5 indicate the length of the calling DTE address in semi-octets. Each DTE address length indicator is binary coded and bit 1 or 5 is the low order bit of the indicator.

5.2.1.1.2   *Called and calling DTE address fields*

Each digit of an address is coded in a semi-octet in binary coded decimal with bit 5 or 1 being the low order bit of the digit.

Starting from the high order digit, a DTE address is coded in consecutive octets with two digits per octet. In each octet, the higher order digit is coded in bits 8, 7, 6 and 5.

When present, the calling DTE address field starts on the first semi-octet following the end of the called DTE address field. Consequently, when the numbering of digits of the called DTE address field is odd, the beginning of the calling DTE address field, when present, is not octet aligned.

When the total number of digits in the called and calling DTE address fields is odd, a semi-octet with zeros in bits 4, 3, 2 and 1 will be inserted after the calling DTE address field in order to maintain octet alignment.

Further information on the coding of called and calling DTE address fields is given in Appendix IV.

Note: These fields may be used for optional addressing facilities such as abbreviated addressing. The optional addressing facilities employed as well as the coding of those facilities are for further study.

5.2.1.2   Format of the address block when the A bit is set to 1 (TOA/NPI address)

Figure 5/X.25 illustrates the format of the address block when the A bit is set to 1.
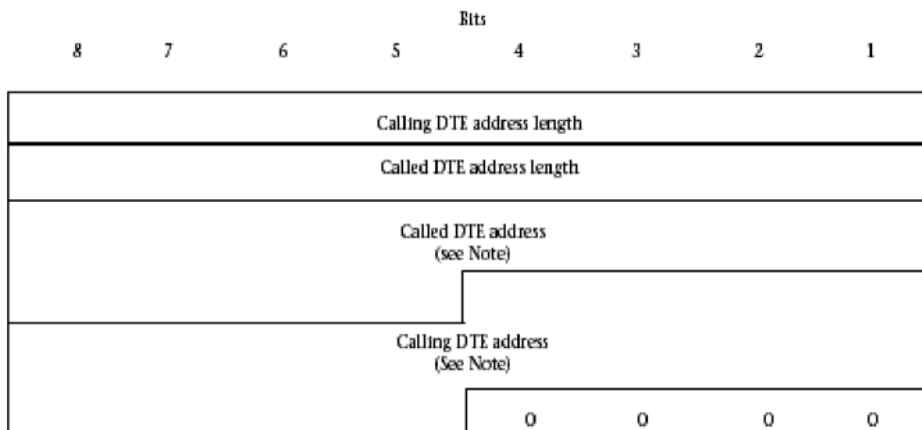
Figure 5/X.25 – Format of the address block when the A bit is set to 1

Note: The figure is drawn assuming the number of semi-octets present in the called DTE address field is odd and the number of semi-octets present in the calling DTE address field is even.

5.2.1.2.1   *Called and calling DTE address length fields*

These fields are one octet long each and consist of field length indicators for the called and calling DTE addresses. They indicate the length of the called DTE address and the calling DTE address, respectively, in semi-octets. Each DTE address length indicator is binary coded and bit 1 is the low order bit of the indicator.

The maximum value of a DTE address field length indicator is 17.

5.2.1.2.2   *Called and calling DTE address fields*

These fields respectively consist of the called DTE address when present, and the calling DTE address when present.

Each DTE address field, when present, has three subfields: type of address subfield (TOA), numbering plan identification subfield (NPI), address digits subfield. The first two subfields are at the beginning of the address and are binary coded with the values indicated in Tables 18/X.25 and 19/X.25.

Note 1:   Currently, no non-BCD encodable values have been allocated for type of address and numbering plan identification subfields.

Note 2:   A DTE address containing type of address and numbering plan identification subfields but no address digits subfield is invalid.

Table 18/X.25 – Coding of the type of address subfield

Bits: or Bits:	8 4	7 3 (see Note 1)	6 2	5 1	Type of address
	0 0 0 to be defined other values	0 0 0	0 0 1	0 1 0	Network-dependent number (see Note 2) International number (see Note 3) National number (see Note 3) Complementary address alone (see Note 4) Reserved

Note 1:   The type of address subfield of the called DTE address field uses bits 8, 7, 6 and 5. The type of address subfield of the calling DTE address field uses bits 4, 3, 2 and 1 if the called DTE address field does not end on an octet boundary; otherwise, it uses bits 8, 7, 6 and 5.

Note 2:   In this case, the address digits subfield present after the type of address and numbering plan identification subfields are organized according to the network numbering plan, e.g., prefix or escape code might be present. This case is equivalent to the use of the same code point in Q.931, where it is called "unknown".

Note 3:   As for Q.931, prefix or escape code shall not be included in the address digits subfield.

Note 4:   See Appendix IV for the definition of a complementary address.

Table 19/X.25 – Coding of the numbering plan identification subfield

Bits: or Bits:	8 4 (see Note 1)	7 3	6 2	5 1	Numbering plan
	0 to be defined other values	0	1	1	X.121 (see Note 2) Network-dependent (see Note 3) Reserved (see Note 4)

Note 1:   The numbering plan identification subfield of the called DTE address field uses bits 4, 3, 2 and 1. The numbering plan identification subfield of the calling DTE address field uses bits 8, 7, 6 and 5 if the called DTE address field does not end on an octet boundary; otherwise, it uses bits 4, 3, 2 and 1.

Note 2:   A mechanism equivalent to that provided by escape digits, as defined in Recommendation X.121 is not yet for use in conjunction with the TOA/NPI capability; such a mechanism will not use the numbering plan identification subfield. Until the availability of such a mechanism (potentially, an optional user facility), only the code point for X.121 shall be used. The X.121 escape codes shall apply and, when they are used, the type of address subfield shall indicate the network-dependent number.

Note 3:   In this case, the address digits subfield present after the type of address and numbering plan identification subfields are organized according to the network numbering plan, e.g., prefix or escape code might be present.

Note 4:   Included among the reserved values are those corresponding to numbering plan identifiers in Q.931 (e.g., F.69, E.164).

        The other semi-octets of a DTE address are digits, coded in binary coded decimal with bit 5 or 1 being the low order bit of the digit. Starting from the high order digit, the address digits are coded in consecutive semi-octets. In each octet, the higher order digit is coded in bits 8, 7, 6 and 5.

        When present, the calling DTE address field starts on the first semi-octet following the end of the called DTE address field. Consequently, when the number of semi-octets of the called DTE address field is odd, the beginning of the calling DTE address field, when present, is not octet aligned.

        When the total number of semi-octets in the called and calling DTE address fields is odd, a semi-octet with zeros in bits 4, 3, 2 and 1 will be inserted after the calling DTE address field in order to maintain octet alignment.

        Further information on the coding of called and calling DTE address fields is given in Appendix IV.

Note: These fields may be used for optional facilities such as abbreviated addressing. The optional addressing facilities employed as well as the coding of those facilities are for further study.

5.2.2   Call request and incoming call packets

        Figure 6/X.25 illustrates the format of call request and incoming call packets.
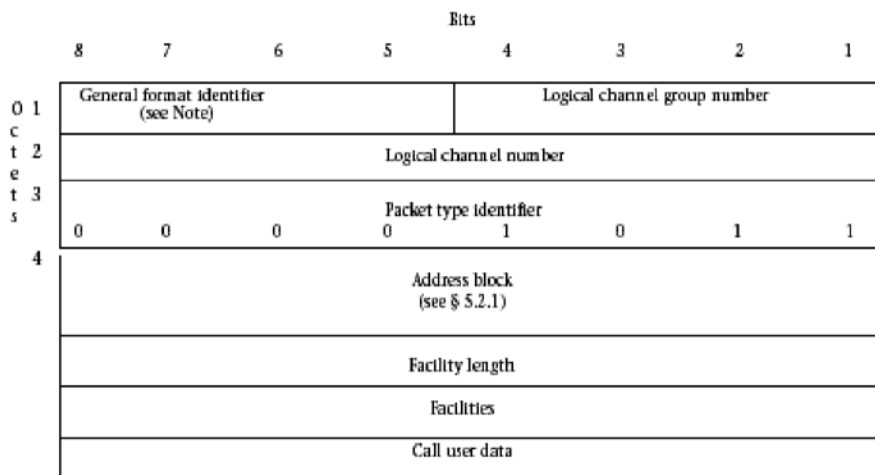
Figure 6/X.25 – Call request and incoming call packet format

Note: Coded XX01 (modulo 8) or XX10 (modulo 128).

5.2.2.1 General format identifier

Bit 8 of octet 1 (A bit) should be set as described in § 5.2.1.

Bit 7 of octet 1 should be set to 0 unless the mechanism defined in § 4.3.3 is used.

5.2.2.2 Address block

The address block is described in § 5.2.1.

5.2.2.3 Facility length field

The octet following the address block indicates the length of the facility field, in octets. The facility length indicator is binary coded and bit 1 is the low order bit of the indicator.

5.2.2.4 Facility field

The facility field is present only when the DTE is using an optional user facility requiring some indication in the call request and incoming call packets.

The coding of the facility field is defined in §§ 6 and 7.

The facility field contains an integral number of octets. The actual maximum length of this field depends on the facilities which are offered by the network. However, this maximum does not exceed 109 octets.

Note: It is for further study whether another value should be defined, relative to the total number of octets in the packet.

5.2.2.5 Call user data field

Following the facility field, the call user data field may be present and has a maximum length of 128 octets when used in conjunction with the fast select facility described in § 6.16, 16 octet in the other case.

Note: Some networks require the call user data field to contain an integral number of octets (see the Note in § 3).

When the virtual call is being established between two packet-mode DTEs, the network does not act on any part of the call user data field. In other circumstances, see Recommendation X.244.

5.2.3 Call accepted and call connected packets

Figure 7/X.25 illustrates the format of call accepted and call connected packets in the basic or extended format.

Bits

8	7	6	5	4	3	2	1
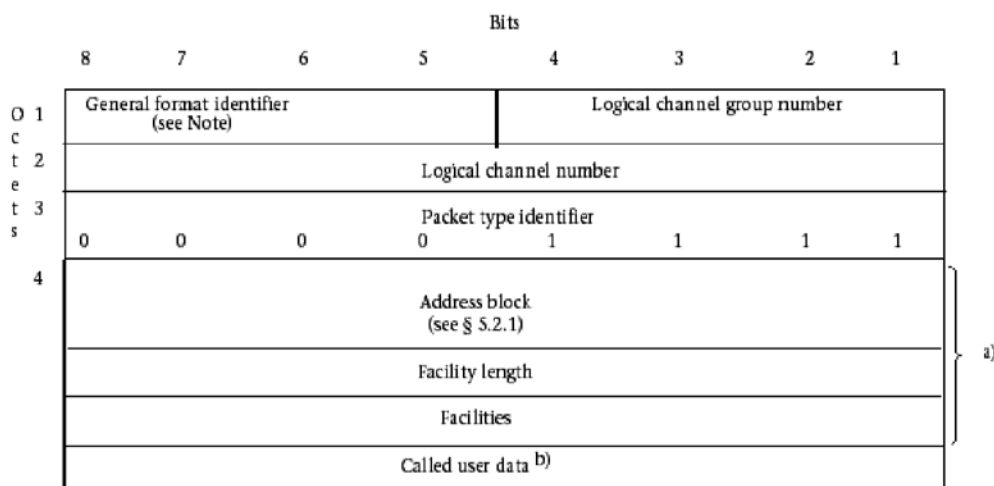
Figure 7/X.25 – Call accepted and call connected packet format

(a) These fields are not mandatory in the basic format of call accepted packets (see § 5.2.3.1).

(b) This field may be present only in the extended format (see § 5.2.3.2).

Note: Coded XX01 (modulo 8) or XX10 (modulo 128).

5.2.3.1   Basic format

5.2.3.1.1   *General format identifier*

Bit 8 of octet 1 (A bit) should be set as described in § 5.2.1.

Bit 7 of octet 1 should be to 0 unless the mechanism defined in § 4.3.3 is used.

5.2.3.1.2   *Address block*

The address block is described in § 5.2.1.

The use of the called and calling DTE address length fields in call accepted packets is only mandatory when the called DTE address field, the calling DTE address field or the facility length field is present.

5.2.3.1.3   *Facility length field*

The octet following the address block indicates the length of the facility field, in octets. The facility length indicator is binary coded and bit 1 is the low order bit of the indicator.

The use of the facility length field in call accepted packets is only mandatory when the facility field is present.

5.2.3.1.4   *Facility field*

The facility field is present only when the DTE is using an optional user facility requiring some indication in the call accepted and call connected packet.

The coding of the facility field is defined in §§ 6 and 7.

The facility field contains an integral number of octets. The actual maximum length of this field depends on the facilities which are offered by the network. However, this maximum does not exceed 109 octets.

Note: It is for further study whether another value should be defined, relative to the total number of octets in the packet.

5.2.3.2   Extended format

The extended format may be used only in conjunction with the fast select facility described in § 6.16. In this case, the called user data field may be present and has a maximum length of 128 octets.

The calling and called DTE address length fields and the facility length field must be present when the called user data field is present.

Note: Some networks require the called user data field to contain an integral number of octets (see the Note in § 3).

When the virtual call is being established between two packet-mode DTEs, the network does not act on any part of the called user data field. See Recommendation X.244.

5.2.4   Clear request and clear indication packets

Figure 8/X.25 illustrates the format of clear request and clear indication packets, in basic and extended formats.
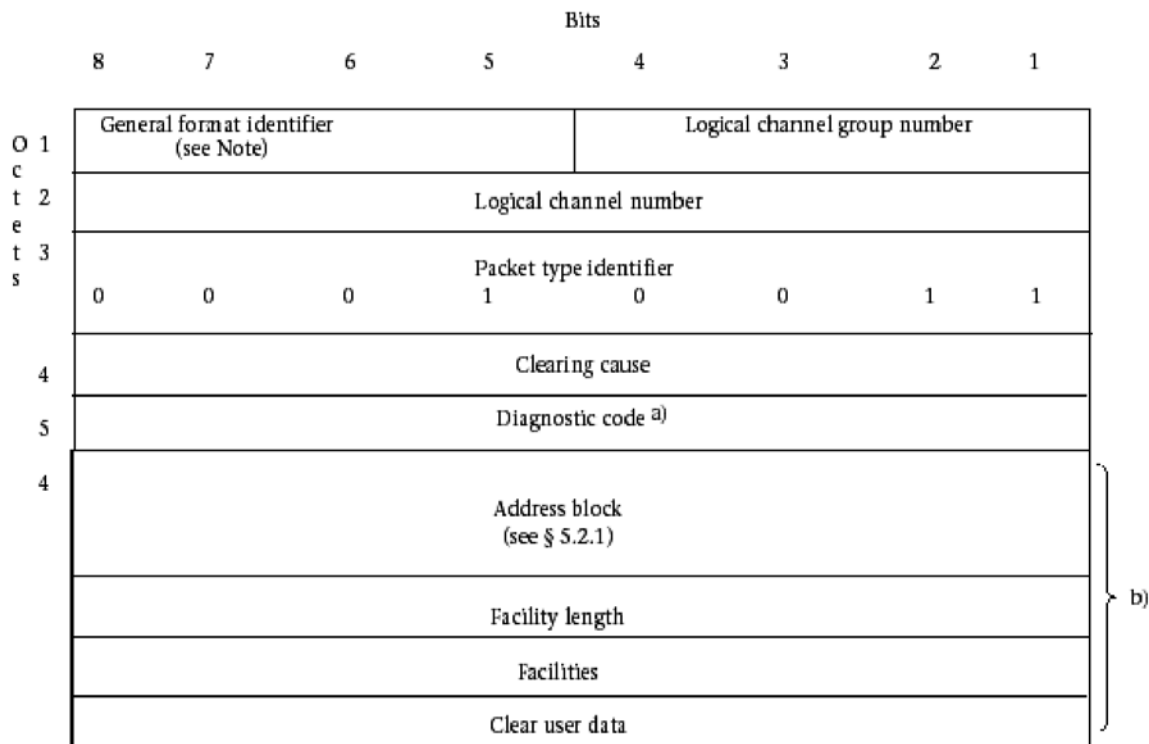
Figure 8/X.25 – Clear request and clear indication packet format

(a) This field is not mandatory in the basic format of clear request packets (see § 5.2.4.1).
(b) Used only in the extended format (see § 5.2.4.2).
Note: Coded X001 (modulo 8) or X010 (modulo 128).

5.2.4.1   Basic format

5.2.4.1.1   *Clearing cause field*

Octet 4 is the clearing cause field and contains the reason for the clearing of the call.

In clear request packets, the clearing cause field should be set by the DTE to one of the following values:

bits:	8 7 6 5 4 3 2 1
value:	0 0 0 0 0 0 0 0
or:	1 X X X X X X where each X may be independently set to 0 or 1 by the DTE.

The DCE will prevent values of the clearing cause field other than those shown above from reaching the other end of the call by either accepting the clear request packet and forcing the clearing cause field to all zeros in the corresponding clear indication packet, or considering the clear request as an error and following the procedure described in Annex C.

The coding of the clearing cause field in clear indication packets is given in Table 20/X.25.

Table 20/X.25 – Coding of clearing cause field in clear indication packet

	Bits							
	8	7	6	5	4	3	2	1
DTE originated	0	0	0	0	0	0	0	0
DTE originated[a]	1	X	X	X	X	X	X	X
Number busy	0	0	0	0	0	0	0	1
Out of order	0	0	0	0	1	0	0	1
Remote procedure error	0	0	0	1	0	0	0	1
Reverse charging acceptance not subscribed[b]	0	0	0	1	1	0	0	1
Incompatible destination	0	0	1	0	1	0	0	1
Fast select acceptance not subscribed[b]	0	0	1	0	0	0	0	1
Ship absent[c]	0	0	1	1	1	0	0	1
Invalid facility request	0	0	0	0	0	0	1	1
Access barred	0	0	0	0	1	0	1	1
Local procedure error	0	0	0	1	0	0	1	1
Network congestion	0	0	0	0	0	1	0	1
Not obtainable	0	0	0	0	1	1	0	1
RPOA out of order[b]	0	0	0	1	0	1	0	1

(a) When bit 8 is set to 1, the bits represented by Xs are those included by the remote DTE in the clearing or restarting cause field of the clear or restart request packet respectively.
(b) May be received only if the corresponding optional user facility is used.
(c) Used in conjunction with mobile maritime service.

5.2.4.1.2   *Diagnostic code*

Octet 5 is the diagnostic code and contains additional information on the reason for the clearing of the call.

In a clear request packet, the diagnostic code is not mandatory.

In a clear indication packet, if the clearing cause field indicates "DTE originated", the diagnostic code is passed unchanged from the clearing DTE. If the clearing DTE has not provided a diagnostic code in its clear request packet, then the bits of the diagnostic code in the resulting clear indication packet will all be zero.

When a clear indication packet results from a restart request packet, the value of the diagnostic code will be that specified in the restart request packet, or all zeros in the case where no diagnostic code has been specified in the restart request packet.

When the clearing cause field does not indicate "DTE originated", the diagnostic code in a clear indication packet is network generated. Annex E lists the codings for network generated diagnostics. The bits of the diagnostic code are all set to 0 when no specific additional information for the clearing is supplied.

Note: The contents of the diagnostic code field do not alter the meaning of the cause field. A DTE is not required to undertake any action on the contents of the diagnostic code field. Unspecified code combinations in the diagnostic code field shall not cause the DTE to refuse the cause field.

5.2.4.2   Extended format

The extended format is used for clear request and clear indication packets only when the DTE or the DCE needs to use the called and/or calling DTE address fields, the facility field and/or the clear user data field in conjunction with one or several optional user facilities described in §§ 6 and 7. The called DTE address field is used only when the called line address modified notification facility is used in clearing, in response to an incoming call or call request packet.

When the extended format is used, the diagnostic code field, the DTE address length fields and the facility length field must be present. Optionally, the clear user data field may also be present.

5.2.4.2.1   *Address block*

The address block is described in § 5.2.1.

5.2.4.2.2   *Facility length field*

The octet following the address block indicates the length of the facility field, in octets. The facility length indicator is binary coded and bit 1 is the low order bit of the indicator.

5.2.4.2.3   *Facility field*

The facility field is present in the clear request or the clear indication packet only in conjunction with one or several optional user facilities requiring some indication in this packet.

The coding of the facility field is defined in §§ 6 and 7.

The facility field contains an integral number of octets. The actual maximum length of this field depends on the facilities which are offered by the network. However, this maximum does not exceed 109 octets.

Note: It is for further study whether another value should be defined, relative to the total number of octets in the packet.

5.2.4.2.4   *Clear user data field*

This field may be present only in conjunction with the fast select facility (see § 6.16) or the call deflection selection facility (see § 6.25.2.2). It has a maximum length of 128 octets in the first case, of 16 or 128 octets in the second case: whether the maximum length is 16 or 128 octets when using the call deflection selection facility is specified in § 6.25.2.2.

Note 1:   Some networks require the clear user data field to contain an integral number of octets (see the Note in § 3).

Note 2 : The network does not act on any part of the clear user data field. See Recommendation X.244.

5.2.5   DTE and DCE clear confirmation packets

Figure 9/X.25 illustrates the format of the DTE and DCE clear confirmation packets, in the basic or extended format.

The extended format may be used for DCE clear confirmation packets only in conjunction with the charging information facility described in § 6.22. It is not used for DTE clear confirmation packet.
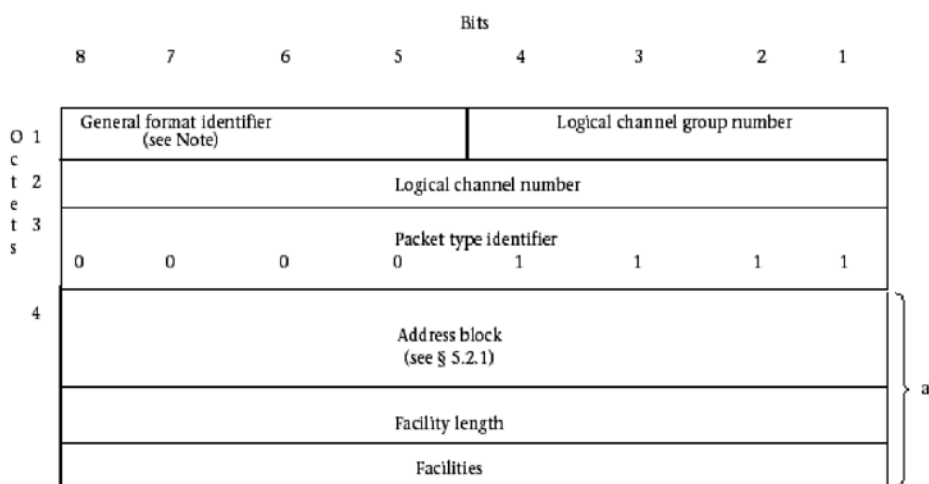
Figure 9/X.25 – DTE and DCE clear confirmation packet format

(a) Used only in the extended format of DCE clear confirmation packets.

Note: Coded X001 (modulo 8) or X010 (modulo 128).

5.2.5.1   Address block

The address block is described in § 5.2.1.

The calling and called DTE address length fields are coded with all zeros and the called and calling DTE address fields are not present.

5.2.5.2   Facility length field

        The octet following the address block indicates the length of the facility field, in octets. The facility length indicator is binary coded and bit 1 is the low order bit of the indicator.

5.2.5.3   Facility length

        The coding of the facility field is defined in §§ 6 and 7.

        The facility field contains an integral number of octets. The actual maximum length of this field depends on the facilities which are offered by the network. However, this maximum does not exceed 109 octets.

Note: It is for further study whether another value should be defined, relative to the total number of octets in the packets.

5.3   Data and interrupt packets

5.3.1   DET and D CE data packets

Figure 10/X.25 illustrates the format of the DTE and DCE data packets.

(modulo 8)

(When extended to modulo 128)
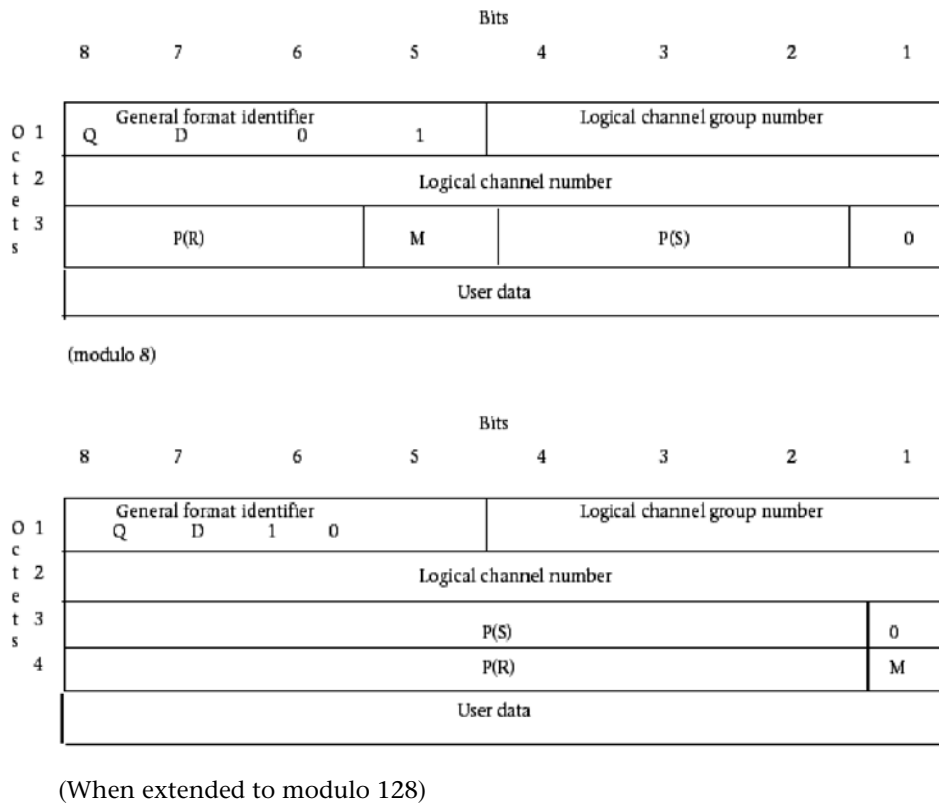
Figure 10/X.25 – DTE and DCE data packet format

D Delivery confirmation bit
M More data bit
Q Qualifier bit

5.3.1.1   Qualifier (Q) bit

        Bit 8 of octet 1 is the qualifier (Q) bit.

5.3.1.2   Delivery confirmation (D) bit

        Bit 7 of octet 1 is the delivery confirmation (D) bit.

5.3.1.3 Packet receive sequence number

Bits 8, 7 and 6 of octet 3, or bits 8 through 2 of octet 4 when extended, are used for indicating the packet receive sequence number P(R). P(R) is binary coded and bit 6, or bit 2 when extended, is the low order bit.

5.3.1.4 More data bit

Bit 5 in octet 3, or bit 1 in octet 4 when extended, is used for the more data mark (M bit): 0 for no more data mark (M bit): 0 for no more data and 1 for more data.

5.3.1.5 Packet send sequence number

Bits 4, 3 and 2 of octet 3, or bits 8 through 2 of octet 3 when extended, are used for indicating the packet send sequence number P(S). P(S) is binary coded and bit 2 is the low order bit.

5.3.1.6 User data field

Bits following octet 3, or octet 4 when extended, contain user data.

Note: Some networks require the user data field to contain an integral number of octets (see the Note in § 3).

5.3.2 DTE and DCE interrupt packets
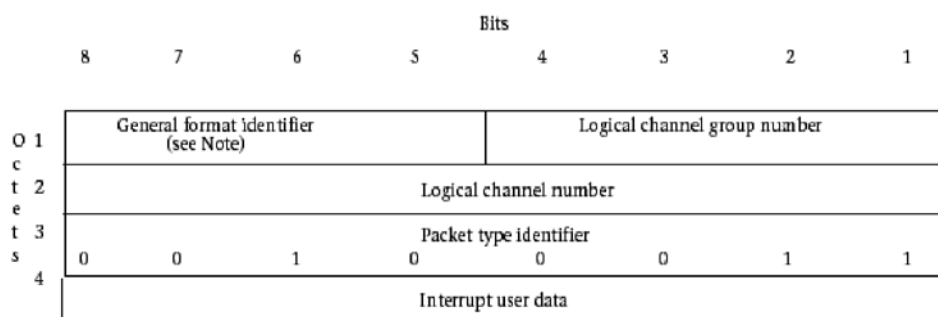
Figure 11/X.25 – DTE and DCE interrupt packet format

Note: Coded 0001 (modulo 8) or 0010 (modulo 128).

5.3.2.1 Interrupt user data field

Octet 4 and any following octets contain the interrupt user data. This field may contain from 1 to 32 octets.

Note: Some networks require the interrupt user data field to contain an integral number of octets (see the Note in § 3).

5.3.3 DTE and DCE interrupt confirmation packets

Figure 12/X.25 illustrates the format of the DTE and DCE interrupt confirmation packets.
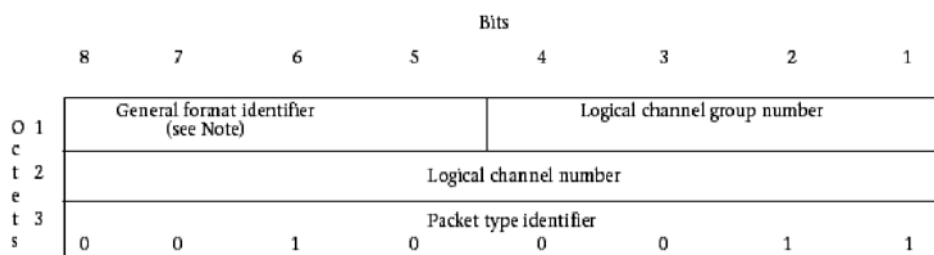
Figure 12/X.25 – DTE and DCE interrupt confirmation packet format

Note: Coded 0001 (modulo 8) or 0010 (modulo 128).

5.4   Flow control and reset packets

5.4.1   DTE and DCE receive ready (RR) packets
Figure 13/X.25 illustrates the format of the DTE and DCE RR packets.

(modulo 8)

(When extended to modulo 128)
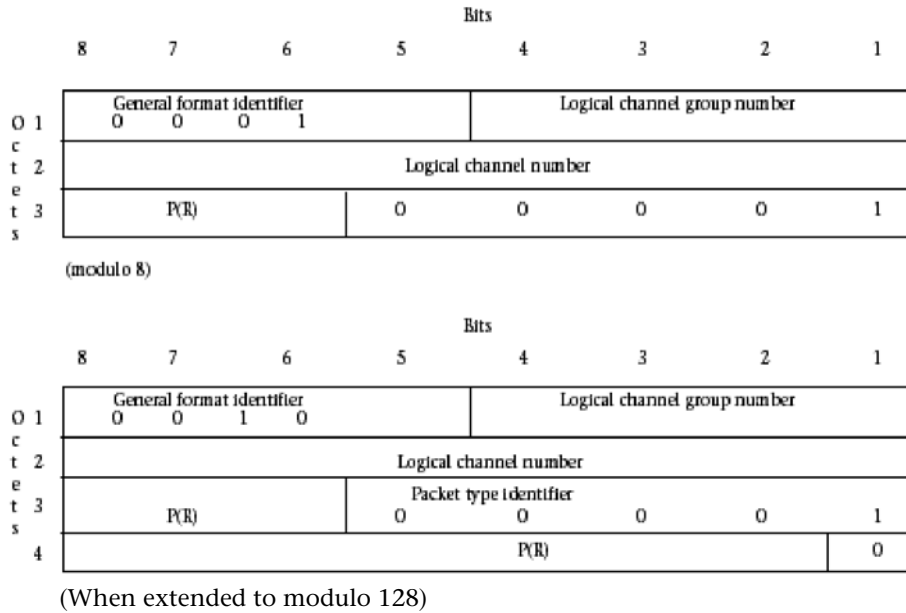
Figure 13/X.25 – DTE and DCE RR packet format

5.4.1.1   Packet receive sequence number

Bits 8, 7 and 6 of octet 3, or bits 8 through 2 of octet 4 when extended, are used for indicating the packet receive sequence number P(R). P(R) is binary coded and bit 6, or bit 2 when extended, is the low order bit.

5.4.2   DTE and DCE receive not ready (RNR) packets
Figure 14/X.25 illustrates the format of the DTE and DCE RNR packets.

(modulo 8)

(When extended to modulo 128)

Figure 14/X.25 – DTE and DCE RNR packet format

5.4.2.1   Packet receive sequence number

Bits 8, 7 and 6 of octet 3, or bits 8 through 2 of octet 4 when extended, are used for indicating the packet receive sequence number P(R). P(R) is binary coded and bit 6, or bit 2 when extended, is the low order bit.

5.4.3   Reset request and reset indication packets

Figure 15/X.25 illustrates the format of the reset request and reset indication packets.

Figure 15/X.25 – Reset request and reset indication packet format

(a) This field is not mandatory in reset request packets.

Note: Coded 0001 (modulo 8) or 0010 (modulo 128).

5.4.3.1   Resetting cause field

Octet 4 is the resetting cause field and contains the reason for the reset.

In reset request packets, the resetting cause field should be set by the DTE to one of the following values:

bit: 8 7 6 5 4 3 2 1

value: 0 0 0 0 0 0 0 0

or: 1 X X X X X X X independently where each X may be independently set to 0 or 1 by the DTE

The DCE will prevent values of the resetting cause field other than those shown above from reaching the other end of the virtual call or permanent virtual circuit by either accepting the reset request packet and forcing the resetting cause field to all zeros in the corresponding reset indication packet, or considering the reset request as an error and following the procedure described in Annex C.

The coding of the resetting cause field in a reset indication packet is given in Table 21/X.25.

Table 21/X.25 – Coding of resetting cause field in reset indication packet

	Bits							
	8	7	6	5	4	3	2	1
DTE originated	0	0	0	0	0	0	0	0
DTE originated[a]	1	X	X	X	X	X	X	X
Out of order[b]	0	0	0	0	0	0	0	1
Remote procedure error	0	0	0	0	0	0	1	1
Local procedure error	0	0	0	0	0	1	0	1
Network congestion	0	0	0	0	0	1	1	1
Remote DTE operational[b]	0	0	0	0	1	0	0	1
Network operational[b]	0	0	0	0	1	1	1	1
Incompatible destination	0	0	0	1	0	0	0	1
Network out of order[b]	0	0	0	1	1	1	0	1

(a) When bit 8 is set to 1, the bits represented by Xs are those indicated by the remote DTE in the resetting cause field (virtual calls and permanent virtual circuits) or the restarting cause field (permanent virtual circuits only) of the reset or restart request packet, respectively.

(b) Applicable to permanent virtual circuits only.

5.4.3.2   Diagnostic code

Octet 5 is the diagnostic code and contains additional information on the reason for the reset.

In a reset request packet the diagnostic code is not mandatory.

In a reset indication packet, if the resetting cause field indicates "DTE originated", the diagnostic code has been passed unchanged from the resetting DTE. If the DTE requesting a reset has not provided a diagnostic code in its reset request packet, then the bits of the diagnostic code in the resulting reset indication packet will all be zeros.

When a reset indication packet results from a restart request packet, the value of the diagnostic code will be that specified in the restart request packet, or all zeros in the case where no diagnostic code has been specified in the restart request packet.

When the resetting cause field does not indicate "DTE originated", the diagnostic code in a reset indication packet is network generated. Annex E lists the codings for network generated diagnostics. The bits of the diagnostic code are all set to 0 when no specific additional information for the reset is supplied.

Note: The contents of the diagnostic code field do not alter the meaning of the cause field. A DTE is not required to undertake any action on the contents of the diagnostic code field. Unspecified code combinations in the diagnostic code field shall not cause the DTE to not accept the cause field.

5.4.4   DTE and DCE reset confirmation packets

Figure 16/X.25 illustrates the format of the DTE and DCE reset confirmation packets.

Figure 16/X.25 – DTE and DCE reset confirmation packet format

Note: Coded 0001 (modulo 8) or 0010 (modulo 128).

5.5   Restart packets

5.5.1   Restart request and restart indication packets

Figure 17/X.25 illustrates the format of the restart request and restart indication packets.

Figure 17/X.25 – Restart request and restart indication packet format

(a) This field is not mandatory in restart request packets.

Note: Coded 0001 (modulo 8) or 0010 (modulo 128).

5.5.1.1   Restarting cause field

Octet 4 is the restarting cause field and contains the reason for the restart.

In restart request packets, the restarting cause field should be set by the DTE to one of the following values:

bit: 8 7 6 5 4 3 2 1

value: 0 0 0 0 0 0 0 0

or: 1 X X X X X X X where each X may be independently set to 0 or 1 by the DTE

The DCE will prevent values of the restarting cause field other than those shown above from reaching the other end of the virtual calls and/or permanent virtual circuits by either accepting the restart request packet and forcing the clearing or resetting cause field to all zeros in the corresponding clear and/or reset indication packets, or considering the restart request as an error and following the procedure described in Annex C.

The coding of the restarting cause field in the restart indication packets is given in Table 22/X.25.

Table 22/X.25 – Coding of restarting cause field in restart indication packet

	Bits							
	8	7	6	5	4	3	2	1
Local procedure error	0	0	0	0	0	0	0	1
Network congestion	0	0	0	0	0	0	1	1
Network operational	0	0	0	0	0	1	1	1
Incompatible destination	0	0	0	0	0	0	1	1
Registration/cancellation confirmed[a]	0	1	1	1	1	1	1	1

(a) May be received only if the optional on-line facility registration facility is used.

5.5.1.2   Diagnostic code

Octet 5 is the diagnostic code and contains additional information on the reason for the restart.

In a restart request packet, the diagnostic code is not mandatory. The diagnostic code, if specified, is passed to the corresponding DTEs as the diagnostic code of a reset indication packet for permanent virtual circuits of a clear indication packet for virtual calls.

The coding of the diagnostic code field in a restart indication packet is given in Annex E. The bits of the diagnostic code are all set to zero when no specific additional information for the restart is supplied.

Note: The contents of the diagnostic code field do not alter the meaning of the cause field. A DTE is not required to undertake any action on the contents of the diagnostic code field. Unspecified code combinations in the diagnostic code field shall not cause the DTE to not accept the cause field.

5.5.2   DTE and DCE restart confirmation packets

Figure 18/X.25 illustrates the format of the DTE and DCE restart confirmation packets.

Figure 18/X.25 – DTE and DCE restart confirmation packet format

Note: Coded 0001 (modulo 8) or 0010 (modulo 128).

[. . .]

ANNEX A

(to Recommendation X.25)

Range of logical channels used for virtual calls and permanent virtual circuits

In the case of a single logical channel DTE, logical channel 1 will be used.

For each multiple logical channel DTE/DCE interface, a range of logical channels will be agreed upon with the Administration according to Figure A–1/X.25.

LCN

0		
1	}	Permanent virtual circuits
LIC		
HIC	}	One way incoming
LTC		
HTC	}	Two way
LOC		
HOC	}	One way outgoing
4095		ITU-T-34901

Virtual calls

LCN	Logical channel number
LIC	Lowest incoming channel
HIC	Highest incoming channel
LTC	Lowest two-way channel
HTC	Highest two-way channel
LOC	Lowest outgoing channel
HOC	Highest outgoing channel
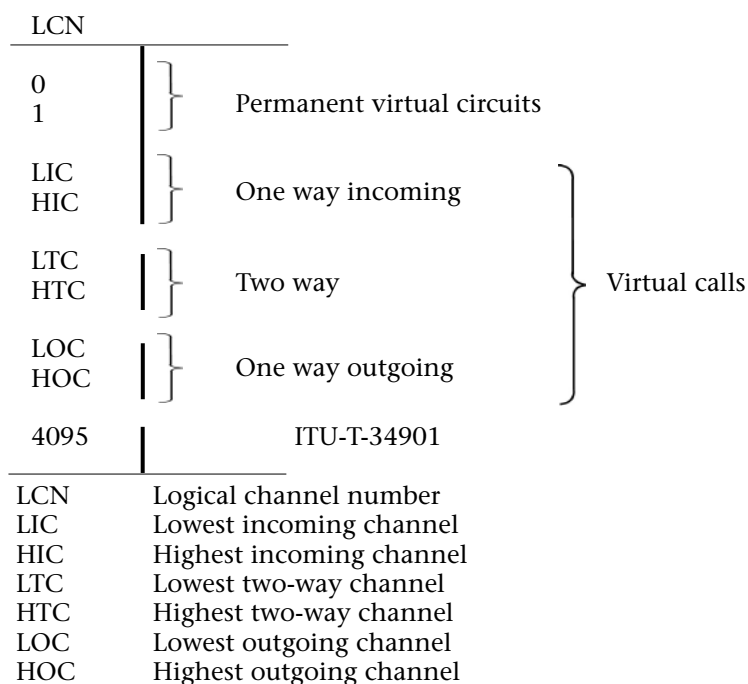
Figure A–1/X.25

Logical channels 1 to LIC–1: range of logical channels which may be assigned to permanent virtual circuits.
Logical channels LIC to HIC: range of logical channels which are assigned to one-way incoming logical channels for virtual calls (see § 6.8).
Logical channels LTC to HTC: range of logical channels which are assigned to two-way logical channels for virtual calls.
Logical channels LOC to HOC: range of logical channels which are assigned to one-way outgoing logical channels for virtual calls (see § 6.7).
Logical channels HIC + 1 to LTC – 1, HTC + 1 to LOC – 1, and HOC + 1 to 4095 are non-assigned logical channels.
Note 1: The reference to the number of logical channels is made according to a set of contiguous numbers from 0 (lowest) to 4095 (highest) using 12 bits made up of the 4 bits of the logical channel group number (see § 5.1.2) and the 8 bits of the logical channel number (see § 5.1.3). The numbering is binary coded using bit positions 4 through 1 of octet 1 followed by bit positions 8 through 1 of octet 2 with bit 1 of octet 2 as the low order bit.
Note 2: All logical channel boundaries are agreed with the Administration for a period of time.
Note 3: In order to avoid frequent rearrangement of logical channels, not all logical channels within the range for permanent virtual circuits are necessarily assigned.
Note 4: In the absence of permanent virtual circuits, logical channel 1 is available for LIC. In the absence of permanent virtual circuits and one-way incoming logical channels, logical channel 1 is available for LTC. In the absence of permanent virtual circuits, one-way incoming logical channels and two-way logical channels, logical channel 1 is available for LOC.
Note 5: The DCE search algorithm for a logical channel for a new incoming call will be to use the lowest logical channel in the ready state in the range of LIC to HIC and LTC to HTC.
Note 6: In order to minimize the risk of call collision, the DTE search algorithm is suggested to start with the highest numbered logical channel in the ready state. The DTE could start with the two-way logical channel or one-way outgoing logical channel ranges.

ANNEX B

(to Recommendation X.25)

Packet layer DTE/DCE interface state diagrams

B.1 SYMBOL DEFINITION OF THE STATE DIAGRAMS
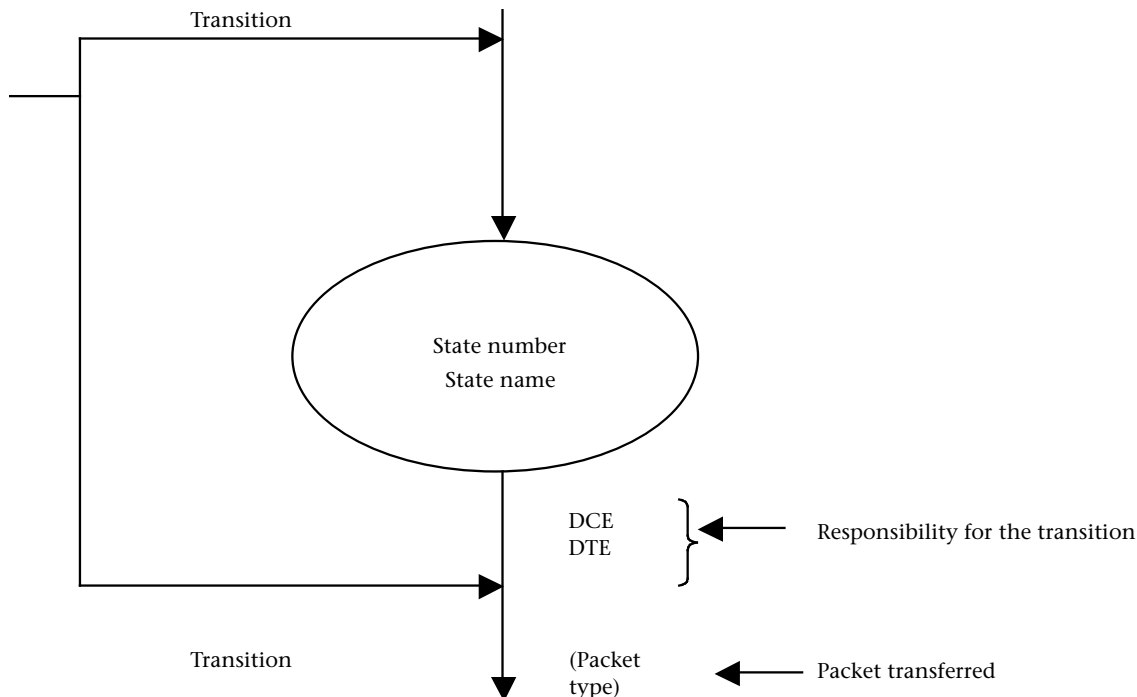
ITU-T-19172

Note 1: Each state is represented by an ellipse wherein the state name and number are indicated.

Note 2: Each state transition is represented by an arrow. The responsibility for the transition (DTE or DCE) and the packet that has been transferred is indicated beside that arrow.

B.2 ORDER DEFINITION OF THE STATE DIAGRAMS

For the sake of clarity, the normal procedure at the interface is described in a number of small state diagrams. In order to describe the normal procedure fully, it is necessary to allocate a priority to the different figures and to relate a higher order diagram with a lower one. This has been done by the following means:

• The figures are arranged in order of priority with Figure B-1/X.25 (restart) having the highest priority and subsequent figures having lower priority. Priority means that when a packet belonging to a higher order diagram is transferred, that diagram is applicable and the lower order one is not.

• The relation with a state in a lower order diagram is given by including that state inside an ellipse in the higher order diagram.
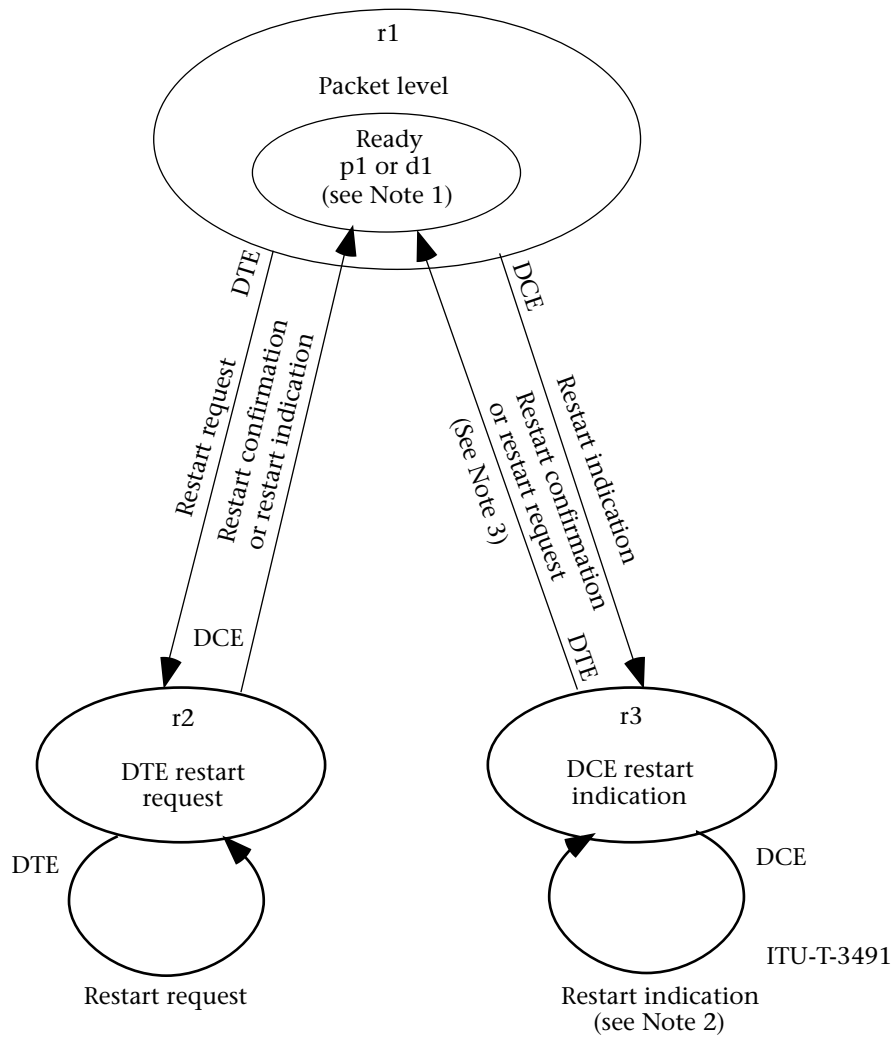
Figure B-1/X.25 – Diagram of states for the transfer of restart packets

Note 1:   State p1 for virtual calls or state d1 for permanent virtual circuits.

Note 2:   This transition takes place after time-out T10 expires the first time.

Note 3:   This transition also takes place after time-out T10 expires the second time (without transmission of any packet, except, possibly, a diagnostic packet).
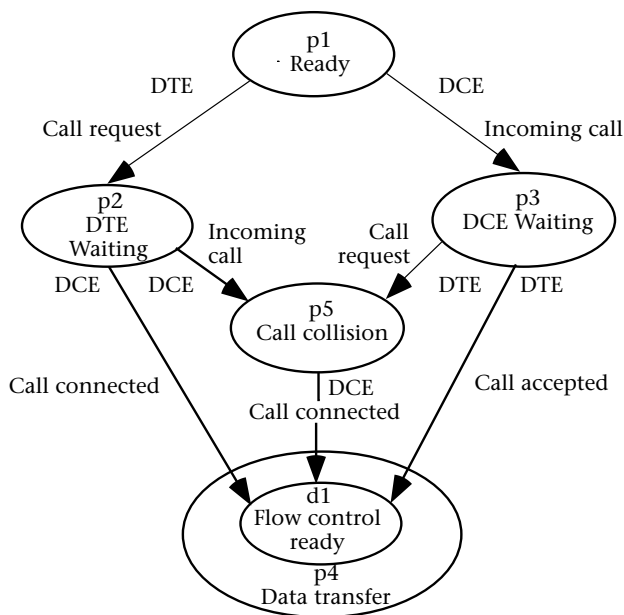
(a) Call set-up
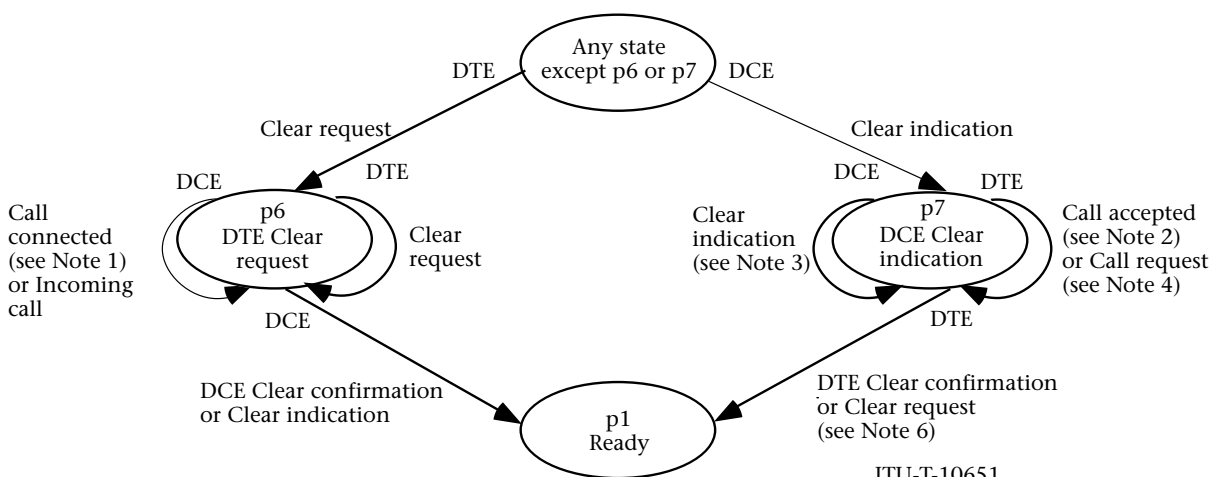
ITU-T-10651

(b) Call clearing phase

Figure B-2/X.25 – Diagram of states for the transfer of call set-up and call clearing packets
within the packet level ready (p1) state

Note 1:   This transition is possible only if the previous state was DTE Waiting (p2).

Note 2:   This transition is possible only if the previous state was DCE Waiting (p3).

Note 3:   This transition takes place after time-out T13 expires the first time.

Note 4:   This transition is possible only if the previous state was Ready (p1) or DTE Waiting (p3).

Note 5:   This transition is possible only if the previous state was Ready (p1) or DCE Waiting (p2).

Note 6:   This transition also takes place after time-out T13 expires the second time (without transmission of any
             packet, except, possibly, a diagnostic packet).
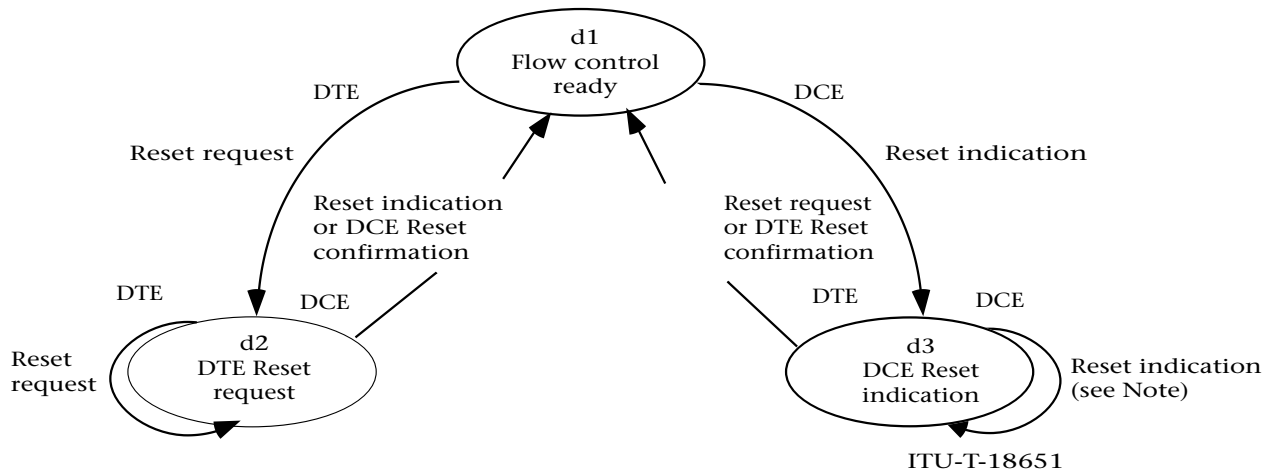
Figure B-3/X.25 – Diagram of states for the transfer of reset packets within the data transfer (p4) state

Note: This transition takes place after time-out T12 expires the first time.

[. . .]

ANNEX D

(to Recommendation X.25)

Packet level DCE time-outs and DTE time-limits

D.1   DCE TIME-OUTS

Under certain circumstances this Recommendation requires the DTE to respond to a packet issued from the DCE within a stated maximum time.

Table D-1/X.25 covers these circumstances and the actions that the DCE will initiate upon the expiration of that time.

The time-out values used by the DCE will never be less than those indicated in Table D-1/ X.25.

D.2   DTE TIME-LIMITS

Under certain circumstances, this Recommendation requires the DCE to respond to a packet from the DTE within a stated maximum time. Table D-2/X.25 gives these maximum times. The actual DCE response times should be within the specified time-limits. The rare situation where a time-limit is exceeded should only occur when there is a fault condition.

To facilitate recovery from such fault conditions, the DTE may incorporate timers. The time-limits given in Table D-2/X.25 are the lower limits of the times a DTE should allow for proper operation. A time-limit longer than the values shown may be used. Suggestions on possible DTE actions upon expiration of the time-limits are given in Table D-2/X.25.

Note: A DTE may use a time shorter than the value given for T21 in Table D-2/X.25. This may be appropriate when the DTE knows the normal response time of the called DTE to an incoming call. In this case, the timer should account for the normal maximum response time of the called DTE and the estimated maximum call set-up time.

Table D-1/X.25 – DCE time-outs

Time-out number	Time-out value	Started when	State of the logical channel	Normally terminated when	Actions to be taken the first time the time-out expires		Action to be taken the second time the time-out expires	
					Local side	Remote side	Local side	Remote side
T10	60 s	DCE issues a *restart indication*	r3	DCE leaves the r3 state (i.e., the *restart confirmation* or *restart request* is received)	DCE remains in r3, signals a *restart indication* (local procedure error #52) again, and restarts time-out T10	For permanent virtual circuits, DCE may enter the d3 state signalling a *reset indication* (remote procedure error #52)	DCE enters the r1 state may issue a diagnostic packet (#52)	For permanent virtual circuits, DCE may enter the d3 state signalling *a reset indication* (remote procedure error #52)
T11	180 s	DCE issues an *incoming call*	p3	DCE leaves the p3 state (eg the call accepted, *clear request* or *call request* is received)	DCE enters the p7 state signalling a *clear indication* local procedure (error #49)	DCE enters the p7 state signalling a *clear indication* (remote procedure error #49)		
T12	60 s	DCE issues a *reset indication*	d3	DCE leaves the d3 state (eg the *reset confirmation* or *reset request* is received)	DCE remains in d3, signals a *reset indication* (local procedure error #51) again, and restarts time-out T12	DCE may enter the d3 state signalling a *reset indication* remote procedure error #51	For virtual call, DCE enters the p7 state signalling a *clear indication* (local procedure error #51). For permanent virtual circuits, DCE enters the d1 state and may issue a *diagnostic* packet (#51)	For virtual calls DCE enters the p7 state signalling a *clear indication* (local procedure error #51). For permanent virtual circuits, DCE may enter the d3 state signalling *a reset indication* (remote procedure error #51)
T13	60 s	DCE issues a *clear indication*	p7	DCE leaves the p7 state (eg the *clear confirmation* or *clear request* is received)	DCE remains in p7 signals a *clear indication* (local procedure error #50) again, and restarts time-out T13		DCE enters the p1 state and may issue a *diagnostic* packet (#50)	

Table D-2/X.25 – DTE time-limits

Time-limit number	Time-limit value	Started when	State of the logical channel	Normally terminated when	Preferred action to be taken when time-limit expires
T20	180 s	DTE issues a *restart request*	r2	DTE leaves the r2 state (ie the *restart confirmation* or *restart indication* is received)	To retransmit the *restart request* (see Note 1)
T21	200 s	DTE issues a *call request*	p2	DTE leaves the p2 state (eg the *call connected*, *clear indication* or *incoming call* is received)	To transmit a *clear request*
T22	180 s	DTE issues a *reset request*	d2	DTE leaves the d2 state (eg the *reset confirmation* or *reset indication* is received)	For virtual calls, to retransmit the *reset request* or to transmit a *clear request*. For permanent virtual call circuits, to retransmit the *reset request* (see Note 2)
T23	180 s	DTE issues a *clear request*	p6	DTE leaves the p6 state (eg the *clear confirmation* or *clear indication* is received)	To retransmit the *clear request* (see Note 2)
T28 (see Note 3)	300 s	DTE issues a *registration request*	Any	DTE received the *registration confirmation* or a *diagnostic packet*	May retransmit the *registration request*, but should at some point recognize that the on-line facility is not offered

Note 1: After unsuccessful retries, recovery decisions should be taken at higher layers.

Note 2: After unsuccessful retries, the logical channel should be considered out of order. The restart procedure should only be invoked for recovery if reinitialization of all logical channels is acceptable.

Note 3: The DTE timers T24 through T27 have been assigned by ISO in the specification of the packet level for X.25 DTEs. To avoid ambiguity and confusion, the time-limit number has therefore been assigned T28.

[. . .]

ANNEX G

(to Recommendation X.25)

ITU-T-specified DTE facilities to support the OSI Network service

G.1   INTRODUCTION

The facilities described in this annex are intended to support end-to-end signalling required by the OSI Network service. They follow the ITU-T-specified DTE facility marker defined in § 7.1. These facilities are passed unchanged between the two packet mode DTEs involved.

Procedures for the use of these facilities by DTEs are specified in ISO 8208. Subsequent provision of X.25 facilities to be acted on by public data networks is for further study. Coding of the facilities in this annex is defined here in order to facilitate a consistent facility coding scheme in such future evolution.

G.2   CODING OF THE FACILITY CODE FIELDS

Table G-1/X.25 gives the coding of the facility code field for each ITU-T-specified DTE facility and the packet types in which they may be present. These facilities are conveyed after the ITU-T-specified DTE facility marker.

Table G-1/X.25 – Coding of the facility code field

Facility	Packet types in which the facility may be used						Facility code							
	Call request	Incoming call	Call accepted	Call connected	Clear request	Clear indication	Bits							
							8	7	6	5	4	3	2	1
Calling address extension	X	X			X (see Note)		1	1	0	0	1	0	1	1
Called address extension	X	X	X	X	X	X	1	1	0	0	1	0	0	1
Quality of service negotiation: minimum throughput class	X	X	X		X (see Note)		0	0	0	0	1	0	1	0
end-to-end transit delay	X	X	X	X	X (see Note)		1	1	0	0	1	0	1	0
priority	X	X	X	X	X (see Note)		1	1	0	1	0	0	1	0
protection	X	X	X	X	X (see Note)		1	1	0	1	0	0	1	1
Expedited data negotiation	X	X	X	X	X (see Note)		0	0	0	0	1	0	1	1

Note: Only when the call deflection selection facility is used (see § 6.25.2.2).

G.3   CODING OF THE FACILITY PARAMETER FIELD

G.3.1   Calling address extension facility

The octet following the facility code field indicates the length of the facility parameter field in octets. It has a value of n + 1, where n is the number of octets necessary to hold the calling address extension. The facility parameter field follows the length and contains the calling address extension.

The first octet of the facility parameter field indicates, in bits 8 and 7, the use of the calling address extension, as shown in Table G-2/X.25.

Table G-2/X.25 – Coding of bits 8 and 7 in the first octet of the calling
extension facility parameter field

Bits 8 7	Use of calling address extension
0 0	To carry a calling address assigned according to Recommendation X.213/ISO 8348 AD2
0 1	Reserved
1 0	Other (to carry a calling address not assigned according to Recommendation X.213/ISO 8348 AD2)
1 1	Reserved

Bits 6, 5, 4, 3, 2 and 1 of this octet indicates the number of semi-octets (up to a maximum of 40) in the calling address extension. This address length indicator is binary coded, where bit 1 is the low-order bit.

The following octets contain the calling address extension.

If bits 8 and 7 of the first octet of the facility parameter field are coded "00", the following octets are encoded using the preferred binary encoding (PBE) defined in Recommendation X.213. Starting from the high-order digit of the Initial Domain Part (IDP), the address is coded in octet 2 and consecutive octets of the facility parameter field. Each digit, with padding digits applied as necessary, is coded in a semi-octet in binary coded decimal, where bit 5 or 1 is the low-order bit of the digit. In each octet, the higher-order bit is coded in bits 8, 7, 6 and 5. The Domain Specific Part (DSP) of the calling OSI NSAP follows the IDP and is coded in decimal or binary, according to the PBE. For example, if the syntax of the DSP is decimal, each digit is coded in binary coded decimal (with the same rules applying to the DSP as to the IDP above). If the syntax of the DSP is binary, each octet of the calling address extension contains an octet of the DSP.

If bits 8 and 7 of the first octet of the facility parameter field are coded "10", each digit of the calling address extension is coded in a semi-octet in binary coded decimal, where bit 5 or 1 is the low-order bit of the digit. Starting from the high-order digit, the address is coded in octet 2 and consecutive octets of the facility parameter field with two digits per octet. In each octet, the higher order digit is coded in bits 8, 7, 6 and 5. When necessary, the facility parameter field shall be rounded up to an integral number of octets by inserting zeros in bits 4, 3, 2 and 1 of the last octet of the field.

G.3.2   Called address extension facility

The octet following the facility code field indicates the length of the facility parameter field in octets. It has a value of n + 1, where n is the number of octets necessary to hold the called address extension. The facility parameter field follows the length and indicates the called address extension.

The first octet of the facility parameter field indicates, in bits 8 and 7, the use of the called address extension, as shown in Table G-3/X.25.

Table G-3/X.25 – Coding of bits 8 and 7 in the first octet of the called
extension facility parameter field

Bits 8 7	Use of calling address extension
0 0	To carry a calling address assigned according to Recommendation X.213/ISO 8348 AD2
0 1	Reserved
1 0	Other (to carry a calling address not assigned according to Recommendation X.213/ISO 8348 AD2)
1 1	Reserved

Bits 6, 5, 4, 3, 2 and 1 of this octet indicates the number of semi-octets (up to a maximum of 40) in the called address extension. This address length indicator is binary coded, where bit 1 is the low-order bit.

The following octets contain the called address extension.

If bits 8 and 7 of the first octet of the facility parameter field are coded "00", the following octets are encoded using the preferred binary encoding (PBE) defined in Recommendation X.213. Starting from the high-order digit of the Initial Domain Part (IDP), the address is coded in octet 2 and consecutive octets of the facility parameter field. Each digit, with padding digits applied as necessary, is coded in a

semi-octet in binary coded decimal, where bit 5 or 1 is the low-order bit of the digit. In each octet, the higher-order bit is coded in bits 8, 7, 6 and 5. The Domain Specific Part (DSP) of the called OSI NSAP follows the IDP and is coded in decimal or binary, according to the PBE. For example, if the syntax of the DSP is decimal, each digit is coded in binary coded decimal (with the same rules applying to the DSP as to the IDP above). If the syntax of the DSP is binary, each octet of the called address extension contains an octet of the DSP.

If bits 8 and 7 of the first octet of the facility parameter field are coded "10", each digit of the called address extension is coded in a semi-octet in binary coded decimal, where bit 5 or 1 is the low-order bit of the digit. Starting from the high-order digit, the address is coded in octet 2 and consecutive octets of the facility parameter field with two digits per octet. In each octet, the higher order digit is coded in bits 8, 7, 6 and 5. When necessary, the facility parameter field shall be rounded up to an integral number of octets by inserting zeros in bits 4, 3, 2 and 1 of the last octet of the field.

G.3.3 Quality of service negotiation facilities

G.3.3.1 *Minimum throughput class facility*

The minimum throughput class for the direction of data transmission from the calling DTE is indicated in bits 4, 3, 2 and 1. The minimum throughput class for the direction of data transmission from the called DTE is indicated in bits 8, 7, 6 and 5.

The four bits indicating each throughput class are binary coded and correspond to throughput classes as indicated in Table 30/X.25.

G.3.3.2 *End-to-end transit delay facility*

The octet following the facility code field indicates the length in octets of the facility parameter field and has the value 2, 4 or 6.

The first and second octets of the facility parameter field contain the cumulative transit delay. The third and fourth octets are optional and, when present, contain the requested end-to-end transit delay. If the third and fourth octets are present, then the fifth and sixth octets are also optional. The fifth and sixth octets, when present, contain the maximum acceptable end-to-end transit delay. The optional octets are not present in call accepted and call connected packets.

Transit delay is expressed in milliseconds and is binary-coded, with bit 8 of the first of a pair of octets being the high-order bit and bit 1 of the second of a pair of octets being the low-order bit. The value of all ones for cumulative transit delay indicates that the cumulative transit delay is unknown or exceeds 65534 milliseconds.

G.3.3.3 *Priority facility*

The octet following the facility code field indicates the length, in octets, of the facility parameter field. This may take the value 1, 2, 3, 4, 5 or 6.

The first, second and third octets of the facility parameter field contain the target (call request packet), available (incoming call packet) or selected (call accepted and call connected packets) values for the priority of data on connection, priority to gain a connection and priority to keep a connection, respectively. The fourth, fifth and sixth octets of the facility parameter field in call request and incoming call packets contain the lowest acceptable values for the priority of data on connection, priority to gain a connection and priority to keep a connection, respectively. When the facility is present in call request and incoming call packets, octets 2 through 6 of the facility parameter field are optional. For example, if the only values to be specified are the target and lowest acceptable values for priority to gain a connection, then the facility parameter field will contain at least 5 octets with octets 1, 3 and 4 containing the value "unspecified", and octets 2 and 5 containing the specified values. When the facility is present in the call accepted and call connected packets, octets 2 and 3 are optional.

The potential range of specified values for each sub-parameter is 0 (lowest priority) to 254 (highest priority). The value 255 (1111 1111) indicates "unspecified".

G.3.3.4 *Protection facility*

The octet following the facility code indicates the length, in octets, of the facility parameter field.

The two highest order bits of the first octet (i.e., bits 8 and 7) of the facility parameter field specify the protection format code as indicated in Table G-4/X.25.

Table G-4/X.25 – Coding of the two highest order bits in the first
octet of the protection format code

Bits 8 7	Protection format code
0 0	Reserved
0 1	Source address specific
1 0	Destination address specific
1 1	Globally unique

The remaining six bits of the octet are reserved and must be set to zero.

The second octet of the facility parameter field specifies the length "n", in octets, of the target (call request packet), available (incoming call packet) or selected (call accepted and call connected packets) protection level. The actual value is placed in the following "n" octets. Optionally, the "n + 3" octet of the facility parameter field specifies the length "m", in octets, of the lowest acceptable protection level in call request and incoming call packets. The actual value is placed in the following "m" octets. The optional octets are not present in call accepted and call connected packets.

Note: The values of "n" and "m" are bounded firstly by the overall length of the facility (first octet), and secondly by each other.

G.3.4   Expedited data negotiation facility

The coding of the facility parameter field is:

bit 1 = 0 for no use of expedited data

bit 1 = 1 for use of expedited data

Note: Bits 8, 7, 6, 5, 4, 3 and 2 may be used for other facilities in the future; presently, they are set to zero.

[. . .]

APPENDIX I

(to Recommendation X.25)

Examples of data link layer transmitted bit patterns by the DCE and the DTE

This appendix is provided for explanatory purposes and indicates the bit patterns that will exist on the physical link for some of the unnumbered frames. It is included for the purpose of furthering the understanding of the transparency mechanism and the frame check sequence implementation.

I.1   The following are examples of the bit patterns that will be transmitted by a DCE for some unnumbered frames.

Example 1: SABM command frame with address = A, P = 1

First bit transmitted   Last bit transmitted

↓   ↓

| 0111 1110 | 1100 0000 | 1111 1(0[3])100 | 1101 1010 0011 0111 | 0111 1110 |
| Flag | Address = A | SABM(P = 1) | Frame check sequence | Flag |

Example 2: UA response frame with address = B, F = 1

First bit transmitted   Last bit transmitted

↓   ↓

| 0111 1110 | 1000 0000 | 1100 1110 | 1100 0001 1110 1010 | 0111 1110 |
| Flag | Address = B | UA(F = 1) | Frame check sequence | Flag |

I.2   The following are examples of the bit patterns that should be transmitted by a DTE for some unnumbered frames:

Example 1: SABM command frame with address = B, P = 1

First bit transmitted   Last bit transmitted

↓   ↓

| 0111 1110 | 1000 0000 | 1111 1(0[3])100 | 1101 0111 11(0[3])11 1011 | 0111 1110 |
| Flag | Address = B | SABM(P = 1) | Frame check sequence | Flag |

Example 2: UA response frame with address = A, F = 1

First bit transmitted   Last bit transmitted

↓   ↓

| 0111 1110 | 1100 0000 | 1100 1110 | 1100 1100 0010 0110 | 0111 1110 |
| Flag | Address = A | UA(F = 1) | Frame check sequence | Flag |

———

[3] Zero inserted for transparency.

APPENDIX II

(to Recommendation X.25)

An explanation of how the values for N1 in Section 2.4.8.5 are derived

INTRODUCTION

This appendix provides a description of how the values given for the link level parameter N1 in Section 2.4.8.5 are derived.

DTE N1

Section 2.4.8.5 states that for universal operation a DTE should support a value of DTE N1 which is not less than 1080 bits (135 octets).

For universal operation, a DTE must be capable of accepting at least the largest packet that can be transmitted across a DTE/DCE interface when no options apply. This implies that the DTE may choose not to support, for example, any optional facilities for universal operations, but must support, for example, a data packet using the standard default packet size. Therefore, the determining factor for the maximum value of N1 that a DTE must support is the standard default packet size of a data packet rather than the size of a call setup packet. Thus, for universal operation a DTE should support a value of DTE N1 which is not less than 135 octets, derived as shown in the following table.

Table II-1/X.25 – Derivation of the minimum value of N1 for a DTE

Name of the Field	Length of the Field (octets)
Packet Header (Layer 3)	3
User Data (Layer 3)	128
Address (Layer 2)	1
Control (Layer 2)	1
FCS (Layer 2)	2
TOTAL	135

Note: A DTE will need to support larger values of N1 when optional facilities will apply.

DCE N1

Section 2.4.8.5 also states that all networks shall offer to a DTE which requires it a value of DCE N1 which is greater than or equal to 2072 bits (259 octets) plus the length of the address field plus the length of the control field and plus the length of the FCS field.

When the maximum length of the data field of a data packet supported is less than or equal to the standard default value of 128 octets, the determining factor (for the value of DCE N1) is the clear request packet rather than the data packet. Therefore, the network shall offer to a DTE, a value of DCE N1 which is not less than 263 or 264 octets, derived as shown in the following table.

Table II-2/X.25 – Derivation of the minimum value of N1 for a DCE

Name of the Field	*Length of the Field (octets)*
Header (Layer 3)	3
Clearing Cause (Layer 3)	1
Diagnostic Code (Layer 3)	1
DTE Address Length (Layer 3)	1
DTE Address(es) (Layer 3)	15
Facility Length (Layer 3)	1
Facilities (Layer 3)	109
Clear User Data (Layer 3)	128
Layer 3 Total	259
Address (Layer 2)	1
Control (Layer 2)	1 or 2*
Multilink Procedure	2**
FCS (Layer 2)	2
TOTAL	263 or 264* or 265** or 266*,**

* If Level 2 Modulo 128 operation is supported.
** Multilink Procedures (MLP) are supported.

When the maximum length of the user data field of a data supported is greater than the standard default value of 128 octets, the determining factor (for the value of DCE N1) is the data packet rather than the clear request packet. Therefore, the network shall offer to a DTE, a value of DCE N1 which is greater than or equal to:

{the maximum length of the data packet +
the length of the address field (Layer 2) +
the length of the control field (Layer 2) +
the length of the FCS field (Layer 2)}.

GENERAL DCE N1 CALCULATIONS

The following table indicates the value of DCE N1 for each possible case. The table shows for each case, whether

(a) Layer 2 Modulo 128 is used;
(b) Multilink Procedures are used;
(c) Layer 3 Modulo 128 is used; and/or
(d) The maximum length of the data field (p) in a data packet is greater than or equal to 256 octets.

Table II-3/X.25 – Various cases and corresponding minimum N1 value for a DCE

Layer 2 Modulo 128	MLP	Layer 3 Modulo 128	p ≥ 256	DCE N1 (octets)
				259 + 4*
	X			259 + 4* + 2*****
			X	p + 3** + 4*
	X		X	p + 3** + 4* + 2*****
		X		259 + 4*
	X	X		259 + 4* + 2*****
		X	X	p + 3** + 1*** + 4*
	X	X	X	p + 3** + 1*** + 4* + 2*****
X				259 + 4* + 1****
X	X			259 + 4* + 1**** + 2*****
X			X	p + 3** + 1**** + 4*
X	X		X	p + 3** + 1**** + 4* + 2*****
X		X		259 + 4* + 1****
X	X	X		259 + 4* + 1**** + 2*****
X		X	X	p + 3** + 1*** + 4* + 1****
X	X	X	X	p + 3** + 1*** + 4* + 1**** + 2*****

*   The number of octets for Modulo 8 Layer 2 frame fields.
**   The number of octets for Layer 3 packet header fields.
***   Additional octet for Layer 3 Modulo 128 operations.
****   Additional octet for Layer 2 Modulo 128 operations.
*****   Additional octets for MLP support.

[. . .]

ATTACHMENT II-14

USE OF X.25 SWITCHED VIRTUAL CIRCUITS (SVCs)

The X.25 virtual calls, also called switched virtual circuits (SVC), are used on the GTS. The X.25 SVCs can be used in a pure X.25 environment or in conjunction with other communications protocols such as TCP/IP. In all cases, the use of SVCs has the following advantages over permanent virtual circuits (PVC):

(a) Reduces data loss on circuits with packet switches;
(b) Enables backup circuits to be operated with minimum disruption;
(c) Allows flexible data exchange via negotiation of packet size, window size, throughput class, etc.

The following sections describe the typical uses and configuration characteristics of X.25 SVCs on the GTS. Basic recommendations for the implementation of X.25 SVCs are also given.

1. PURE X.25

1.1 Traffic type

Traditional MSS traffic, i.e. continuous routine messages.

1.2 Configuration characteristics

A pure X.25 SVC connection may be treated as either:

(a) A constant X.25 connection between centres which is operated in a similar manner to that of a PVC;
(b) A transient X.25 connection between centres.

1.3 Recommended operation

1.3.1 Traffic flow

As the operation of individual SVCs for incoming and outgoing traffic is easier to control and less ambiguous to implement on the MSS, it is recommended that the traffic flow on a X.25 SVC be one-way. In this case, a transmitting centre initiates the X.25 call set-up to establish an SVC for its outgoing traffic.

1.3.2 X.25 Call clearing
SVCs may be either:

(a) Kept open wherever possible;
(b) Cleared down on an inactivity timer by either centre.

The former is the simplest approach to exchange routine messages on a leased circuit as it is similar to a PVC connection. However, the latter may provide a desirable solution in such conditions as the use of public data networks or existence of packet switch restrictions. It is recommended that the chosen option be agreed on a bilateral basis.

2. IP OVER X.25

2.1 Traffic type

Data not traditionally associated with an MSS (e.g. satellite imagery), exchanged intermittently on real-time basis – usually via FTP. Data is typically transmitted in bursts.

2.2 Configuration characteristics

2.2.1 The X.25 SVC is typically intermittent between adjacent centres.

2.2.2 Specific connection details (e.g. the number of SVCs allowed, an idle timer for call clearing) may be dependent on router brand and configuration.

2.3   Recommended operation

The routers provide flexible functions to handle the X.25 call set-up and call clearing in the case of both one-way and two-way traffic on an SVC. As the data tends to be transmitted in bursts it is undesirable that unnecessary SVCs remain for a long period. It is therefore recommended that an idle timer for call clearing in routers be configured for efficient operation.

3.   X.25 OVER IP

3.1   Traffic type

Traditional MSS traffic, i.e. continuous routine messages.

3.2   Configuration characteristics

3.2.1   The X.25 may be a constant or transient connection between adjacent centres.

3.2.2   There is no standard for X.25 over IP.

3.3   Recommended operation

The recommended operation for the X.25 based portion is as in section 1.3. As no standard exists for X.25 over IP this solution is router specific. Therefore any router and router configuration must be adopted bilaterally.

It should be noted that IP over X.25 and X.25 over IP are not as efficient as pure X.25 or pure IP. While IP over X.25 is standardized (with the associated advantages this gives) centres may wish to move to using X.25 over IP or pure IP if the amount of IP traffic becomes significant as the more IP has to be encapsulated within X.25 the less efficient the link will become.

ATTACHMENT II-15

RECOMMENDED PRACTICES AND PROCEDURES FOR THE IMPLEMENTATION, USE AND APPLICATION OF TCP/IP ON THE GTS

FOREWORD

The strategic direction for development of the GTS, as endorsed by CBS, has since the early eighties, been based on the OSI standards, especially the ITU-T recommendation X.25. However, CBS now considers that the TCP/IP protocols as used on the Internet, should replace X.25 for supporting GTS operations in the future.

The change in strategic direction has evolved within the CBS in recent years. It has occurred for various reasons, including the expanding functional needs of the various WMO programs and the evolution of the Internet and its supporting technical standards, as a dominant force in the information technology industry, supplanting the OSI standards in many areas.

The transition to TCP/IP is considered appropriate because:

(a) Vendor support for X.25 technology is declining and becoming more expensive due to industry concentration on TCP/IP;

(b) TCP/IP supports numerous application utilities available off the shelf, which offer solutions to information communications needs of Members, such as file transfer, Web browsers, electronic mail and future applications such as multimedia communications;

(c) TCP/IP provides connectivity between Members in a more flexible and versatile manner than the X.25 based equivalent.

These benefits equate to direct savings in financial and human resource costs to Members by:

(a) Reduced costs for communications equipment purchase and maintenance; and

(b) Reduced software development work through use of industry standard software systems.

Considerable efforts have been applied in defining the framework for applying TCP/IP to the GTS and for the orderly transition from the OSI/X.25 based origin of the GTS. Furthermore, it is understood that TCP/IP will be the basis for all new telecommunication functions implemented in support of the WMO Information Systems (WIS).

Procedures are defined to ensure that the primary function of the GTS in carrying real time operational traffic with minimum delay is preserved. The issue of securing the GTS from interference via the Internet is also addressed in general terms. Reliance must however be placed on all Members with a TCP/IP based connection to the GTS, who are also connected to the Internet, to implement and maintain thorough security practices.

This Attachment was originally written as the culmination of work undertaken by CBS during 1997 and 1998. The TCP/IP procedures have since been implemented by most national Centres. The opportunity has been taken to capture the practical experiences gained in the use of TCP/IP and update material accordingly. In addition, a World Wide Web resource has been set-up which gives further details of the technical implementation of many of the concepts and procedures introduced within this Attachment. This is available on the following WMO web pages:

http://www.wmo.int/pages/prog/www/manuals.html

http://www.wmo.int/pages/prog/www/documents.html

Members are strongly advised to take account of the adoption of the TCP/IP based strategy for the future development of the GTS, in planning the future development of systems within their national Centres.

1.   INTRODUCTION

Historical perspective

The GTS at present is predominantly used to support the message switching application using message exchange in WMO format. This exchange is done using:

The TCP/IP protocol suite;
Limited OSI transport service based on point to point X.25;

and is supplemented by broadcasts.

This implementation is adequate for the legacy application of message switching but it is recognized that it requires continuous improvements to fully support the various WMO programs and the new requirements of the WIS. For example, the GTS should support:

Distributed Data Bases (DDB);
Data exchange between non adjacent centres;
Exchange of information that cannot readily be handled by message switching systems (MSSs).

Purpose of this Attachment

This Attachment is intended to assist Centres to implement Transmission Control Protocol/ Internet Protocol (TCP/IP) based services on the GTS. Throughout this document, it is understood that the implementation of TCP/IP protocols include all essential protocols that are normally part of the TCP/IP protocol suite, as described in the Internet Engineering Task Force (IETF) reference documents RFC112 and RFC1123. These documents are available from the IETF website at: http://www.ietf.org/.

The aim of this Attachment is to describe those aspects of the application of TCP/IP that apply specifically to the GTS to meet new requirements and also the long established routine data exchange undertaken by Message Switching Systems (MSSs). The Attachment takes account of the technical evolution of the GTS from an X.25 based network, and maintains the philosophy that Centres continue to be autonomous as far as possible. It is recognised that the timing for implementation of new systems is determined by individual Members in the light of their available resources and relative priorities, but it is also understood that new WIS functionality is expected to be achieved mostly via TCP/IP protocols.

This Attachment does not cover fundamentals of TCP/IP but focuses on those aspects that are essential for successful application on the GTS. Such aspects include appropriate use of the GTS compared with the Internet, co-existence of the GTS and the Internet, IP and X.25 and Autonomous System addressing, router management, TCP/IP application services (such as FTP) and fault management. The Attachment also gives an overview of recommended security practices with TCP/IP, but does not address security issues and practices in detail, this being a highly complex subject in itself. Some references on TCP/IP and on computer security are given in Appendix 4. A more comprehensive discussion on security can be found in the "WMO Guide on Information Technology Security", which is available on the WMO website at: http://www.wmo. int/pages/prog/www/manuals.html.

Relationship of the Internet and GTS

The Internet has grown rapidly in capacity, penetration and diversity of applications. As well, day to day performance of the Internet, which used to be recognized as a weakness, is now reaching acceptable levels of reliability in many countries. It should be noted however that the very nature of the Internet will always mean that no one can build a system using the Internet for which specific service levels can be guaranteed, since the Internet is the result of the amalgamation of numerous telecommunication systems, for which no operator has complete responsibility.

It is therefore recognized that the Internet can be used as:

An underlying technology for some components of the GTS in special conditions,
As a backup to the GTS; and
As a complement to the GTS.

Table 1. Usage of GTS and Internet

Communication Component	Underlying Technologies	Function
GTS	Dedicated links, high availability network clouds, VPN via Internet for backup or when no other technology is available	Delivery of time critical communication for weather, water and climate operations
Internet	As provided by supplier	Communication for less critical requirements and possibly for large volumes of data

Coexistence with the Internet also brings some special security problems that must be addressed to ensure the GTS can fulfil its function. In particular, the networks must be engineered in such a way that the GTS is protected from general Internet traffic and is secured against inappropriate use and unauthorised access. For example, the use of IP and dynamic routing protocols such as BGP4 (Border Gateway Protocol) on the GTS will have to be managed in such a way as to allow communication between non-adjacent Centres only with the knowledge and concurrence of all intermediate Centres. Otherwise there is a danger that large amounts of GTS capacity could be consumed by non-routine traffic, to the detriment of real time operational data exchange.

Evolution of the GTS

The use of the ISO/ITU standard X.25 was adopted by WMO in the early 1980's to facilitate the exchange of data and products encoded in WMO binary code forms (GRIB, BUFR etc) and to act as a base for higher level OSI applications. Although OSI was regarded at the time as the strategic direction for the evolution of data communications, this has changed. Today, there is no doubt TCP/IP protocols are the most accepted and widespread protocols for exchange of data.

TCP/IP is still appropriate because:

(a) It is the dominant protocol suite in everyday use being now packaged with virtually all implementations of Unix and many PC operating systems;

(b) It offers a wide range of standard applications (file transfer, electronic mail, remote logon, World Wide Web, etc.) that will greatly reduce the need for the WMO community to develop special procedures and protocols as it has had to do in the past;

(c) It provides useful features such as automatic alternate routing (in a meshed network) which could improve the reliability of the GTS.

This Attachment however takes account of the fact that centres have based plans and developed systems in line with the OSI standards, particularly X.25, as endorsed by WMO and specified in the *Manual on the GTS*. The transition to TCP/IP based services must continue in an orderly fashion from the X.25 based links in such a way that operation of the GTS is not disrupted or put at risk.

The Attachment provides for this by defining procedures for:

(a) An interim hybrid based on:
    (i) Carrying TCP/IP based services over an X.25 network service; or
    (ii) Carrying X.25 data over IP based network service via directly connected routers;

(b) Subsequent transition to pure IP utilising directly connected routers, together with TCP/IP based application services, such as TCP sockets or File Transfer Protocol (FTP).

The transition to the second step (pure IP) is desirable because:

(a) Operating TCP/IP over X.25 may not provide expected throughput because of router processing overheads involved in packet encapsulation of IP frames within X.25 packets. This appears to become worse as line speeds increases. Limited tests which have been done between Centres in Region VI indicate efficiency less than 70% at 64Kbps;

(b) The management and maintenance activities required for the X.25 network and associated packet switches can be avoided;

(c) Carrying X.25 over IP requires use of proprietary features of specific router brands.

In order to move to pure IP, it is necessary to modify MSSs at each Centre to make use of TCP/IP services such as FTP and Sockets. This is covered in some detail in Chapter 4.

Other related issues

Many Centres now have experience of TCP/IP on the GTS. Experience has shown that the main technical issues, which need to be addressed to establish widespread use of TCP/IP on the GTS, are:

(a) Agreed methods for the message switching application to use TCP/IP either directly or via higher level applications e.g. FTP;
(b) An agreed file naming convention and standard for metadata associated with files;
(c) A community wide Naming and Addressing agreement.

It is the aim of this Attachment to make some progress with these issues, some of which lie in the domain of Data Management as much as Telecommunications. It must also be recognised that overall, the existing GTS is not a homogenous network in the true sense of the word, but a collection of regional networks and discrete point-to-point links. Also managed networks using Frame Relay and MPLS (Multi Protocol Label Switching) technology are now part of the GTS. These developments introduce new issues regarding multi lateral co-operation in operating the GTS. While these issues are raised, they are beyond the scope of this Attachment.

2. PRINCIPLES GOVERNING THE USE OF TCP/IP ON THE GTS

Management of traffic on GTS and Internet

The TCP/IP protocol suite is an enabler to:

(a) Simplify interconnectivity between computer systems by allowing several telecommunication technologies to be integrated into a coherent network which may include automatic redundant backup routes,
(b) Lower costs by providing standard telecommunication solutions;
(c) Build modern applications not just limited to strict, fixed store and forward traffic rules.

However, some care must be taken to address the counter effects of these benefits and in particular, more flexibility in interconnection and in applications comes at the price of less control on where traffic can go. For example, a general purpose link to a GTS cloud network might get flooded with less critical traffic requested by a site that doesn't normally request data through a given link. It may also mean that traffic has trouble reaching its destination because there are several ill-defined routes (through both the GTS and the Internet) to get there.

This care can be achieved through traffic control and segregation, which would address three basic issues:

(a) Traffic management (ensuring timely delivery of critical data, controlling limited bandwidth availability in some areas);
(b) Security (protecting centres from unwanted threatening events);
(c) Routing coherence (ensuring that the overall resulting network can deliver traffic without difficulty to any given location).

To achieve traffic control and segregation, there are several important aspects to consider:

(a) IP addressing: using universally recognizable and coherent network addresses so that all systems only have one unique reference number, which is valid not only within the GTS but across the Internet and any other network which may eventually be interconnected to the GTS;
(b) IP network routing rules: using a common set of routing protocols and rules to ensure that any traffic can be consistently sent to its destination without delay or confusion;
(c) Zoning of each Centre's network elements: creating different network zones with different security levels, to isolate a Centre's critical elements from publicly available areas and ensuring that data can still flow between zones of differing security levels.

Overall topology of interconnection

A general view of the possible interconnectivity between Centers using the GTS and the Internet is given in Appendix 1, as well a typical data flows.

Actual device configuration details to implement these functions in the Cisco family of routers are given in Appendix 2.

Traffic management

Traffic management is an area which is unfortunately not limited to networks, but also involves data management and application configurations. Several groups are therefore involved in this matter.

In general, it can be said that some applications such as file transfer, World Wide Web have potential to place heavy loads on the limited bandwidth circuits that comprise the GTS. Limits need to be applied to ensure that the GTS carries only important traffic such as the real time data and products currently exchanged on the GTS plus data to be carried to fulfil new requirements such as Distributed Data Bases (DDBs), and routinely exchanged large data files such as satellite imagery.

Less important traffic such as ad hoc file exchange, e-mail, general World Wide Web and suchlike should be carried on the Internet. To protect the GTS, the full capabilities of TCP/IP connectivity and information exchange must be restricted. In practical terms, TCP/IP traffic carried on the GTS could be restricted on the basis of:

(a) Protocol type (e.g. FTP, HTTP, SMTP etc);
(b) Originating and destination IP address;
(c) A combination of the above.

If the measures adopted are to be successful, it is necessary that they be:

(a) Not confined to a single router brand since it cannot be assumed that all centres will have the same brand of router; and
(b) Be reasonably straightforward to configure, so that there is minimum risk that configuration errors or omissions will endanger the GTS.

Security issues and segregation of Internet and GTS traffic

Any Centre which has a TCP/IP based GTS connection and a connection to the Internet, is a potential weak point where the GTS could be exposed to deliberate or inadvertent interference through unwanted traffic or unauthorised connection to GTS hosts.

Centres are strongly encouraged to implement protective barriers such as firewall systems on the connection of their Centre with the Internet. It is important that every practical step is taken to prevent accidental or deliberate use of GTS links or unauthorised access to GTS Centres, by Internet users.

When setting up IP on the GTS, it is vital to ensure that the GTS does NOT become part of the Internet or an unintended transmission path for Internet traffic. Each Centre must consider the GTS and the Internet as two separate networks and ensure that inappropriate flow of traffic from one to the other cannot occur. This will ensure that the GTS is used only for transferring bona fide meteorological data between authorised hosts.

Some basic principles for implementing basic security measures for the GTS are shown in figure A1.2 in Appendix 1. It illustrates in a general way, how a Centre with TCP/IP connection to the GTS and an Internet connection might be set up. Functions to be implemented include:

(a) Allowing only GTS designated hosts to communicate through the GTS router;
(b) Blocking access to GTS designated hosts through the firewall and Internet router;
(c) Firewall allows only approved hosts on the Internet to access B hosts and then, only for approved applications such as FTP;
(d) Prevention of access to A hosts from Internet via B hosts.

The actual choice of routers and firewall and the setting up of these will require expertise in the design and configuration of networking and security systems. It is not intended here, to provide detailed coverage of security system implementation and management as it is a large and complex topic. It is simply emphasised that it is important that every Centre should implement the best practical security measures, appropriate to its system complexity and capabilities. Some additional material relevant to small Centres is given in Appendix 4.

In addition to network security measures, it is vital that good security practices are followed in the management of all hosts in a Centre. Computer security is a complex subject in itself and Centres are encouraged to study this in depth and apply appropriate practices. Some references in computer security are given in Appendix 5. As a bare minimum, good password practices should be followed in the management of all host machines in a Centre. Some recommended practices are given in Appendix 6.

Routing and traffic management

Routing algorithms

In order to be able to send a packet, every host, router or equipment connected on an IP network must have a routing table. The table tells the system where to send the packet. This may be achieved by:

(a) Static routing; or

(b) Dynamic routing.

Static routing

With static routing, every required destination and next hop must be entered in the routing tables by the system administrator. Alternatively, a default route can be declared, although this option is mainly applicable to sites with only one connection to the outside world. If a default route is set up, filters must be established to ensure that only authorised hosts can access the GTS.

Whenever a new Centre is connected to the GTS with IP protocol, the site managers of all other IP capable Centres must add the new address to their routing tables. This might become a major task as IP connectivity spreads over the GTS.

Dynamic routing

With dynamic routing, the routing information is automatically exchanged between routers. This enables the network to learn new addresses and to use alternative paths under fault conditions in a partially meshed network topology. The initial set-up of dynamic routing may be somewhat more complex, but the ongoing management task is greatly reduced.

Use of dynamic routing requires selection of an appropriate routing protocol to operate over the links of the GTS. The protocol must be an exterior gateway protocol (e.g. EGP, BGP) as opposed to an interior gateway protocol (such as IGRP, RIP, OSPF) because interior gateway protocols are intended for use within a single management domain. The GTS is an aggregation of many separate management domains. As such, it is necessary to select a gateway protocol that can be autonomously managed by each Centre to implement routing and hence traffic flow, consistent with its particular requirements.

Two exterior gateway protocols are defined by RFCs – EGP and BGP (now release 4 – RFC 1771). As the GTS is not a tree structure, setting up routing with EGP may be difficult. BGP 4 does not suffer topological constraints. It is more powerful, but a little more difficult to configure.

BGP can distribute subnetted routes. This feature might be very useful for the GTS. Instead of propagating host-based routes or full network routes, routing can be based on subnetted networks. Instead of declaring hosts eligible to use the GTS, a Centre could declare a full subnet of eligible hosts. In that case, the routing information consists of just an IP address and a subnet mask. For example, if a Centre has a class C addresses 193.168.1.0, by declaring that the subnet 193.168.1.16 with mask 255.255.255.248 is allowed to use the GTS, all hosts with IP address 193.168.1.17 to 193.168.1.22 will be routable on the GTS.

Recommended routing method

Based on consideration of the above factors the BGP4 routing protocol should be used between Centres on the GTS, unless an alternative is bilaterally agreed on individual links. Examples of BGP4 set-up for the Cisco router family are given in Appendix 2.

Registered and private addresses

It is recommended that Centres strive to use officially registered IP addresses issued by the Internet Assigned Numbers Authority (IANA) or the relevant Regional Internet Registry. Official IP addresses are required for all systems which communicate through the Internet. Their use is also strongly recommended for systems which communicate on any inter-organization network, including of course the GTS.

Since it is recognized that official IP addresses sometimes difficult to obtain in certain areas of the world, some compromise options have been developed to mitigate this problem.

Appendix 7 describes IP addresses in further detail and the recommended options for the use of IP addresses over the GTS.

If Centres use private IP addresses on their internal networks, then Network Address Translation (NAT) must be adopted for any hosts requiring to communicate over the GTS or the Internet.

A sufficient number of official addresses must be obtained to correspond to the number of hosts required to communicate externally, and the type of NAT supported by the Centre's access router. If static NAT is adopted, then a one to one correspondence of internal and official addresses is required. If dynamic NAT is used, then there can be more internal addresses than official addresses, with the router allocating the pool of official addresses dynamically as necessary. The documentation for the Centre's access router should be consulted to ascertain the NAT support provided.

Private addresses must not be visible on the GTS or Internet. Figure 2.1 shows simplified examples of allowable and non-allowable arrangements.
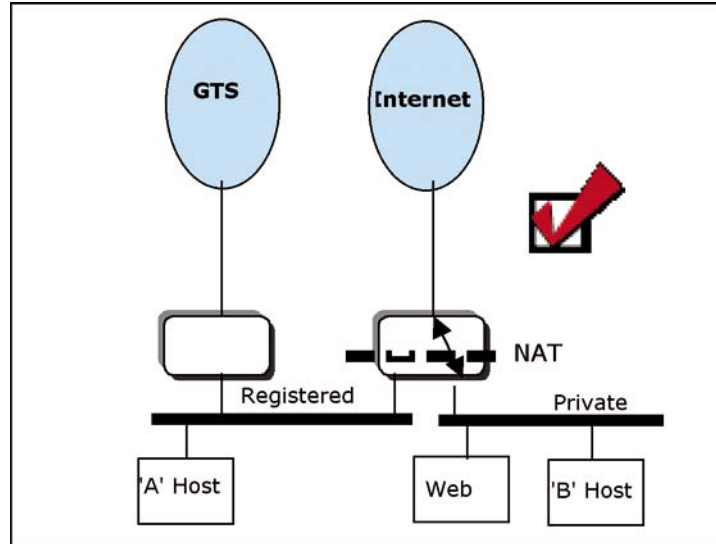
Figure 2.1 (a). (Allowed)
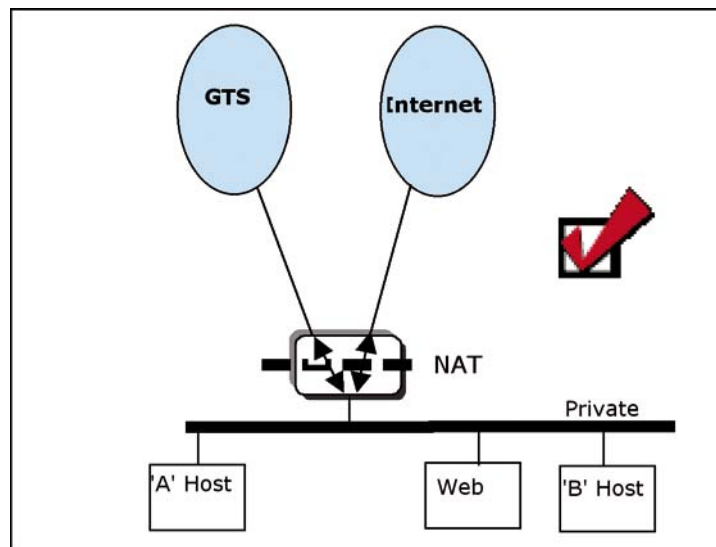
Figure 2.1 (b). (Allowed)
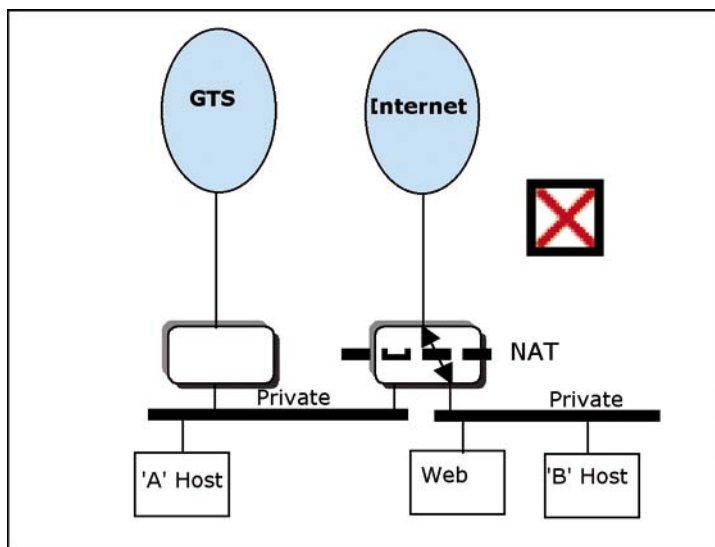
Figure 2.1 (c). (Not allowed)

Implementation of GTS links via Internet

CBS has expressed the view that the use of Internet for GTS links can be considered in circumstances where they are cost effective, offer an acceptable level of service and where adequate security measures are implemented. In general, the same principles for routing and security described above, apply where Internet links are used instead of dedicated links. Further details applying to the use of Internet-based links, especially related to small GTS Centres, are given in Appendix 4.

Summary of tasks to ensure proper use of IP on the GTS

Use only official IP addresses for external communication on the GTS.

Establish an IP connection with one or more Centres. This connection will be pure IP using PPP as a level 2 protocol on the link, (or a proprietary protocol such as Cisco HDLC by bilateral agreement) or IP over X.25 (RFC 1356). In this case use X.121 addresses as defined in Chapter 3. Configure dynamic routing with BGP (unless you are a Centre with only one GTS connection and have agreed with your neighbouring Centre to use static routing).

Check the barrier between Internet and the GTS (prevent routing from the Internet to the GTS).

Filter incoming and outgoing traffic in accordance with the requirements described above.

3.   IMPLEMENTATION GUIDELINES

Introduction

IP based services on the GTS may be implemented with direct IP connections or by using a mixture of X.25 and IP because of the technical evolution of the GTS described in Chapter 1. IP services may be carried over an X.25 network by encapsulating IP packets within X.25 packets. An appropriately configured router at each GTS Centre carries out this function. Alternatively, where routers of the same brand are used in adjacent Centres, X.25 data may be carried on an IP link using X.25 switching capability of the routers.

It is desirable ultimately for Centres to adopt through bilateral agreement, direct IP connections with TCP/IP application services (FTP, Sockets) superseding IP over X.25, or X.25 over IP as the case may be.

It is necessary to have an addressing framework for:

(a) X.25 packet switching between Centres;
(b) IP over X.25;
(c) Direct IP (including X.25 over IP).

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The use of BGP requires introduction of the concept of the Autonomous System (AS).[1] Each GTS Centre manages an AS number to enable the Centre to adopt BGP with neighbouring centres. In addition to addressing, this chapter shows allocation scheme of AS numbers.

Addressing for X.25 packet switching between Centres

Many centres have adopted X.25 for point to point connections between Message Switching Systems (MSS). A number of Centres have installed, or plan to install packet switches to provide capability for connections between non adjacent Centres. An addressing scheme has been developed for this purpose and has been adopted by WG-TEL at its thirteenth session in 1994. It is a 14-digit scheme of the form:

0101xxxiiyyyzz where:

0101 is a pseudo DNIC which does not correspond to any actual DNIC and therefore will ensure calls cannot be mistakenly switched to any network other than the GTS;
xxx is the X.121 Country Code of the Centre;
ii is a Protocol indicator, being 00 for MSS, 11 for TCP/IP, 22 for OSI CONS, 33 for OSI CLNS;
yyy is the nationally assigned port number;
zz is the nationally assigned sub address number;

This addressing scheme is to be used for setting up Virtual Calls (VCs) for MSS applications and for any other GTS applications including carriage of IP traffic over X.25.

Addressing for IP over X.25

In order to carry IP traffic over X.25, two globally co-ordinated address schemes are necessary:

An X.25 scheme as described above; and
An IP address scheme to apply to the interface between the router and packet switch to enable the router to encapsulate the IP packets into X.25 packets.

The general arrangement is shown in Figure 3.1.

For IP over X.25 to function correctly, it is necessary for the underlying X.25 network to be allocated a single IP network address and for each Centre to have an address within this network for the connection point between its router and its packet switch. Each IP node on the network can be assigned a sequential host address within a single Class C IP address as illustrated in Figure 3.1. The Class C address can provide for 254 Centres to be connected using a subnet mask of 255.255.255.0.

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[1] An Autonomous System is defined in RFC1630 as "a set of routers under a single technical administration, using an interior gateway protocol and common metrics to route packets within the AS, and using an exterior gateway protocol to route packets to other ASs.

CENTRE A

X.121: 0101xxx00yyyzz

MSS

Router

Packet switch

Host

X.121: 0101xxx11yyyzz
IP: 193.105.177.1
Mask: 255.255.255.0

X.121: 0101xxx00yyyzz

X.121: 0101xxx11yyyzz
IP: 193.105.177.3
Mask: 255.255.255.0

X.121: 0101xxx00yyyzz

Packet switch

Router

MSS

Host

CENTRE C

Packet switch

Router

CENTRE B

X.121: 0101xxx11yyyzz
IP: 193.105.177.2
Mask: 255.255.255.0

MSS

Host
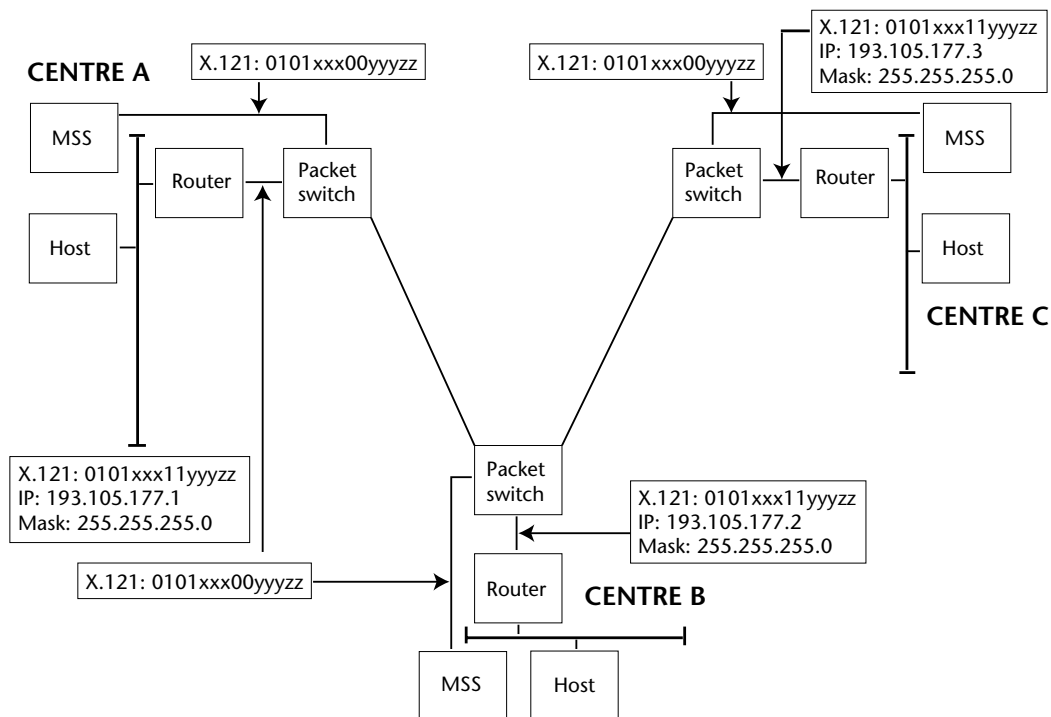
Figure 3.1. IP implementation over X.25 network

The Routers at each centre have to be set up so that they issue an X.25 call request to the X.25 port of the final destination Centre. This means that IP traffic passes through the packet switch only, and not the router of the intermediate Centre.

Addressing for Direct IP

The preferred connection for the future is to use direct IP links. Centres already using IP over X.25 should consider updating the links to use direct IP. This transition should be considered in the near future. Figure 3.2 illustrates how a pair of Centres have agreed to implement a direct IP connection using the first available pair of 'host' numbers using the 193.105.178.0 network as an example.

CENTRE A

X.121: 0101xxx00yyyzz

MSS

Router

Packet switch

Host

X.121: 0101xxx11yyyzz
IP: 193.105.177.1
Mask: 255.255.255.0

X.121: 0101xxx11yyyzz
IP: 193.105.177.2
Mask: 255.255.255.0

X.121: 0101xxx00yyyzz

Router

MSS

Host

CENTRE C

IP: 193.105.178.6
Mask: 255.255.255.252

IP: 193.105.178.5
Mask: 255.255.255.252

Packet switch

Router

CENTRE B

MSS

Host
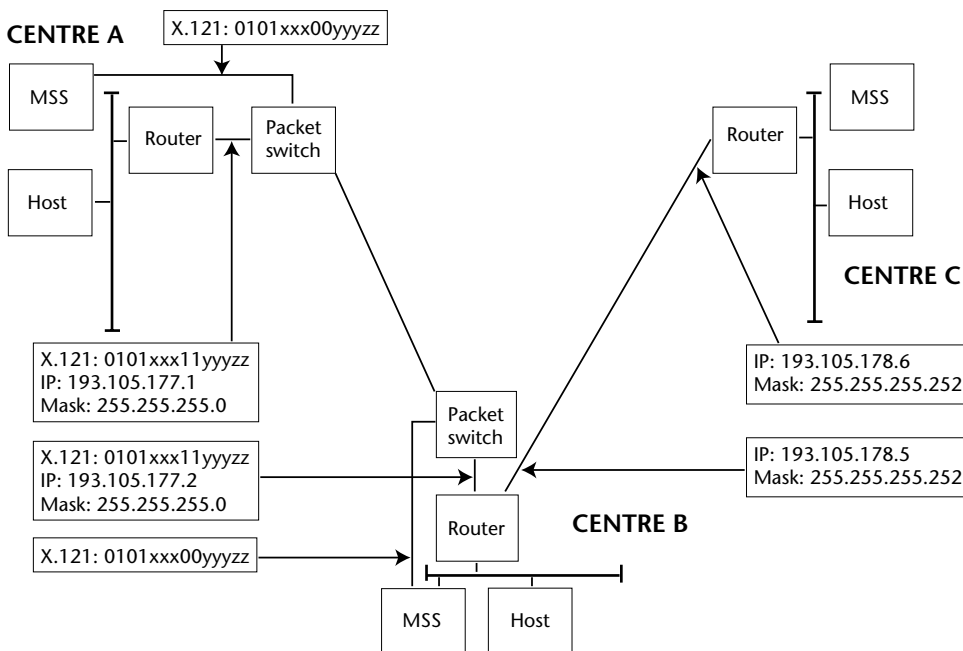
Figure 3.2. Direct IP link between Centres B and C

Allocation of class C addresses for direct IP links

Routers have to be connected by links having unique subnet numbers. To achieve this, a Class C address is used (for example 193.105.178.0) with a mask of 255.255.255.252. This provides 62 subnets each with 2 hosts. These two host numbers are allocated to the ends of the link connecting the routers between the two Centres. The lowest useable network number is 193.105.178.4, with host addresses of 193.105.178.5 and 6. The next network number is 193.105.178.8, with host addresses of 193.105.178.9 and 10, followed by:

  193.105.178.12, with host addresses of 193.105.178.13 and 14, followed by
  193.105.178.16, with host addresses of 193.105.178.17 and 18, followed by
  193.105.178.20, with host addresses of 193.105.178.21 and 22, and so on, up to
  193.105.178.248, with host addresses of 193.105.178.249 and 250.

Addressing for X.25 over IP

Where two Centres have a common brand of Router (e.g. Cisco), and the traffic is mostly IP with some X.25, it may be appropriate to carry the X.25 over the directly connected routers as shown for the link between Centre B and Centre C in Figure 3.3. The X.25 packets are carried within IP packets over the serial link between the routers, which may be a proprietary HDLC protocol, or a standard protocol such as PPP. This functionality requires that routers in each Centre contain X.25 packet switching software and that the X.25 route details are included in the router configuration. Examples of typical configurations are given in Appendix 2.
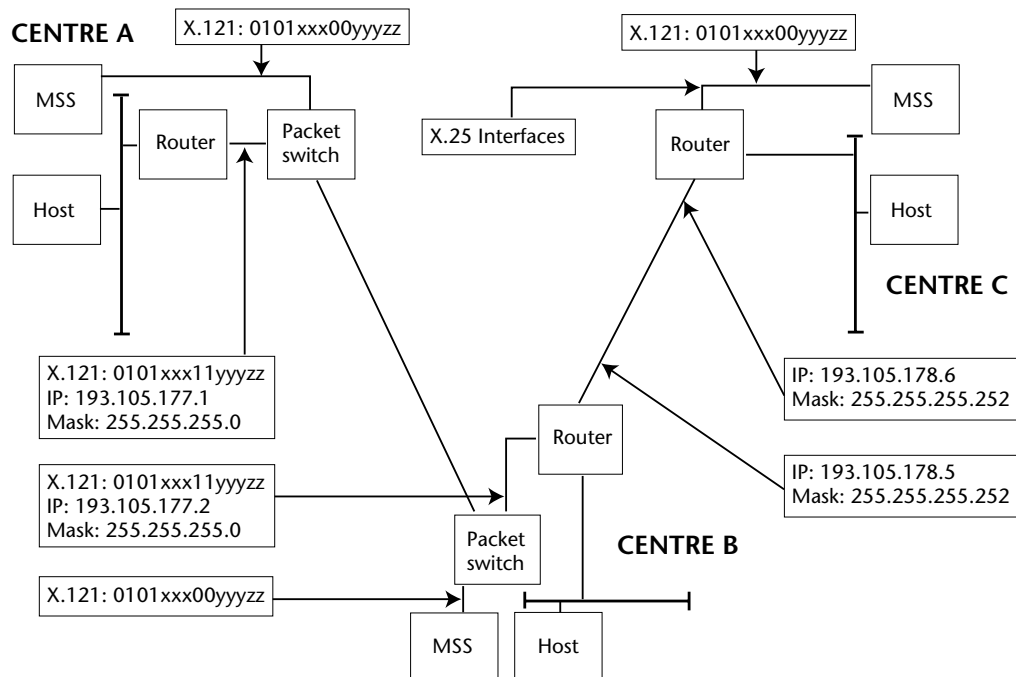
Figure 3.3. Combination of IP over X.25 and X.25 over IP

Autonomous System Numbers

The use of BGP4 as the recommended dynamic routing protocol for the GTS (Chapter 2) requires allocation of Autonomous System (AS) numbers to each GTS Centre.

The Internet Assigned Numbers Authority (IANA), through RFC1930, has reserved the block of AS numbers 64512 through 65535 for private use (not to be advertised on the global Internet). This provides 8 groups of 128 AS numbers to be assigned to GTS Centres, satisfying the current and foreseeable future needs of the GTS. The AS numbers will be assigned as follows:

MTN centres and reserve	64512 to 64639
Centres within RA I	64640 to 64767
Centres within RA II	64768 to 64895
Centres within RA III	64896 to 65023

Centres within RA IV   65024 to 65151
Centres within RA V   65152 to 65279
Centres within RA VI   65280 to 65407
Antarctic and reserve   65408 to 65471
*Private use by GTS Centres   65472 to 65535

* These AS numbers are for national use and are not to be advertised on the GTS.

Implementation details

In order to implement IP services Centres need to know certain details of IP and X.25 addressing at other Centres on the GTS. The following diagrams and associated tables explain in detail, the information required at various Centres:
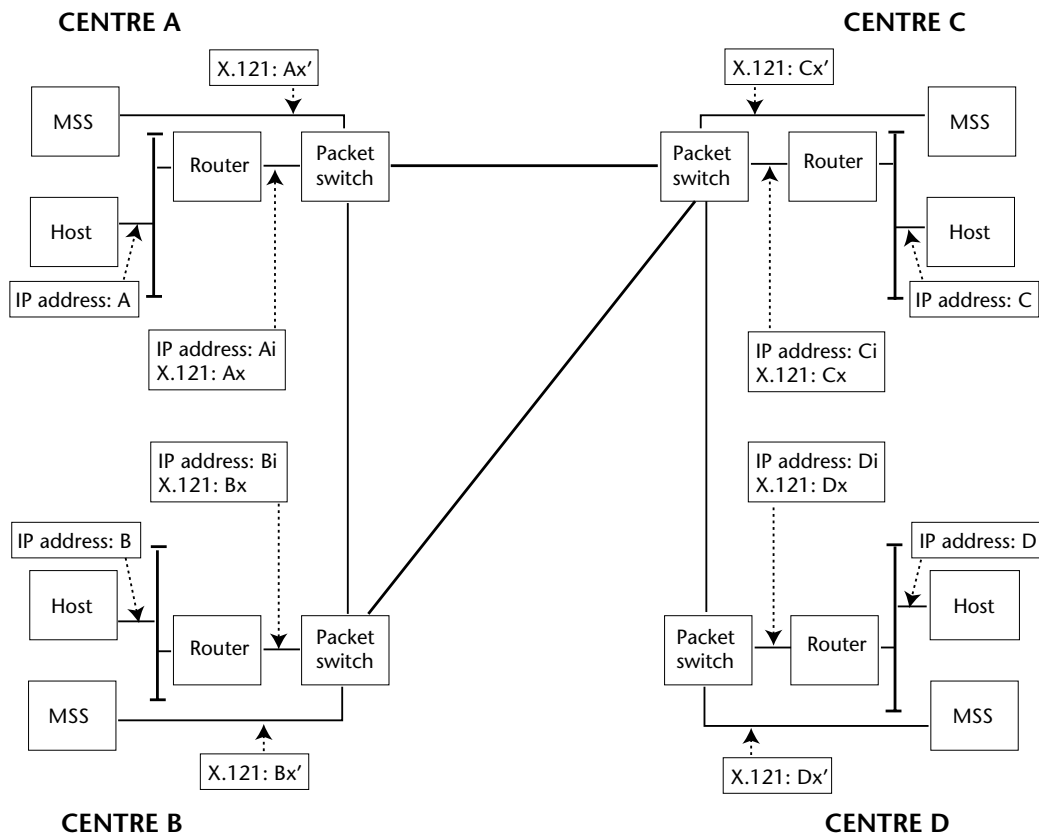
Figure 3.4. IP over X.25 network

Table 3.4A. IP and X.121 addresses to be known at Centre A

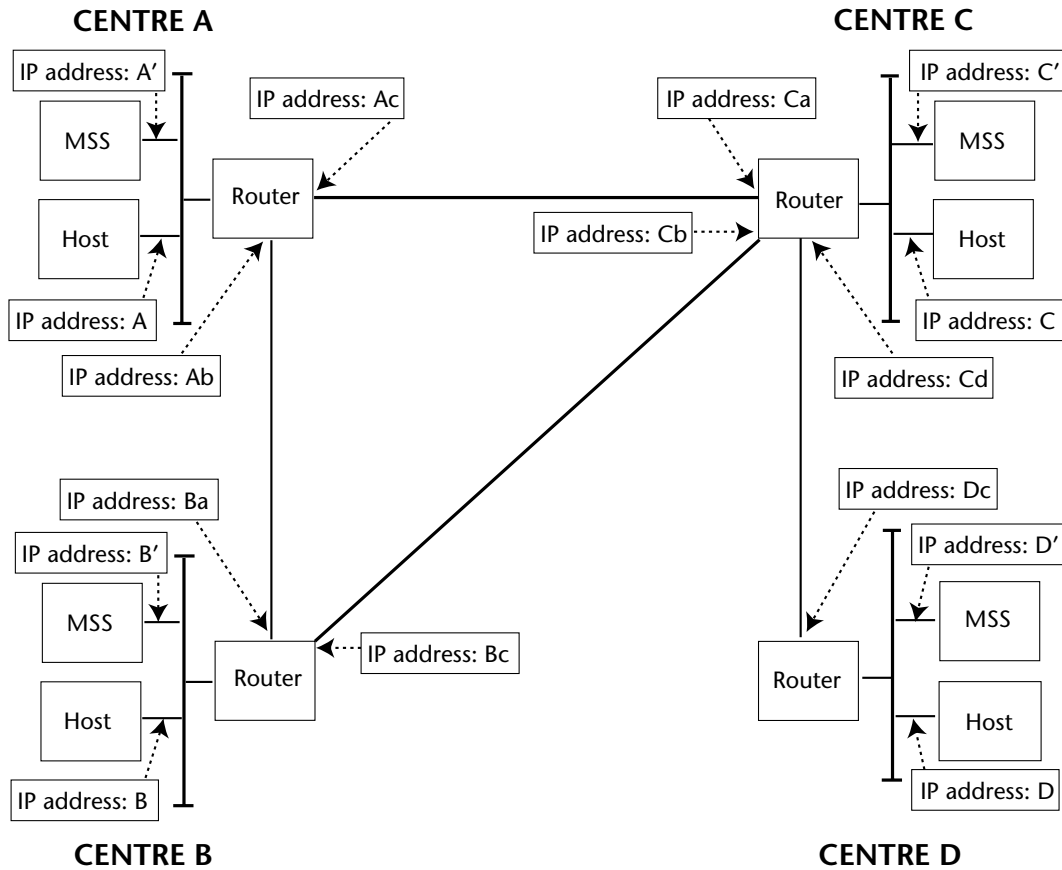| Destination	Addresses to be known		Suitable route
	For communication between ends	For communication between routers	
CENTRE B (Host to host)	IP address : B	IP address : Bi X.121 : Bx	CENTRE A – CENTRE B
CENTRE C (Host to host)	IP address : C	IP address : Ci X.121 : Cx	CENTRE A – CENTRE C
CENTRE D (Host to host)	IP address : D	IP address : Di X.121 : Dx	CENTRE A – CENTRE C – CENTRE D (Host [A] – Router [A] – Packet Switch [A] – Packet Switch [C] – Packet Switch [D] – Router [D] – Host [D]) [x] : CENTRE x
CENTRE B (MSS to MSS)	X.121 : Bx' (X.25 traffic)		CENTRE A – CENTRE B
CENTRE C (MSS to MSS)	X.121 : Cx' (X.25 traffic)		CENTRE A – CENTRE C
CENTRE D (MSS to MSS)	X.121 : Dx' (X.25 traffic)		CENTRE A – CENTRE C – CENTRE D (MSS [A] – Packet Switch [A] – Packet Switch [C] – Packet Switch [D] – MSS [D])

Table 3.4B. IP and X.121 addresses to be known at Centre B

Destination	Addresses to be known		Suitable route
	For communication between ends	For communication between routers	
CENTRE A (Host to host)	IP address : A	IP address : Ai X.121 : Ax	CENTRE B – CENTRE A
CENTRE C (Host to host)	IP address : C	IP address : Ci X.121 : Cx	CENTRE B – CENTRE C
CENTRE D (Host to host)	IP address : D	IP address : Di X.121 : Dx	CENTRE B – CENTRE C – CENTRE D
CENTRE A (MSS to MSS)	X.121 : Ax' (X.25 traffic)		CENTRE B – CENTRE A
CENTRE C (MSS to MSS)	X.121 : Cx' (X.25 traffic)		CENTRE B – CENTRE C
CENTRE D (MSS to MSS)	X.121 : Dx' (X.25 traffic)		CENTRE B – CENTRE C – CENTRE D

Table 3.4C. IP and X.121 addresses to be known at Centre C

Destination	Addresses to be known		Suitable route
	For communication between ends	For communication between routers	
CENTRE A (Host to host)	IP address : A	IP address : Ai X.121 : Ax	CENTRE C – CENTRE A
CENTRE B (Host to host)	IP address : B	IP address : Bi X.121 : Bx	CENTRE C – CENTRE B
CENTRE D (Host to host)	IP address : D	IP address : Di X.121 : Dx	CENTRE C – CENTRE D
CENTRE A (MSS to MSS)	X.121 : Ax' (X.25 traffic)		CENTRE C – CENTRE A
CENTRE B (MSS to MSS)	X.121 : Bx' (X.25 traffic)		CENTRE C – CENTRE B
CENTRE D (MSS to MSS)	X.121 : Dx' (X.25 traffic)		CENTRE C – CENTRE D

Table 3.4D. IP and X.121 addresses to be known at Centre D

Destination	Addresses to be known		Suitable route
	For communication between ends	For communication between routers	
CENTRE A (Host to host)	IP address : A	IP address : Ai X.121 : Ax	CENTRE D – CENTRE C – CENTRE A
CENTRE B (Host to host)	IP address : B	IP address : Bi X.121 : Bx	CENTRE D – CENTRE C – CENTRE B
CENTRE C (Host to host)	IP address : C	IP address : Ci X.121 : Cx	CENTRE D – CENTRE C
CENTRE A (MSS to MSS)	X.121 : Ax' (X.25 traffic)		CENTRE D – CENTRE C – CENTRE A
CENTRE B (MSS to MSS)	X.121 : Bx' (X.25 traffic)		CENTRE D – CENTRE C – CENTRE B
CENTRE C (MSS to MSS)	X.121 : Cx' (X.25 traffic)		CENTRE D – CENTRE C

CENTRE A

CENTRE C

Figure 3.5. Direct IP network

Table 3.5A. IP addresses to be known at Centre A

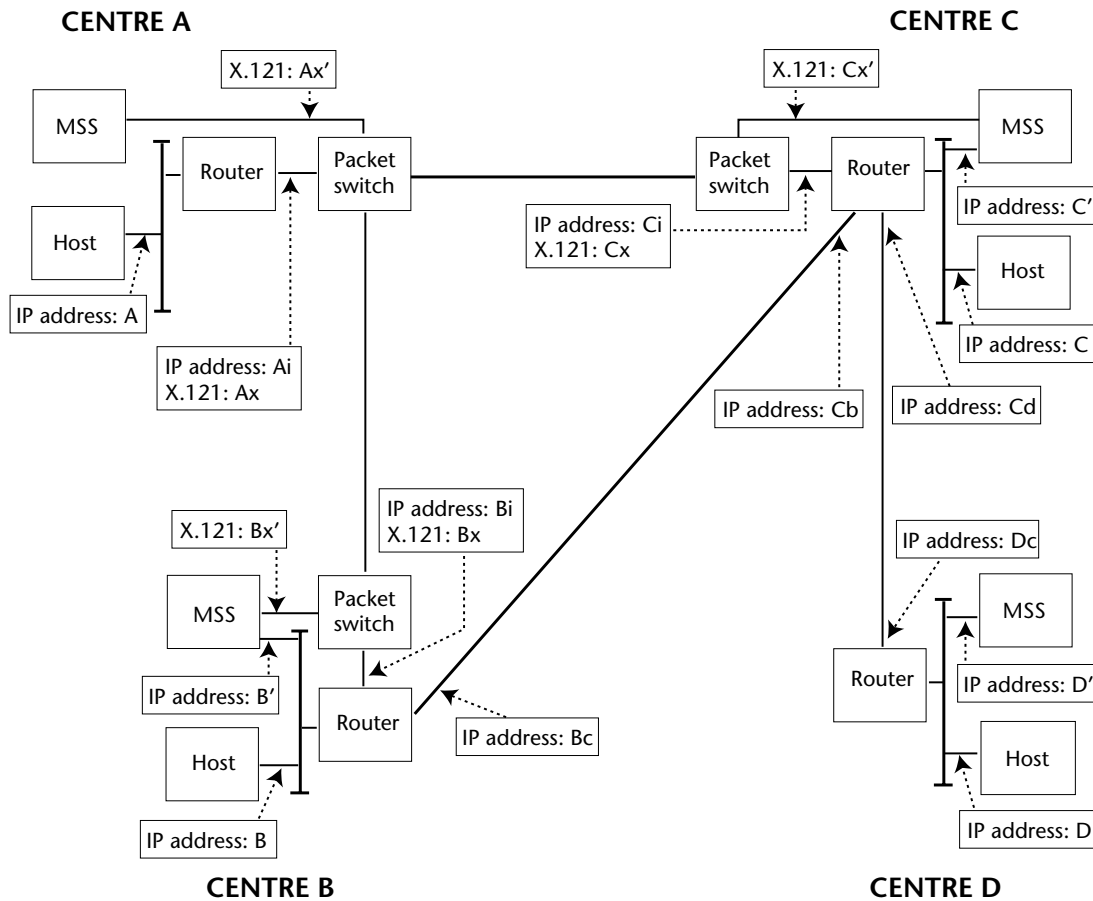| Destination	IP addresses to be known		Suitable route
	For communication between ends	For communication between routers	
CENTRE B (Host to host)	IP address : B	IP address : Ba	CENTRE A – CENTRE B
CENTRE C (Host to host)	IP address : C	IP address : Ca	CENTRE A – CENTRE C
CENTRE D (Host to host)	IP address : D	IP address : Ca	CENTRE A – CENTRE C – CENTRE D (Host [A] – Router [A] – Router [C] – Router [D] – Host [D]) [x] : CENTRE x
CENTRE B (MSS to MSS)	IP address : B'	IP address : Ba	CENTRE A – CENTRE B
CENTRE C (MSS to MSS)	IP address : C'	IP address : Ca	CENTRE A – CENTRE C
CENTRE D (MSS to MSS)	IP address : D'	IP address : Ca	CENTRE A – CENTRE C – CENTRE D

Table 3.5B. IP addresses to be known at Centre B

| Destination | IP addresses to be known | | Suitable route |
	For communication between ends	For communication between routers	
CENTRE A (Host to host)	IP address : A	IP address : Ab	CENTRE B – CENTRE A
CENTRE C (Host to host)	IP address : C	IP address : Cb	CENTRE B – CENTRE C
CENTRE D (Host to host)	IP address : D	IP address : Cb	CENTRE B – CENTRE C – CENTRE D
CENTRE A (MSS to MSS)	IP address : A'	IP address : Ab	CENTRE B – CENTRE A
CENTRE C (MSS to MSS)	IP address : C'	IP address : Cb	CENTRE B – CENTRE C
CENTRE D (MSS to MSS)	IP address : D'	IP address : Cb	CENTRE B – CENTRE C – CENTRE D

Table 3.5C. IP addresses to be known at Centre C

| Destination | IP addresses to be known | | Suitable route |
	For communication between ends	For communication between routers	
CENTRE A (Host to host)	IP address : A	IP address : Ac	CENTRE C – CENTRE A
CENTRE B (Host to host)	IP address : B	IP address : Bc	CENTRE C – CENTRE B
CENTRE D (Host to host)	IP address : D	IP address : Dc	CENTRE C – CENTRE D
CENTRE A (MSS to MSS)	IP address : A'	IP address : Ac	CENTRE C – CENTRE A
CENTRE B (MSS to MSS)	IP address : B'	IP address : Bc	CENTRE C – CENTRE B
CENTRE D (MSS to MSS)	IP address : D'	IP address : Dc	CENTRE C – CENTRE D

Table 3.5D. IP addresses to be known at Centre D

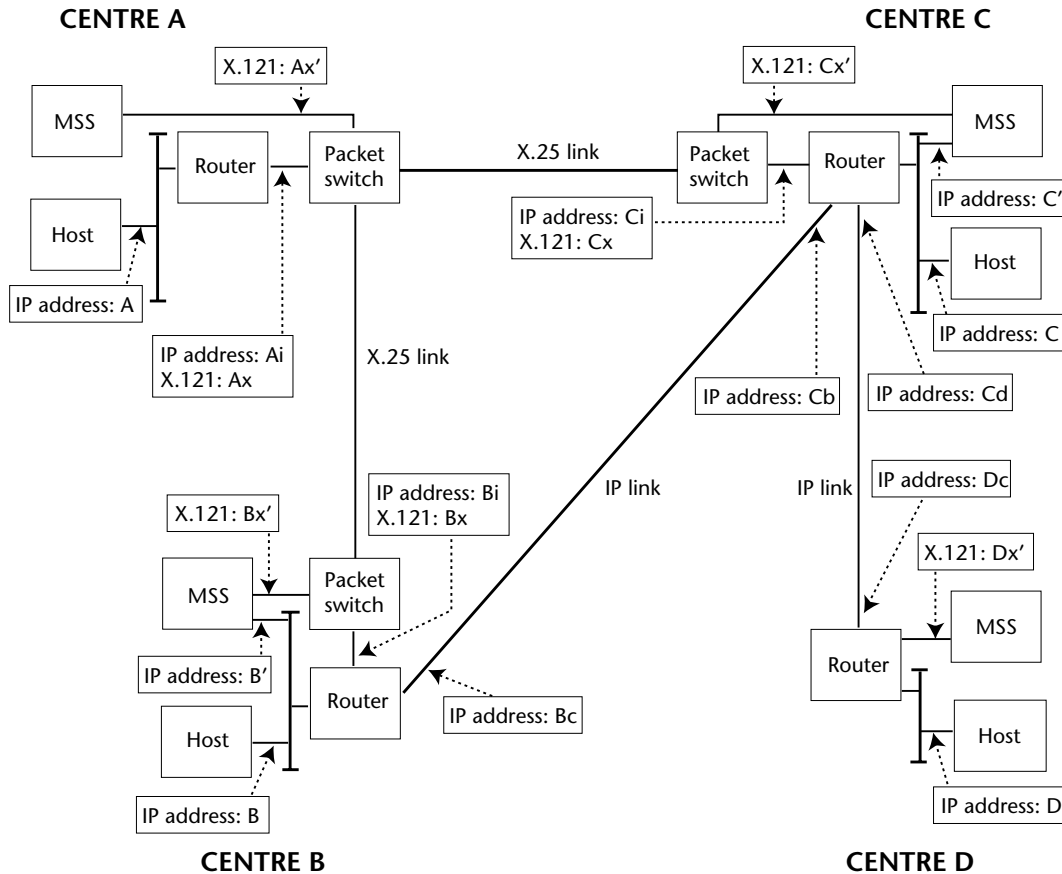| Destination | IP addresses to be known | | Suitable route |
	For communication between ends	For communication between routers	
CENTRE A (Host to host)	IP address : A	IP address : Cd	CENTRE D – CENTRE C – CENTRE A
CENTRE B (Host to host)	IP address : B	IP address : Cd	CENTRE D – CENTRE C – CENTRE B
CENTRE C (Host to host)	IP address : C	IP address : Cd	CENTRE D – CENTRE C
CENTRE A (MSS to MSS)	IP address : A'	IP address : Cd	CENTRE D – CENTRE C – CENTRE A
CENTRE B (MSS to MSS)	IP address : B'	IP address : Cd	CENTRE D – CENTRE C – CENTRE B
CENTRE C (MSS to MSS)	IP address : C'	IP address : Cd	CENTRE D – CENTRE C

Figure 3.6. Coexistence of direct IP with IP over X.25

Table 3.6A. IP and X.121 addresses to be known at Centre A

Destination	Addresses to be known		Suitable route
	For communication between ends	*For communication between routers*	
CENTRE B (Host to host)	IP address : B	IP address : Bi X.121 : Bx	CENTRE A – CENTRE B
CENTRE C (Host to host)	IP address : C	IP address : Ci X.121 : Cx	CENTRE A – CENTRE C
CENTRE D (Host to host)	IP address : D	IP address : Di X.121 : Dx	CENTRE A – CENTRE C – CENTRE D
CENTRE B (MSS to MSS)	X.121 : Bx′ (X.25 traffic)		CENTRE A – CENTRE B
CENTRE C (MSS to MSS)	X.121 : Cx′ (X.25 traffic)		CENTRE A – CENTRE C
CENTRE D (MSS to MSS)	Possible only by store and forward via MSS at Centre C (X.25 traffic)		

Table 3.6B. IP and X.121 addresses to be known at Centre B

Destination	Addresses to be known		Suitable route
	For communication between ends	For communication between routers	
CENTRE A (Host to host)	IP address : A	IP address : Ai X.121 : Ax	CENTRE B – CENTRE A
CENTRE C (Host to host)	IP address : C	IP address : Cb	CENTRE B – CENTRE C
CENTRE D (Host to host)	IP address : D	IP address : Cb	CENTRE B – CENTRE C – CENTRE D
CENTRE A (MSS to MSS)	X.121 : Ax' (X.25 traffic)		CENTRE B – CENTRE A
CENTRE C (MSS to MSS)	IP address : C'	IP address : Cb	CENTRE B – CENTRE C
CENTRE D (MSS to MSS)	IP address : D'	IP address : Cb	CENTRE B – CENTRE C – CENTRE D

Table 3.6C. IP and X.121 addresses to be known at Centre C

Destination	Addresses to be known		Suitable route
	For communication between ends	For communication between routers	
CENTRE A (Host to host)	IP address : A	IP address : Ai X.121 : Ax	CENTRE C – CENTRE A
CENTRE B (Host to host)	IP address : B	IP address : Bc	CENTRE C – CENTRE B
CENTRE D (Host to host)	IP address : D	IP address : Dc	CENTRE C – CENTRE D
CENTRE A (MSS to MSS)	X.121 : Ax' (X.25 traffic)		CENTRE C – CENTRE A
CENTRE B (MSS to MSS)	IP address : B'	IP address : Bc	CENTRE C – CENTRE B
CENTRE D (MSS to MSS)	IP address : D'	IP address : Dc	CENTRE C – CENTRE D

Table 3.6D. IP and X.121 addresses to be known at Centre D

Destination	Addresses to be known		Suitable route
	For communication between ends	For communication between routers	
CENTRE A (Host to host)	IP address : A	IP address : Cd	CENTRE D – CENTRE C – CENTRE A
CENTRE B (Host to host)	IP address : B	IP address : Cd	CENTRE D – CENTRE C – CENTRE B
CENTRE C (Host to host)	IP address : C	IP address : Cd	CENTRE D – CENTRE C
CENTRE A (MSS to MSS)	Possible only by store and forward via MSS at Centre C (X.25 traffic)		
CENTRE B (MSS to MSS)	IP address : B'	IP address : Cd	CENTRE D – CENTRE C – CENTRE B
CENTRE C (MSS to MSS)	IP address : C'	IP address : Cd	CENTRE D – CENTRE C

Figure 3.7. Coexistence of direct IP, IP over X.25 and X.25 over IP

Table 3.7A. IP and X.121 addresses to be known at Centre A

Destination	Addresses to be known		Suitable route
	For communication between ends	For communication between routers	
CENTRE B (Host to host)	IP address : B	IP address : Bi X.121 : Bx	CENTRE A – CENTRE B (Host [A] - Router [A] - "IP over X.25" - Packet Switch [A] - "IP over X.25" - Packet Switch [B] - "IP over X.25" - Router [B] - Host [B])
CENTRE C (Host to host)	IP address : C	IP address : Ci X.121 : Cx	CENTRE A – CENTRE C (Host [A] - Router [A] - "IP over X.25" - Packet Switch [A] - "IP over X.25" - Packet Switch [C] - "IP over X.25" - Router [C] - Host [C])
CENTRE D (Host to host)	IP address : D	IP address : Di X.121 : Dx	CENTRE A – CENTRE C – CENTRE D (Host [A] - Router [A] - "IP over X.25" - Packet Switch [A] - "IP over X.25" - Packet Switch [C] - "IP over X.25" - Router [C] - "Direct IP" - Router [D] - Host [D])
CENTRE B (MSS to MSS)	X.121 : Bx' (X.25 traffic)		CENTRE A – CENTRE B (MSS [A] - Packet Switch [A] - Packet Switch [B] - MSS [B])
CENTRE C (MSS to MSS)	X.121 : Cx' (X.25 traffic)		CENTRE A – CENTRE C (MSS [A] - Packet Switch [A] - Packet Switch [C] - MSS [C])
CENTRE D (MSS to MSS)	X.121 : Dx' (X.25 traffic)		CENTRE A – CENTRE C – CENTRE D (MSS [A] - Packet Switch [A] - Packet Switch [C] - Router [C] - "X.25 over IP" - Router [D] MSS [B])

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Table 3.7B. IP and X.121 addresses to be known at Centre B

Destination	Addresses to be known		Suitable route
	For communication between ends	For communication between routers	
CENTRE A (Host to host)	IP address : A	IP address : Ai X.121 : Ax	CENTRE B – CENTRE A
CENTRE C (Host to host)	IP address : C	IP address : Cb	CENTRE B – CENTRE C (Host [B] - Router [B] - "Direct IP" - Router [C] - Host [C])
CENTRE D (Host to host)	IP address : D	IP address : Db	CENTRE B – CENTRE C – CENTRE D (Host [B] - Router [B] - "Direct IP" - Router [C] - "Direct IP" - Router [D] - Host [D])
CENTRE A (MSS to MSS)	X.121 : Ax' (X.25 traffic)		CENTRE B – CENTRE A
CENTRE C (MSS to MSS)	IP address : C'	IP address : Cb	CENTRE B – CENTRE C (MSS [B] - Router [B] - "Direct IP" - Router [C] - MSS [C])
CENTRE D (MSS to MSS)	X.121 : Dx' (X.25 traffic)		CENTRE B – CENTRE C – CENTRE D (MSS [B] - Packet Switch [B] - Router [B] - "X.25 over IP" - Router [C] - "X.25 over IP" - Router [D] MSS [D])

Table 3.7C. IP and X.121 addresses to be known at Centre C

Destination	Addresses to be known		Suitable route
	For communication between ends	For communication between routers	
CENTRE A (Host to host)	IP address : A	IP address : Ai X.121 : Ax	CENTRE C – CENTRE A
CENTRE B (Host to host)	IP address : B	IP address : Bc	CENTRE C – CENTRE B
CENTRE D (Host to host)	IP address : D	IP address : Dc	CENTRE C – CENTRE D (Host [C] - Router [C] - "Direct IP" - Router [D] - Host [D])
CENTRE A (MSS to MSS)	X.121 : Ax' (X.25 traffic)		CENTRE C – CENTRE A
CENTRE B (MSS to MSS)	IP address : B'	IP address : Bc	CENTRE C – CENTRE B
CENTRE D (MSS to MSS)	X.121 : Dx' (X.25 traffic)		CENTRE C – CENTRE D (MSS [C] - Packet Switch [C] - Router [C] - "X.25 over IP" - Router [D] - MSS [D])

Table 3.7D. IP and X.121 addresses to be known at Centre D

Destination	Addresses to be known		Suitable route
	For communication between ends	For communication between routers	
CENTRE A (Host to host)	IP address : A	IP address : Cd	CENTRE D – CENTRE C – CENTRE A
CENTRE B (Host to host)	IP address : B	IP address : Cd	CENTRE D – CENTRE C – CENTRE B
CENTRE C (Host to host)	IP address : C	IP address : Cd	CENTRE D – CENTRE C
CENTRE A (MSS to MSS)	X.121 : Ax' (X.25 traffic)		CENTRE D – CENTRE C – CENTRE A
CENTRE B (MSS to MSS)	X.121 : Bx' (X.25 traffic)		CENTRE D – CENTRE C – CENTRE B
CENTRE C (MSS to MSS)	X.121 : Cx' (X.25 traffic)		CENTRE D – CENTRE C

Management and allocation of addresses and AS numbers

X.25 addresses

The framework described above allows Centres full autonomy in allocating X.25 numbers. The WMO Secretariat will maintain a current list of X.25 addresses which Centres have allocated for use on the GTS. Centres are requested to notify the Chief of the Information and Telecommunication System Division of the Observing and Information Systems Department, WMO Secretariat by e-mail or fax of X.25 addresses allocated.

IP addresses

IP addresses should be acquired or agreed on as per the instructions in Appendix 7.

GTS nominated host/network addresses

Host and subnet IP addresses for use with GTS nominated Centres should be notified to WMO as described above.

AS numbers

AS numbers for use on the GTS will be coordinated and issued by the WMO Secretariat as required. Centres should direct their requests for AS numbers to WMO as described above.

Publication of addresses and AS numbers

The WMO will publish updated lists of addresses and AS numbers in the monthly WWW *Operational Newsletter* and will also make these lists available in ASCII text form for access by FTP on the WMO web server and in World Wide Web format at http://www.wmo.int.

4.   ADAPTING MESSAGE SWITCHING SYSTEMS TO TCP/IP

Introduction

Although there are new requirements emerging, for the time being GTS usage is dominated by the traditional Message Switching application, which has been developed to use X.25 packet switching. We now need to consider how best to migrate the message switching task to use TCP/IP to satisfy the new requirements by providing "Internet like" facilities on the GTS, and to stay aligned with IT industry trends. Additionally, migration of Message Switching Systems (MSS) to use TCP/IP means that X.25 infrastructure can be removed, greatly simplifying the technology of the GTS by moving to a pure IP network rather than a mixture of IP and X.25.

There are two possible technical approaches to this problem, one using TCP Sockets and the other FTP. In the long term the FTP approach is thought to be the most strategically attractive but may require more work to implement in operational Message Switching Systems. It may suit some Centres to adopt an approach based on TCP Sockets as the first step towards a TCP/IP based GTS.

The transition of the MSSs to TCP/IP does not imply any change in the basic store and forward architecture of the GTS. It is envisaged that the store and forward architecture, with automatic on forwarding based on routing tables, will remain. However, the adoption of FTP means there is an additional option for data exchange to be achieved through bilateral arrangements, by the use of FTP retrieve initiated by the receiving centre.

TCP Sockets based MSS

TCP Socket is an approach which is highly suitable for a programmatic implementation to provide regular exchange of messages. As such it should simply be regarded as an alternative protocol to X.25. A centre will be required to produce MSS application programs capable of transmitting and receiving via a TCP socket. Centres with current applications capable of driving an X.25 virtual circuit should be able to very quickly and simply produce a sockets version by changing a few system calls (see Appendix 3 for sample programs). The programming work involved is minimal and more importantly all other areas of the MSS such as queuing, routing, data management, operator interfaces etc. remain unchanged because the communication exchange is still based on the traditional message.

The protocol defined here, is based on the assumption that the physical circuit over which the data is to be transmitted has low error rate and is subject to interruptions rarely. On such circuits, the TCP protocol can be expected to deliver error free data. However, some GTS circuits may not be of sufficient quality for the standard TCP socket to function reliably. The development of special protocols for use on low quality circuits may be studied further.

Loss of data may occur if the TCP session is lost. This may be due to MSS hardware, application or communications failure. A special case of this is when a Centre with more than one MSS switches from the primary to the backup systems. Recommendations to avoid this problem are given below.

One useful feature of the X.25 based communication that is not available using TCP sockets, is the ability to detect start and end of message by reference to the M bit in the X.25 packet header. No such bit or any equivalent feature exists in TCP. Therefore, to enable receiving centres to detect end of message, each message is preceded with an 8 character string giving the message length, plus two characters indicating message type (binary, alphanumeric or fax). Thereafter the message is structured within an SOH/ETX envelope as for exchange via X.25. The complete structure is illustrated in figure 4.1. Note that the message length does not include itself or the type indicator. It should always be eight characters long and include leading zeroes as required. The message type indicator should be encoded using ASCII characters BI for binary, AN for alphanumeric, and FX for facsimile. All new connections established must begin with a message length and type structure.

Message length (8 characters)	Message type (2 characters)	SOH	CR	CR	LF	nnn or nnnnn	CR	CR	LF	Heading		CR	CR	LF	ETX

Message length: Length from SOH to ETX (e.g. 00001826 = 1826 bytes)
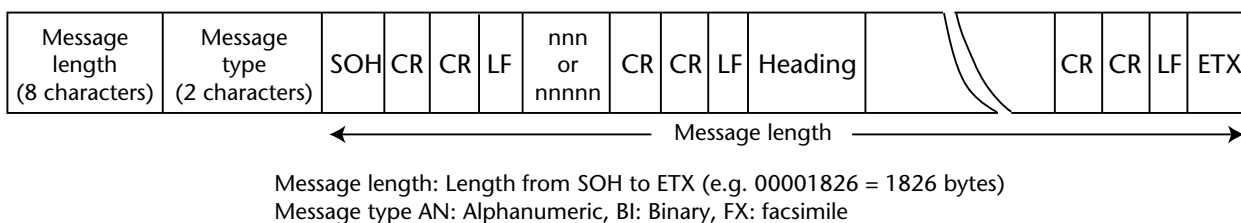Message type AN: Alphanumeric, BI: Binary, FX: facsimile

Figure 4.1. Message structure for socket exchange applications

The rules for use of TCP/IP socket exchange can be summarized as:

1. All new connections must start from a new message.
2. Each message is preceded by a message length field of eight ASCII characters and a message type field of two ASCII characters.
3. Message length is counted from SOH to ETX inclusive and must contain leading zeroes as necessary.
4. Message type must be encoded as BI for binary, AN for alphanumeric or FX for facsimile.
5. Receiving centres will check synchronization as follows:
   • Check that the first 8 characters are ASCII numeric
   • Check that the 9th and 10th characters are BI, AN or FX

- Check that the 11th character is SOH
- Check that the last character is ETX.

6. If synchronization is lost the receiver shall break the connection using the following sequence of TCP user primitives:
   - Shutdown (to make sure that all data in the TCP send buffer has been transferred)
   - Close.

7. It is recommended to use separate sockets for ASCII and binary messages, and separate connections for sending and receiving. The sender should always be responsible for establishing the connection.

8. Once a connection is established, it should be maintained.

9. If there should be a need to close a socket, the procedure should be as follows:
   - Shutdown (to make sure that all data in the TCP send buffer has been transferred)
   - Close.

10. This procedure should also be used when a MSS is being shutdown.

11. If the receiving side receives a new unexpected connection request on a port for which it has an established socket, the old socket should be closed and the new socket accepted.

12. TCP/IP Service/Port numbers for these connections will be decided by bilateral agreement. The use of reserved ports (1 to 1023) should be avoided. The use of ports above 10000 is recommended.

13. To reduce the amount of data lost if an established connection fails, the TCP send and receive buffer sizes can be adjusted. The recommended value for the buffer size is 4KByte, however this value may be agreed on a bilateral basis.

14. To enable detection of message loss, the use of the channel sequence number, (CSN) is mandatory. When using the CSN to check for missing messages, the WMO request/repeat procedures should be used to recover these. It may be useful to automate this mechanism to avoid delays caused by manual interaction. In order to minimize data loss it is strongly recommended that Centres implement a 5 character long CSN in the future.

15. The channel sequence number 000 (or 00000 respectively) should indicate an initialisation, and should not cause retransmission requests.

FTP Procedures

Introduction

FTP (File Transfer Protocol) is a convenient and reliable method for exchanging files, especially large files. The protocol is defined in RFC 959.

The main issues to be considered are:

1. Procedures for accumulating messages into files so as to minimise FTP overheads with short messages (applies only to existing message types);
2. File naming conventions for existing message types (existing AHL);
3. General file naming conventions;
4. File renaming;
5. Use of directories;
6. Account names and passwords;
7. FTP sessions;
8. Local FTP requirements;
9. File compression.

Accumulating messages into files

One of the problems with using FTP to send traditional GTS messages is the overhead if each message is sent in a separate file. To overcome this problem, multiple messages in the standard GTS message envelope should be placed in the same file according to the rules set out below. This method of accumulating multiple messages applies only to messages for which AHLs have been assigned.

Centres have the option of including or deleting the Starting Line and End of Message strings and indicating which option they are using via the format identifier (refer to points 2 and 4 below).

1. Each message should be preceded by an 8 octet message length field (8 ASCII characters). The length includes the Starting Line (if present), AHL, text and End of Message (if present).

2. Each message should start with the currently defined Starting Line and AHL as shown in Figure 4.2.
3. Messages should be accumulated in files thus:
    (a) Length indicator, message 1 (8 characters);
    (b) Format identifier (2 characters);
    (c) Message 1;
    (d) Length indicator, message 2 (8 characters);
    (e) Format identifier (2 characters);
    (f) Message 2;
    (g) And so on, until the last message;
    (h) If necessary, and subject to bilateral agreement, a 'dummy' message of zero length may be inserted after the last real message, to assist with end of file detection in certain MSS systems. This requirement does not exist in most cases and need only be implemented where necessary, and agreed between centres.
4. Format identifier (2 ASCII characters) has the following values:
    (a) 00 if Starting Line and End of Message strings present;
    (b) 01 if Starting Line and End of Message strings absent (not preferred, to be discontinued).
5. The sending centre should combine messages in the file for no more than 60 seconds to minimise transmission delays; this limit should be set to a value depending upon the characteristics of the link.
6. The sending centre should limit the number of messages in a file to a maximum of 100; this limit should be set to a value depending upon the characteristics of the link.
7. The format applies regardless of the number of messages, i.e. it applies even if there is only one message in the file.

Message 1 length (8 characters)	Format identifier 00	SOH	CR	CR	LF	nnn or nnnnn	CR	CR	LF	Heading	Text		CR	CR	LF	ETX	Message 2 length (8 characters)

←———————————————— Message length ————————————————→

Starting line and end of message present.
Message length: Length from SOH to ETX (e.g. 00001826 = 1826 bytes)

Message 1 length (8 characters)	Format identifier 01	CR	CR	LF	Heading	Text		Message 2 length (8 characters)	Format identifier 01

←——————— Message length ———————→

Option (not preferred, to be discontinued). Starting line and end of message absent.
Message length: Length from first CR to end of text (e.g. 00001826 = 1826 bytes)

Figure 4.2. Structure of a typical message in a file

File naming conventions for existing message types (existing AHL)

　　　　The file naming convention is:

CCCCNNNNNNNN.ext
where:
CCCC is the international four letter location identifier of the sending Centre, as defined in WMO publication No. 9, Volume C;
NNNNNNNN is a sequential number from 1 to 99999999 generated by the sending Centre for each data type determined by ext; 0 is used for (re-) initialization; through bilateral agreement, Centres may use NNNN instead of NNNNNNNN in case of limitation on filename length.
ext is
　　'ua' for urgent alphanumeric information
　　'ub' for urgent binary information
　　'a' for normal alphanumeric information
　　'b' for normal binary information
　　'f' for facsimile information
Note: Where, through bilateral agreement, Centres allow alphanumeric and binary data in the one file, the b or ub extent shall be used.

General file naming conventions

The following file naming convention should be implemented with a transition period not exceeding 2008. The implementation date is subject to review by CBS.

The procedure is based on transmission of file pairs, one file being the information file and the other being the associated metadata file. The concept of file pairs allows the communications function to be implemented independently of data management requirements for structure of metadata, yet provides for the carriage of whatever metadata is required. It is not compulsory to always have a .met file, such as when the information file itself is self-specifying or when a single .met file can describe several information files (for example as in the case of same data type for different times). There is always however a clear relation between the Information File Name and the Metadata File Name, which should only differ from their Extension field and possible wildcards. File names for new message types (no existing AHL) shall follow the following format. It should be noted that file names for existing message types (existing AHL) can also follow the following format.

The File Name format is a predetermined combination of fields, delimited by the _ (underscore) character except for the last 2 fields, which are delimited by the . (period) character.

Each field can be of variable length, except for the Date/time stamp field which is predetermined.

The order of the fields is mandatory.

The File Name fields are as follows:

> pflag_productidentifier_oflag_originator_yyyyMMddhhmmss[_freeformat].type[.compression]

where the mandatory fields are:

pflag is a character or combination of characters indicating how to decode the productidentifier field. At this time, the pflag field has only the following acceptable value:

Table 4.1. Accepted pflag values

pflag	*Meaning*
T	The productidentifier field will be decoded as a standard $T_1T_2A_1A_2ii$ data designator (The WMO standard data designators are given in Attachment II-5)
A	The productidentifier field will be decoded as a standard Abbreviated Heading, including BBB as appropriate, space characters being discarded, e.g. $T_1T_2A_1A_2iiCCCCYYGGgg[BBB]$
W	WMO Product Identifier
Z	Originating centre's local product identifier

productidentifier is a variable length field containing information that describes the nature of the data in the file. The productidentifier field should be decoded according to the pflag.

The WMO Product Identifier to be used with pflag = W shall be decoded as follows:

<location indicator>,<data designator>,<free description>,<International date-timegroup>,<BBB modification header>

The WMO Product Identifier is composed of two parts: the "static part" for description of the product and the "optional part" to define the time stamp and status of the product (correction, amendment).

The WMO Product Identifier is not case sensitive. These two parts are defined as follows:

Static part: <location indicator>,<data designator>,<free description>

<location indicator> defines the producer: Country, organization and the production centre;

The country shall be represented by the official ISO 3166 standard 2 letter code. Example: <gb-metoffice-exeter>. Each field shall be separated by "-" symbol.

The ISO 3166 standard 2-letter code xx shall be used for international organizations and shall therefore be the two first characters of the location indicator of international organizations, e.g. "xx-eumetsat-darmstadt", "xx-ecmwf-reading".

<data designator> specifies the type of data with reference to the categories and subcategories defined in the Common Table C-13 of the *Manual on Codes*, e.g. <SYNOP>, <TAF>, <MODEL>, <RADAR>, <SATELLITE>, etc. When the type of data is a composite type, use the sign "+" for concatenation.

<free description> is determined by the production centre to characterize the product.

Optional part: [,<International date-time group>,<BBB modification header>]
<International date-time group> is a YYYYMMDDHHMMSS time stamp of the product, full format without substitution characters (only decimal digits). This field is optional because it can be recovered from the file name field: yyyyMMddhhmmss

<BBB modification header> is a complementary group with a similar purpose as the current BBB group of AHL

Note: In order to facilitate the identification of each field of the product identifier, the static part, as well as the optional part if used, shall comprise two symbols "," separating the fields. Each field shall not contain any symbol ",". If a field is empty, no character shall be inserted between the relevant field delimiters "_" or ",".

oflag is a character or combination of characters indicating how to decode the originator field. At this time, the oflag field has only the following acceptable value:

Table 4.2. Accepted oflag values

pflag	*Meaning*
C	The originator field will be decoded as a standard CCCC country code

originator is a variable length field containing information that states where the file originated from. The originator field should be decoded according to the oflag.

yyyyMMddhhmmss is a fixed length date and time stamp field. The interpretation of this field should be in accordance with the standard rules set for specific data description and types. Therefore it may have various significance such as date of creation or the file, or date of collection of data. If a particular date and time stamp field is not specified, it should be replaced by a `-` (minus) character. For example: ------311500-- represents a stamp that specifies only the day (31st), hours (15) and minutes (00). If there are no rules for a specific data type, this field should represent the date and time of creation of the file by the originator.

Type is a variable length field that describes the general format type of the file. Although this information could be considered somewhat redundant to the productidentifier field, it is kept as such for industry accepted standard compatibility. It should be noted that the delimiter before the type field is a . (period). This is to help parse the file name for fields, since the freeformat field could make use of further _ (underscore) to delimit subfields.

Table 4.3. Accepted type values

Type	Meaning
met	The file is a metadata file pair which describes the content and format of the corresponding information file with the same name
tif	TIFF file
gif	GIF file
png	PNG file
ps	Postscript file
mpg	MPEG file
jpg	JPEG file
txt	text file
htm	HTML file
bin	a file containing data encoded in a WMO binary code form such as GRIB or BUFR
doc	a Microsoft Word file
wpd	a Corel WordPerfect file
hdf	HDF file
nc	NetCDF file
pdf	Portable Document Format file

And the non-mandatory fields are:

(a) Freeformat is a variable length field containing further descriptors as required by a given originator. This field can be further divided in sub-fields. Originating countries should strive to make their freeformat descriptions available to others;

(b) Compression is a field that specifies if the file uses industry standard compression techniques.

Table 4.4. Accepted compression values

Compression	Meaning
Z	The file has been compressed using the Unix COMPRESS technique
zip	The file has been compressed using the PKWare zip technique
gz	The file has been compressed using the Unix gzip technique
bz2	The file has been compressed using the Unix bzip2 technique

Maximum file name length: Although no maximum length is specified for the entire file name, the mandatory fields shall not exceed 128 characters (including all delimiters) to allow processing by all international systems.

Character set: The filenames shall be composed of any combination of the standard character set (ITU-T Rec. X.4) with the exceptions noted in Table 4.5. Case insensitivity shall be used as it is widely accepted and implemented in the industry (for example email addresses and URLs). However, it is recommended to use the "canonical form" of file names when files are being processed in a system. In this manner it would be expected that:

(a) File names be saved in their original form as received (with any combination of upper-lower case characters or any character set);

(b) Files would be saved with lower case characters only for internal processing, comparison, name searches, etc.;

(c) Files would be retransmitted with the original saved name to preserve character set and the upper lower case differences.

This keeps the benefits of readability of upper lower case throughout the systems, but provides case independence for processing and reference.

Table 4.5. Symbols for file names

Symbol	Allowed	Meaning
_	Yes	The underscore symbol is used as a delimiter symbol. To be used only as a delimiter of fields. The underscore is also accepted in the freeformat field, but not in other fields.
-	Yes	The minus symbol shall be used only as a field delimiter inside the "location indicator" and "free description" fields of the WMO Product Identifier in the productidentifier field. For example, in the case of location indicator: gb-metoffice-exeter. This symbol shall not appear in the "data designator" field.
+	Yes	The plus symbol shall be used to concatenate several words in a field of the WMO Product Identifier in the productidentifier field. For example, in the "data designator" field: TEMP+MOBIL or CLIMAT+TEMP+SHIP.
.	Yes	The period symbol is used has a delimiter symbol. To be used only before the type and compression fields.
/	No	Forward stroke often has special meaning for the full path specification of a filename in some operating systems.
\	No	Backward stroke often has special meaning for the full path specification of a filename in some operating systems.

Table 4.5 (*continued*)

Symbol	Allowed	Meaning
>	No	Greater than symbol shall not be used since it often represents special file manipulation in some operating systems.
<	No	Less than symbol shall not be used since it often represents special file manipulation in some operating systems.
|	No	Vertical bar (pipe) symbol shall not be used since it often represents special file manipulation in some operating systems.
?	No	Question mark symbol shall not be used.
'	No	Single quote shall not be used.
"	No	Double quotes shall not be used.
*	No	The star symbol is often used for wildcard specification in procedures that process filenames.
Space	No	The space symbol shall not be used.
,	Yes	The comma symbol shall be used as a field delimiter in the WMO Product Identifier of the productidentifier field. For example, in the static part: <location indicator>,<data designator>,<free description>. The comma symbol can be also used in the freeformat field.
A-Z a-z 0-9	Yes	

The structure of the '.met' file, related to the WMO Metadata standard, is not defined in this guide.

Examples

- A possible imagery file (Sig Weather Chart) that would have originated from the United States:
  T_PGBE07_C_KWBC_20020610180000_D241_SIG_WEATHER_250-600_VT_06Z.tif
- A possible model output file from France:
  A_HPWZ89LFPW131200RRA_C_LFPW_20020913160300.bin
- A possible synoptic surface observations file from France:
  W_fr-meteofrance-
  Toulouse,SYNOP,MAIN+HOURS,,RRA_C_LFPW_20060913030000.txt
- A possible model output file from France:
  W_fr-meteofrance-toulouse,GRIB,ARPEGE-75N10N-
  60W65E_C_LFPW_200610000000.bin
- A possible image from Australia:
  Z_IDN60000_C_AMMC_20020617000000.gif
  Note that this shows that the date and time stamp is to be interpreted to be 00 hours,
  00 minutes and 00 seconds.
- A possible compressed TOVS satellite data file from the United Kingdom:
  Z_LWDA_C_EGRR_20020617000000_LWDA16_0000.BIN.Z
- A possible image (radar) from Canada:
  T_SDCN50_C_CWAO_200204201530--_WKR_ECHOTOP,2-0,100M,AGL,78,N.gif
- A possible single-record GRIB file from Canada:
  Z__C_CWAO_2002032812----_CMC_reg_TMP_ISBL_500_ps60km_2002032812_P036.bin
- A possible multiple record batch file from China:
  Z_SM_C_BABJ_20020520101502.TXT

File renaming

The method used by receiving centres to detect the presence of a new file may depend on the type of machine used. However most centres will do this by scanning a directory for new files.

To avoid problems with the receiving centre processing a file before it has completely arrived, all sending centres must remotely rename the files they send.

The file shall be sent with the added extent '.tmp' and then renamed to the appropriate extent defined above when the transfer is completed, e.g.

(a) Put xxxxx RJTD00220401.a.tmp   (xxxxx = local file name)
     rename RJTD00220401.a.tmp
            RJTD00220401.a
(b) Put xxxxx AMMC09871234.ub.tmp
     rename AMMC09871234.ub.tmp
            AMMC09871234.ub

Use of directories

Some receiving centres may wish the files to be placed in specific sub-directories. This should be limited to require only that all files of the same type be delivered to the same directory. It is recommended that a separate directory be used for each host system which is initiating FTP sessions to avoid the possibility of filename duplication.

Account names and passwords

Using FTP the sender "logs in" to a remote machine using a specific account name and password. The receiving centre defines the account name and the password. There are potential security implications for centres so care needs to be taken.

The following general rules should however apply.

1. The receiving centre defines the user account and password for the sending centre.
2. Anonymous FTP may be used or a specific account may be created. (If anonymous FTP is used, each sending Centre must have its own sub-directory on the FTP server).

FTP sessions

To limit the load on both the sending and receiving systems, no more than one FTP session per file type should exist at the same time. If for example, Centre A wishes to send two files to Centre B of the same type (say .ua), the second file must not be sent until the first is finished. Centres should limit the number of concurrent sessions with a particular Centre to five maximum.

The idle timer for closing the FTP session should be set to a value between the cut-off time for accumulating messages (max. 60 seconds) and a maximum of 3 minutes.

Local FTP requirements

All sending centres will need to allow for additional "static" FTP commands to be included in the FTP commands that they issue. For example some MVS centres may require the inclusion of "SITE" commands to define record and block lengths. Centres should support FTP commands as specified in RFC 959 unless some are excluded by bilateral agreement. There may also need to be bilaterally agreed procedures and commands.

It is the responsibility of receiving Centres to delete files after they have been processed.

Use of file compression

If large files are to be sent then it is often desirable to compress them first.

Centres should only use compression by bilateral agreement.

Backup with an IP based GTS

A final consideration is that of MSS backup. The new GTS will use IP addresses, where an individual address is usually associated with only one system. Should a system fail and an alternative be used there are implementation issues to be considered by transmitting centres. Ideally a transmitting centre should be unaffected by a receiving Centre's backup arrangements. This is a good principle, which all Centres should seek to adhere to. However it may not always be possible to achieve complete IP transparency. If this cannot be done sending Centres must be prepared to try an alternate IP address. Once using such an alternate address it must periodically try the primary address. It is suggested that such periodicity be established by bilateral agreement between centres because it will be heavily influenced by each centres backup strategy.

5.   TROUBLE SHOOTING AND PROBLEM RESOLUTION

IP layer tools

In a large IP network, every router involved in the path between two hosts must know the next hop to be used to reach the destination address. As every router and/or link might be a point of failure, it is very important to determine rapidly where the problem is, and then how to solve it.

Suggested steps in resolving problems (not necessarily in the order given) are:

(a) Check the remote centre (if the security policy of the remote centre allows it);
(b) Check if the link to the "outside" network is reachable;
(c) Check the local network by trying to reach the next/default gateway;
(d) Check the local IP stack and configuration.

Some basic tools that can be used such as Ping, Traceroute and Netstat are described below. PING and TRACEROUTE provide information on paths between hosts. They both use ICMP (traceroute also need UDP), but it should be noted that many sites block ICMP packets as part of their firewall security measures. To be able to locate problems in a network, it is necessary to have an exact documentation of the network.

PING

PING will check if the destination IP address can be reached. This tool is standard in almost every operating system with TCP/IP. On a Unix host the output looks like:

```
zinder# ping -s cadillac
PING cadillac: 56 data bytes
64 bytes from cadillac ( 193.168.1.17 ) : icmp_seq=0. time=3. ms
64 bytes from cadillac ( 193.168.1.17 ) : icmp_seq=1. time=2. ms
64 bytes from cadillac ( 193.168.1.17 ) : icmp_seq=2. time=3. ms
64 bytes from cadillac ( 193.168.1.17 ) : icmp_seq=3. time=3. ms
64 bytes from cadillac ( 193.168.1.17 ) : icmp_seq=4. time=5. ms
64 bytes from cadillac ( 193.168.1.17 ) : icmp_seq=5. time=3. ms
64 bytes from cadillac ( 193.168.1.17 ) : icmp_seq=6. time=3. ms
----cadillac PING statistics----
7 packets transmitted, 7 packets received, 0% packet loss
round-trip (ms) min/avg/max = 2/3/5
```

A useful test could be to ping the MSS of the neighbouring Centre. If this ping succeeds with an acceptable time delay, it would indicate that the network is operating correctly. If the ping fails, it could mean that the circuit is down or the ICMP ping packets are being blocked by the neighbouring Centre's router or firewall. In this event, it could be useful to ping the serial interface of the neighbouring Centre's router. If this succeeds, then the communications link to the neighbouring Centre is working. Any malfunction would then be within the neighbouring Centre.

Ping can be used to check whether the network performance is reasonable. The time is the delay between sending and receiving back the packet. It is not really possible to give an average value of the delay, but it is more important to notice any variation.

Finally, it might happen that packets are lost. In this case, there are missing numbers in the icmp_seq number. Either packet loss or variation in delays will badly degrade the performance.

TRACEROUTE

This tool is used to show which routers are transited on the network between A and B. As said above, traceroute need UDP and ICMP packets to work. Firewalls or packet filter on router may block such traffic as part of local security policy. It is not available on all systems, but is rather easy to compile. It is a free tool available on the Internet.

Traceroute output looks like:

```
cadillac 22: traceroute ftp.inria.fr
traceroute to ftp.inria.fr (192.93.2.54), 30 hops max, 40 byte packets
  1  antonio.meteo.fr (137.129.1.5)  3 ms  2 ms  2 ms
```

```
    2  clara.meteo.fr (137.129.14.249)  1 ms  2 ms  2 ms
    3  andrea.meteo.fr (193.105.190.253)  4 ms  3 ms  2 ms
    4  octares1.octares.ft.net (193.48.63.5)  30 ms  35 ms  10 ms
    5  192.70.80.97 (192.70.80.97)  9 ms  15 ms  27 ms
    6  stamand1.renater.ft.net (195.220.180.21)  40 ms  96 ms  29 ms
    7  stamand3.renater.ft.net (195.220.180.41)  56 ms  100 ms  108 ms
    8  stlambert.rerif.ft.net (195.220.180.10)  63 ms  56 ms  34 ms
    9  193.55.250.34 (193.55.250.34)  46 ms  28 ms  26 ms
   10  rocq-gwr.inria.fr (192.93.122.2)  21 ms  147 ms  85 ms
   11  ftp.inria.fr (192.93.2.54)  86 ms  58 ms  128 ms
```

When a router does not know where to send the packet, the result may be like the following:

```
cadillac 22: traceroute 193.105.178.5
traceroute to 193.105.178.5 (193.105.178.5), 30 hops max, 40 byte packets
    1  antonio.meteo.fr (137.129.1.5)  2 ms  1 ms  1 ms
    2  clara.meteo.fr (137.129.14.249)  1 ms  4 ms  1 ms
    3  andrea.meteo.fr (193.105.190.253)  4 ms  11 ms  4 ms
    4  octares1.octares.ft.net (193.48.63.5)  42 ms  39 ms  42 ms
    5  192.70.80.97 (192.70.80.97)  8 ms  7 ms  7 ms
    6  stamand1.renater.ft.net (195.220.180.5)  48 ms  86 ms  113 ms
    7  rbs1.renater.ft.net (195.220.180.50)  63 ms  107 ms  154 ms
    8  Paris-EBS2.Ebone.net (192.121.156.105)  146 ms  167 ms  140 ms
    9  stockholm-ebs-s5-2.ebone.net (192.121.154.21)  100 ms  80 ms  92 ms
   10  Amsterdam-ebs.Ebone.NET (192.121.155.13)  249 ms  227 ms  205 ms
   11  amsterdam1.NL.EU.net (193.0.15.131)  257 ms  249 ms  316 ms
   12  * Amsterdam5.NL.EU.net (134.222.228.81)  300 ms  297 ms
   13  Amsterdam6.NL.EU.net (134.222.186.6)  359 ms  218 ms  304 ms
   14  Paris1.FR.EU.net (134.222.228.50)  308 ms  311 ms  388 ms
   15  * Etoile0.FR.EU.net (134.222.30.2)  177 ms *
   16  Etoile0.FR.EU.net (134.222.30.2)  * * *
```

In the second case, cadillac would not be able to reach 193.105.178.5 because the router Etoile0. fr.eu.net failed to send the packet. With traceroute, it is not possible to know if it is a router failure or a link failure.

NETSTAT

This is a command available on most computing platforms. It gives information about the set up of the host's IP stack.

Netstat can be used to find out if the local IP address and subnet mask are configured correctly as well as if the routing information is still correct. There are many other options but is it not the intention of this guide to describe them all.

A sample output looks like:

```
$ netstat -rn
Routing tables
```

Internet:

Destination	Gateway	Netmask	Flags	Refs	Use	Interface
default	141.38.48.2		UG	12	4014211	ec0
127.0.0.1	127.0.0.1		UH	9	2321	lo0
141.38.48	141.38.48.12	0xffffff00	U	3	68981	ec0
141.38.48.12	127.0.0.1		UGH	10	253410	lo0
195.37.164.100	141.38.48.5		UGH	2	345	lo0
224	141.38.48.12	0xf0000000	U	1	19848	ec0

```
$
```

The output shows that this particular host has the IP address 141.38.48.12 with a subnet mask of 24 bit (0Xffffff00 or 255.255.255.0). It also shows that the host 195.37.164.100 can be reached via the

gateway 141.38.48.5, and the flags indicate that the route is up (U), that it is a route to a gateway (G) and that it is a host route (H). The first line indicates that all other destinations are reachable via the hosts default gateway 141.38.48.2.

In the next output:

$ netstat -rn
Routing tables

Internet:

Destination	Gateway	Netmask	Flags	Refs	Use	Interface
default	141.38.48.2		UG	12	4014211	ec0
127.0.0.1	127.0.0.1		UH	9	2321	lo0
141.38.48	141.38.48.12	0xffffff00	U	3	68981	ec0
141.38.48.12	127.0.0.1		UGH	10	253410	lo0
195.37.164.100	141.38.48.2		UGHM	2	345	lo0
224	141.38.48.12	0xf000000	U	1	19848	ec0

$

The only difference to the first sample output is, that the host route to 195.37.164.100 is now flagged with an M, which means that this route was modified by an ICMP redirect message from the old gateway 141.38.48.5. This usually means that the router with the IP address 141.38.48.5 has lost it's route to 195.37.164.100 and may indicate a problem with the link to the remote network.

Other monitoring tools

Verifying correct IP connectivity is a necessary first step. Other tools can be used to provide more information on what is happening. There are many options. It is possible to use protocol analysers and SNMP based software tools. For example, Sun Microsystems bundles with Solaris a tool called snoop who can replace in most cases a local area network analyser. Others tools such as TCPDUMP are available free on the Internet and can be installed on various systems. TCPDUMP is often bundled in various Linux distributions. These tools require a rather good knowledge of IP protocol. But, for example, TCPDUMP might be used to diagnose application level problems.

The following is a simple example on the host 'pontiac', of the capture of ICMP exchanges between zinder and cadillac.

```
pontiac# /usr/local/bin/tcpdump -i nf0 host cadillac and zinder and proto icmp
15:28:06.68 cadillac.meteo.fr > zinder.meteo.fr: icmp: echo request
15:28:06.68 zinder.meteo.fr > cadillac.meteo.fr: icmp: echo reply
15:28:19.45 cadillac.meteo.fr > zinder.meteo.fr: icmp: echo request
15:28:19.45 zinder.meteo.fr > cadillac.meteo.fr: icmp: echo reply
15:28:29.44 cadillac.meteo.fr > zinder.meteo.fr: icmp: echo request
15:28:29.45 zinder.meteo.fr > cadillac.meteo.fr: icmp: echo reply
```

SNMP

The simple Network Management Protocol (SNMP) was developed in the late 1980s in order to offer to network manager a standard tool for controlling networks. In most case SNMP could be used to replace more crude tools describe above. Unfortunately, good SNMP software is not cheap. SNMP is a client-server protocol. In order to be able to gather information with SNMP, the equipment connected on the network must have Management Information Base (MIB). These bases are catalogues of integer, counters, strings, etc.... The manager asks the agents to send it some values. These values might be for example, IP routing table. The example below is obtained by requesting with HP Open View (a commercial package) the routeing table on the host monica.meteo.fr.

Title: : monica.meteo.fr
Name or IP Address: monica.meteo.fr

IpRouteDest	ipRouteMask	ipRouteNextHop	ipRouteProto	ipRouteMetric1
0.0.0.0	0.0.0.0	137.129.1.5	local	0
136.156.0.0	255.255.0.0	137.129.1.5	ciscoIgrp	8786
137.129.1.0	255.255.255.0	137.129.1.6	local	0
137.129.2.0	255.255.255.0	137.129.1.5	ciscoIgrp	1110

137.129.3.0	255.255.255.0	137.129.3.254	local	0
137.129.4.0	255.255.255.0	137.129.4.254	local	0
137.129.5.0	255.255.255.0	137.129.5.254	local	0
137.129.6.0	255.255.255.0	137.129.1.62	local	0
137.129.7.0	255.255.255.0	137.129.7.254	local	0
137.129.8.0	255.255.255.0	137.129.8.254	local	0
137.129.9.0	255.255.255.0	137.129.1.5	ciscoIgrp	1110

The information given above with TCPDUMP might be obtained with SNMP but to do so, probes running the Remote Monitoring MIB must be connected on the network.

On a bilateral basis, it might be useful for Centres to allow SNMP access to their router from the other NMC. However, regular polling of other Centres' routers should be avoided to avoid overloading of circuits.

MRTG

Another public domain package, called Multi Router Traffic Grapher (MRTG), is a very helpful tool to gather information about the local network and about connected links. The MRTG is a tool to monitor the traffic load on networks and links. It generates HTML pages containing images which provide a live visual representation of this traffic. It can also be implemented to indicate failures of network links. MRTG consists of a Perl script which uses SNMP to read the traffic counters of your router(s) and a fast C program which logs the traffic data and creates graphs representing the traffic on the monitored network connection(s). Below is a sample output. It shows traffic statistics for a dedicated link and gives information about the traffic pattern on the link. This is just one of many other graphs one can create with MRTG.
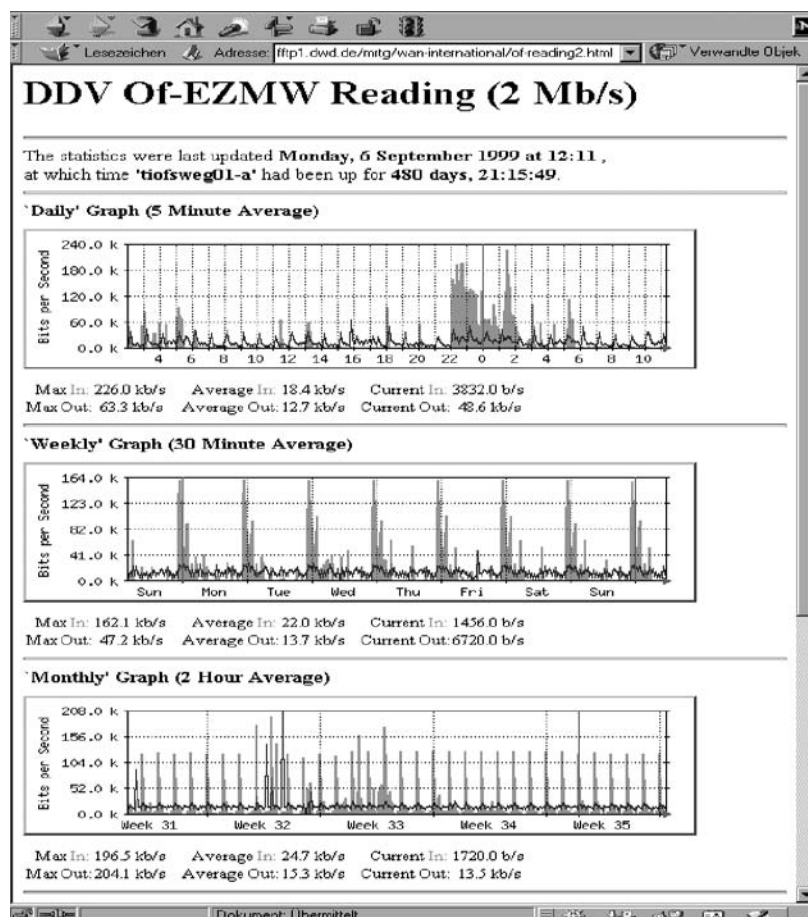
SYSLOG

Many of the possible problems can be located if one not only looks at the SYSLOG files on the hosts, but uses a SYSLOG server as well and lets the router(s) send their messages to it. This file can then

be checked regularly e.g. for messages that indicate high CPU load, processes that use up much memory or CPU cycles, lines going up and down, and messages about events regarding the used routing protocol.

There are 8 different levels of messages the router will log to the syslog server.

They are:

Emergencies	0	System unusable
Alerts	1	Immediate action needed
Critical	2	Critical conditions
Errors	3	Error conditions
Warnings	4	Warning conditions
Notifications	5	Normal but significant condition
Informational	6	Informational messages only
Debugging	7	Debugging messages

The default logging facility on a Cisco router is set to local7, this is important to know when configuring a host to be a syslog server and will be explained there.

The configuration commands on a Cisco router to activate logging are:

cisco-gts-1(config)#logging trap level-of-messages-to-log
cisco-gts-1(config)#logging 141.38.48.12

and can be checked with the command "show logging":

cisco-gts-1#sho logging
Syslog logging: enabled (0 messages dropped, 0 flushes, 0 overruns)
Console logging: level debugging, 117892 messages logged
Monitor logging: level debugging, 8317 messages logged
Trap logging: level debugging, 117150 message lines logged
Logging to 141.38.48.12, 117150 message lines logged
Buffer logging: disabled
cisco-gts-1#

In this example, logging is set to the level debugging ("logging trap debugging"), and all messages from level 7 up to level 0 will be sent to the syslog server with the IP address 141.38.48.12.

To activate the SYSLOG server on for instance a SGI UNIX machine, the following entries should be there:

In the file /etc/services: syslog   514/udp
In the file /etc/syslog.conf: local7.debug   /usr/people/cisco/logs/cisco.log

The local7.debug relates to the default facility of logging that is defined on a cisco router as mentioned (local7). The file above will be the file to which the syslog daemon writes all incoming syslog messages for local7.

The last action on the host is to have the syslog daemon reread it's config file (kill –1 pid-of-syslogd).

Bandwidth Management

On an IP network, all packets will be routed over the links without any prioritization mechanism. Therefore an FTP transfer can occupy all the bandwidth available starving all others applications. When traffic increases, it might therefore be needed to introduce some bandwidth management in the network configuration. Further information may be available on the online reference (http://www.wmo.int/).

APPENDIX 1

HIGH LEVEL TCP/IP TOPOLOGY AND TCP/IP DATA FLOWS

The following diagrams show a high level view of the topology of a simple Centre and the main data flows regarding GTS and Internet telecommunication. More detailed X.25 over IP configurations can be found in the following appendices.
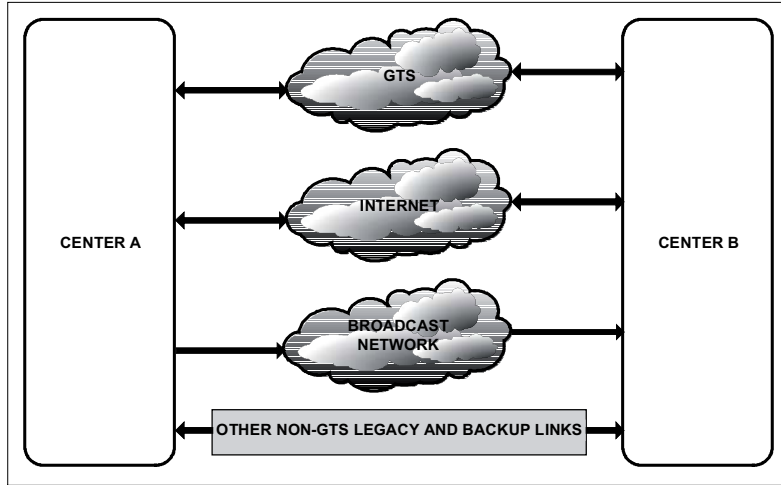
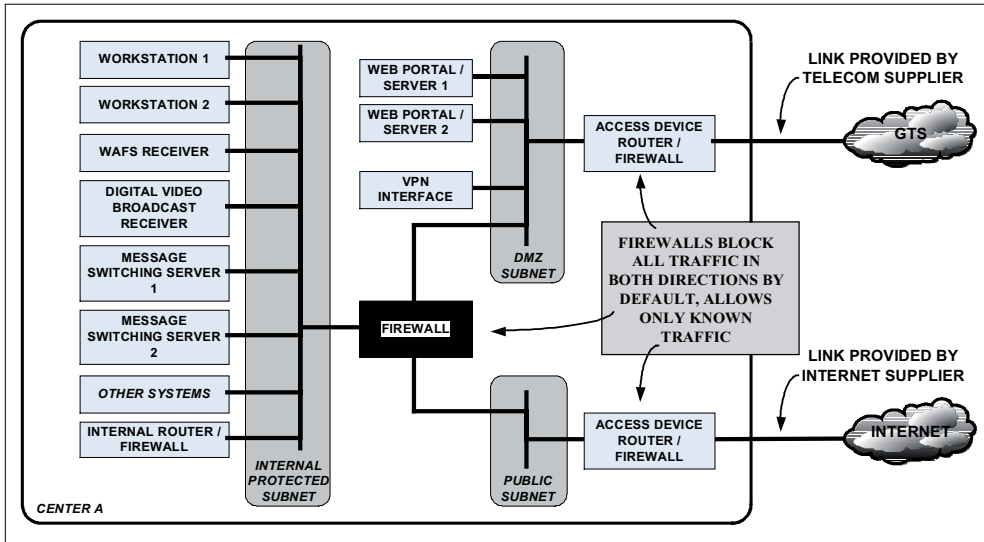Figure A1.1. General interconnectivity between Centres

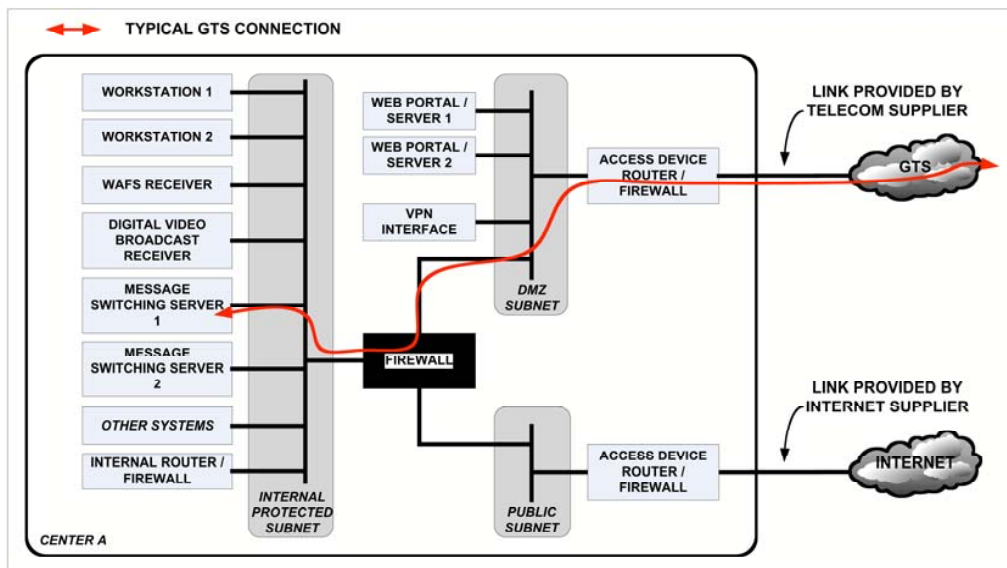Figure A1.2. Topology of TCP/IP network in a simple Centre

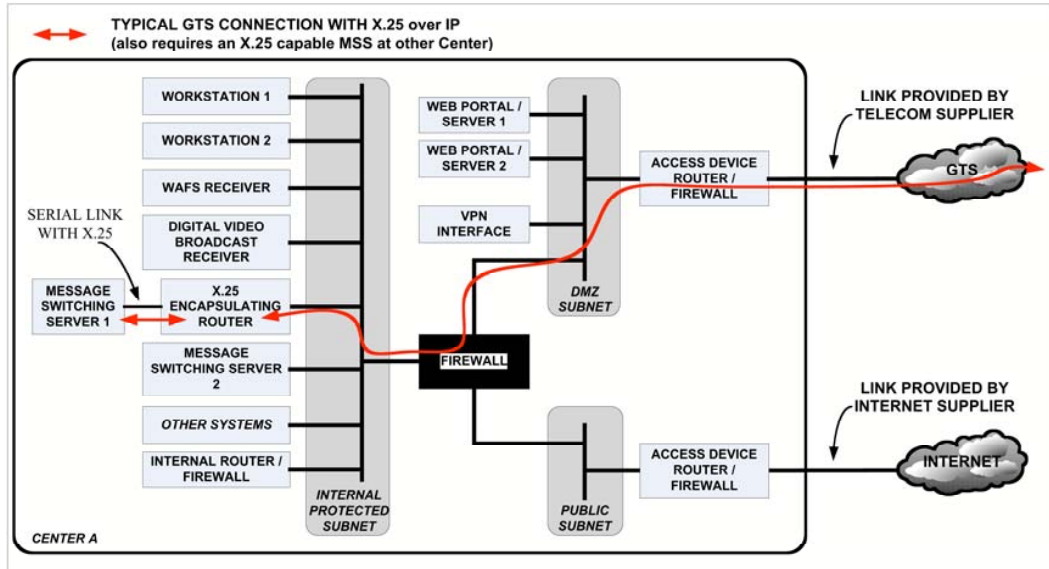Figure A1.3. Data flow of traffic over the GTS – IP only

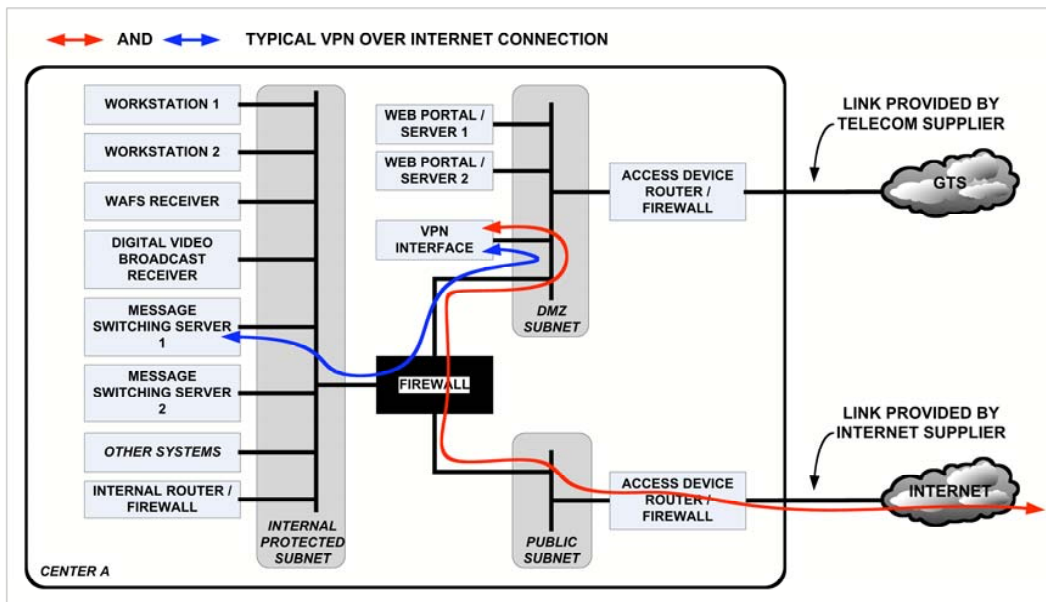Figure A1.4. Data flow of traffic over the GTS – X.25 over IP

Figure A1.5. Data flow of traffic using VPN over the Internet

APPENDIX 2

CISCO ROUTER CONFIGURATIONS

This appendix is not intended to be a complete description of all available commands in a Cisco, nor a full course on this equipment, but it is useful to describe more precisely the configuration tasks in order to comply with the policy outlined in Chapter 2.

The configuration described below respects what is available in release 11.1 of Cisco IOS software. Some features are not available in previous releases, and some will be modified in the future.

We are going to describe different steps:

1. Establishing IP connection
   - IP over PPP
   - IP over X25
   - X25 over IP (in fact it is X25 over TCP, the XOT protocol)

2. Routing configuration
   - Leaf node with static routes (Centre A)

- Leaf node with dynamic routing (Centre C)
- Configuration in a non-leaf node (in our case two different GTS connections, Centre B)

3. Security configuration
- Filtering traffic based on declared IP addresses
- Controlling routing exchanges between GTS and the Internet

In our example A is connected to B with IP over X25 link, B is connected to C with IP over PPP. There is also the option for the MSSs at B and C to communicate using X.25 over TCP/IP. A is a leaf node, B and C are non-leaf nodes. B and C are also connected to the Internet. B and its Internet provider use static routes,[1] C and its Internet provider use RIP.[2]
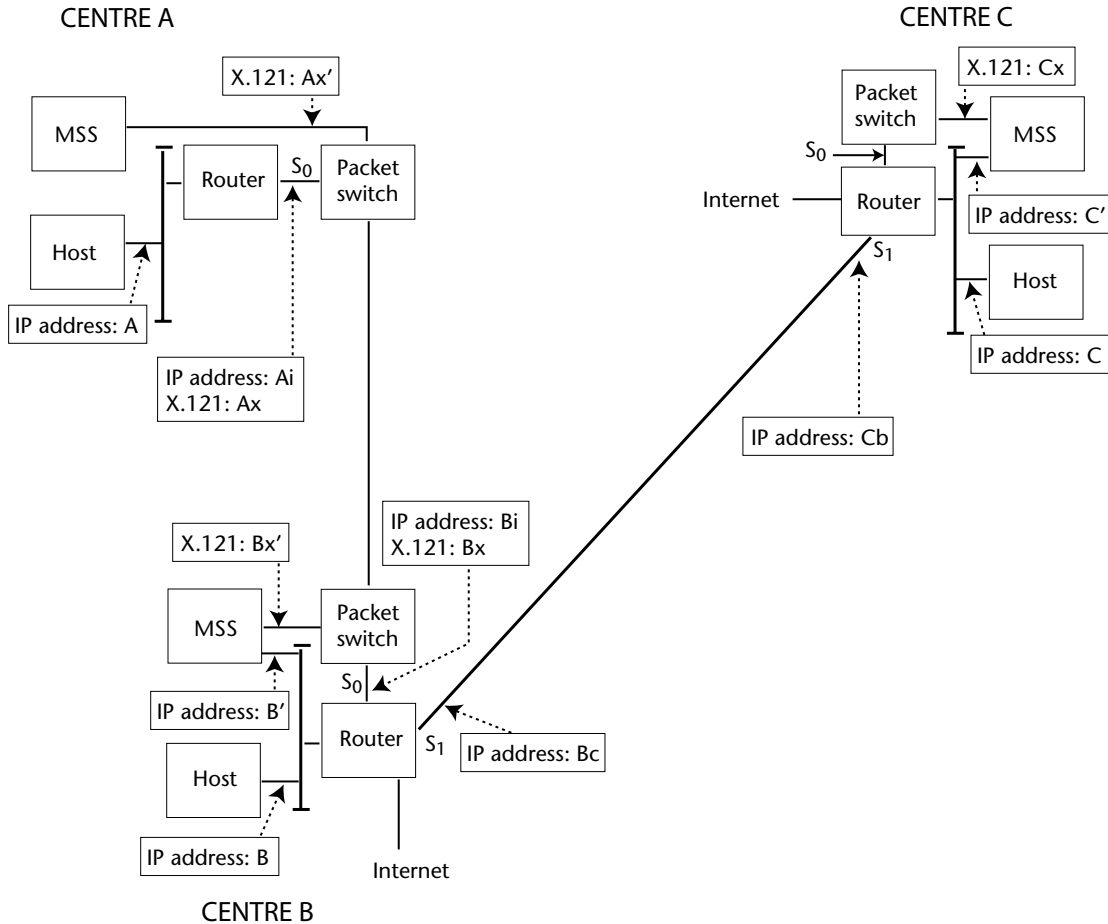
The following will be used along this appendix:

	X121 router address	IP router address	IP hosts address for GTS	Autonomous System
Centre A	01016661166666	193.105.177.1	194.168.1.16/255.255.255.248	N.A.
Centre B	01017771177777	193.105.177.2 193.105.178.5	137.129.9.0/255.255.255.0	65001
Centre C	01018881188888	193.105.178.6	195.1.1.0/255.255.255.0	65200

Centres A and B use serial interface 0 to connect to the packet switches. Centres B and C use serial interfaces 1 for the PPP link.

_____

1 B cannot use EGP and BGP on the same router; one router cannot belong to more than one AS.
2 RIP is NOT a good choice for this type of configuration. But as RIP is the most basic protocol, it is used in this case too.

Step 1: Establishing connections

Centre A:
interface serial 0
encapsulation X25
! depending on local set-up (virtual channels,
! windows...) extra configuration might be necessary
x25 address 01016661166666
ip address 193.105.177.1 255.255.255.0
!
x25 map ip 193.105.177.2 01017771177777
Centre B:
interface serial 0
encapsulation X25
x25 address 01017771177777
! depending on local set-up (virtual channels,
! windows...) extra configuration might be necessary
ip address 193.105.177.2 255.255.255.0
!
x25 map ip 193.105.177.1 01016661166666
!
interface serial 1
encapsulation PPP
ip address 193.105.178.5 255.255.255.252
!
! X25 over TCP commands
x25 routing
x25 route 010188811* ip 193.105.178.6
x25 route 010177711* interface serial 0
Centre C:
interface serial 0
encapsulation X25
x25 address 01018881188888
! depending on local set-up (virtual channels,
! windows...) extra configuration might be necessary
interface serial 1
encapsulation PPP
ip address 193.105.178.6 255.255.255.252
!
! X25 over TCP commands
x25 routing
x25 route 010177711* ip 193.105.178.5
x25 route 010188811* interface serial 0

After this first step, IP configuration between the routers is complete. The router in Centre A can then ping router in B. B can ping A and C, but A and C cannot communicate because there is no routing set up.

MSS at B and C can communicate with IP (once end-to-end routing is established) or with X25 over TCP. Experience has shown that all the X25 parameters on router in centres B and C MUST be the same (packet size, window size) to avoid any strange behaviour.

Step 2: Routing

Centre A:
! Simply define a default route with a metric 10 (the price) via B
ip route 0.0.0.0 255.255.255.255 193.105.177.2 10

Centre B:
! First define static route with A
ip route 194.168.1.16 255.255.255.248 193.105.177.1 10
ip route 0.0.0.0 ip_provider_address 10

! BGP routing
router bgp 65001
network 137.129.9.0 mask 255.255.255.0
neighbour 193.105.178.6 remote-as 65200
! Route to A is static, force sending to C
redistribute static

Centre C:
! BGP routing
router bgp 65200
network 195.1.1.0
neighbour 193.105.178.5 remote-as 65001
! 196.1.1.0 is network address for non-GTS hosts in C
router rip
version 2
network 195.1.1.0
no auto-summary

A defines a default route. So, when A wants to communicate with C, the router knows where to send packets. C is going to receive routing information from B, so A is also reachable from C. It is also important to note that if A tries to reach an Internet site, attempts will be made through B's Internet connection. It will fail because the Internet site A tries to reach can not return packets to A (only B's address is reachable on the internet via B's Internet connection). The link A to B link will thus carry some inappropriate data. Also note that we use RIP version 2.

Step 3: Security

Centre A:
! Declare which hosts can use GTS
access-list 1 permit 194.168.1.16 0.0.0.7
! Declare which hosts can come from GTS
access-list 2 permit 195.1.1.0 0.0.0.255
access-list 2 permit 137.129.9.0 0.0.0.255
!
interface serial 0
ip access-group 1 out
ip access-group 2 in

Centre B:
! Declare which hosts can use GTS
access-list 1 permit 137.129.9.0 0.0.0.255
! Declare which hosts can come from GTS
access-list 2 permit 195.1.1.0 0.0.0.255
access-list 2 permit 194.168.1.16 0.0.0.7
! Only accept BGP updates from AS neighbour
ip as-path access-list 3 permit ^$
ip as-path access-list 3 permit ^65200
!
interface serial 0
ip access-group 1 out
ip access-group 2 in
!
interface serial 1
ip access-group 1 out
ip access-group 2 in
! Restrict BGP updates
router bgp 65001
network 137.129.9.0 mask 255.255.255.0
neighbour 193.105.178.6 remote-as 65200
neighbour 193.105.178.6 filter-list 3 in
neighbour 193.105.178.6 filter-list 3 out
redistribute static

Centre C:
! Declare which hosts can use GTS
access-list 1 permit 195.1.1.0 0.0.0.255
! Declare which hosts can come from GTS
access-list 2 permit 137.129.9.0 0.0.0.255
access-list 2 permit 194.168.1.16 0.0.0.7
! Only accept BGP updates from AS neighbour
ip as-path access-list 3 permit ^$
ip as-path access-list 3 permit ^65001
!
interface serial 0
 ip access-group 1 out
 ip access-group 2 in
! Restrict BGP updates
router bgp 65200
network 195.1.1.0 mask 255.255.255.0
neighbour 193.105.178.5 remote-as 65001
neighbour 193.105.178.5 filter-list 3 in
neighbour 193.105.178.5 filter-list 3 out

In these configurations, there are two important features used:

(a) BGP filtering

The access-list 3 in both B and C checks the autonomous system number sent by its neighbour. By filtering in and out in the BGP process this guarantees that all known routes must be issued from one of these ASs.

(b) IP filtering

The access-list 1 list allows IP addresses issued from within each Centre. This list should be quite stable. The access-list 2 checks the incoming IP addresses. As new Centres are added to the IP network, the corresponding addresses must be added to these access-lists.

It must also be noted that despite Internet connections in B and C no extra attention is required to control routing exchange. A static default route is not sent even if « redistribute static » is enabled. RIP and BGP ignore routing information known via the other protocol.

APPENDIX 3

SAMPLE SOCKET SEND AND RECEIVE ROUTINES

```
/**********************************************************************************************************
* Sample TCP/IP Socket program that SENDS a single message
**********************************************************************************************************/
#include <stdio.h>
#include <unistd.h>
#include <stdlib.h>
#include <signal.h>
#include <string.h>
#include  <memory.h>
#include  <sys/socket.h>
#include  <netinet/in.h>
#include  <netdb.h>

/* TCP/IP DESTINATION and SERVICE ARE DEFINED BY THE RECEIVING CENTRE */
#define DESTINATION   "localhost"
#define SERVICE           39000
#define GTS_LENFIELD 8
#define MAX_MSGSIZE 15000  /*  value of the send buffer size, recommended: 4096 */
static void GetDestinationInfo();
static void SetupSocket();
```

```
static void SendData();
static void MakeConnection();

static struct sockaddr_in dest;
static int       pr_sock;
/*************************************************************************************************
*                          MAINLINE
* 1. Ignore SIGPIPE signals. These are generated if a connection
*    is lost. By default they cause a program to terminate.
* 2. Get information about the destination (GetDestinationInfo):
*            - IP number (and name)
*            - Service/Port number
* 3. Create a TCP/IP Socket (SetupSocket)
* 4. Connect to the destination centre (MakeConnection)
* 5. Send the message (SendData)
* 6. Close the socket (shutdown + close)
*************************************************************************************************/
main(int argc, char *argv[])
{

signal (SIGPIPE,SIG_IGN);

GetDestinationInfo();
SetupSocket();
MakeConnection();
SendData();
/* shutdown(pr_sock,1) */
close(pr_sock);
}
/*************************************************************************************************
*                     GET DESTINATION INFO
* Store the destination IP number and service number in a socket
* structure (dest).
* 1. Convert the destination name to an IP number (gethostbyname)
* 2. Store the IP number and service number in the "dest" structure.
*************************************************************************************************/
static void GetDestinationInfo()
{
struct hostent *hp;

hp = gethostbyname (DESTINATION);
if ( hp == NULL ) {
  printf("host error\n");
  exit(1);
  }

memset ((char *)&dest, 0, sizeof dest);
memcpy (&dest.sin_addr.s_addr, hp->h_addr, hp->h_length);
dest.sin_family = AF_INET;
dest.sin_port = SERVICE;
}
/*************************************************************************************************
*                          SETUP SOCKET
* Setup a TCP/IP Socket
* 1. Create the socket
* 2. Set the socket KEEPALIVE option.
*    This enables the automatic periodic transmission of "check"
*    messages to be sent on the connection. If the destination
*    does not respond then it is considered broken and this process
*    is notified (by SIGPIPE or end-of-file)
*3. Set the socket REUSEADDR option. Enable quicker restarting of
*    terminated processes.
*4. Reduce the size of the Socket send buffer to reduce the amount of data lost
*    if the connection fails.
*************************************************************************************************/
```

```c
static void SetupSocket()
{
int        on = 1;
int        rc;
int        buffsize = MAX_MSGSIZE;

pr_sock = socket (AF_INET, SOCK_STREAM, 0);
if (pr_sock < 0) {
  printf("sock error\n");
  exit(1);
  }

 rc = setsockopt(pr_sock,SOL_SOCKET,SO_KEEPALIVE,(char *)&on,sizeof(on));
 if (rc != 0) {
   printf("keepalive error\n");
    }

 rc = setsockopt(pr_sock,SOL_SOCKET,SO_REUSEADDR,(char *)&on,sizeof(on));
 if (rc != 0) {
   printf("reuse error\n");
    }

rc = setsockopt(pr_sock,SOL_SOCKET,SO_SNDBUF,(char *)&buffsize,sizeof(buffsize));
 if (rc != 0) {
   printf("unable to set send buffer size\n");
    }

}
/********************************************************************************************
*                              MAKE CONNECTION
* Attempt to make a TCP/IP Socket connection to the destination on
* the agreed service/port number.
********************************************************************************************/
static void MakeConnection()
{
int        length;

length = sizeof (dest);
if ( connect (pr_sock,(struct sockaddr *)&dest,length) == -1 ) {
  printf("connection error\n");
  exit(1);
  }
printf("connected\n");
}
/********************************************************************************************
*                              SEND DATA
* Send a message on the socket (5 times actually).
*
* NOTE: A real program would check the return code from the write
* and if the write failed it would close the socket, raise an operator
* alarm, and then try to re-send from the start of the message
********************************************************************************************/
static void SendData()
{
char       msg[MAX_MSGSIZE+1], buffer[MAX_MSGSIZE+GTS_LENFIELD+3];
int        buflen, i, rc = 0;

strcpy(msg,"\001\r\r\n001\r\r\nTTAA01 AMMC 000000\r\r\n");
for (i=0;i<60;i++)
   strcat(msg,"THE QUICK BROWN FOX JUMPS OVER THE LAZY DOG 0123456789\r\r\n");
strcat(msg,"\r\r\n\003");
```

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```
sprintf(buffer,"%0*dAN%s",GTS_LENFIELD,strlen(msg),msg);
buflen = strlen(buffer);

for (i=0; i<5; i++) {
  rc = write(pr_sock,buffer,buflen);
  printf("write. rc = %d\n",rc);
  }

}
/**********************************************************************************************
* TEST TCP/IP SOCKET RECEIVING PROGRAM.
* Program is designed to give some ideas as to how to receive GTS
* style messages on a TCP/IP Socket connection.
**********************************************************************************************/
#include <stdio.h>
#include <unistd.h>
#include <stdlib.h>
#include <signal.h>
#include <string.h>
#include  <memory.h>
#include  <sys/socket.h>
#include  <netinet/in.h>
#include  <netdb.h>

#define SERVICE                 39000
#define MAX_MSGSIZE             15000
#define MAX_BUFLEN              MAX_MSGSIZE + 100
#define  SOH                    '\001'
#define  ETX            '\003'
#define  GTS_LENFIELD                   8
#define  GTS_SOCKET_HEADER              10
static void SetupService();
static void RecvData();
static void AcceptConnection();
static int  ExtractMsg(char *buffer, int *buflen);
static int  CheckMsgBoundaries (char *, int);
static int  FindMessage (char *, int, int *);
static void ShiftBuffer (char *, int *, int);
static struct sockaddr_in dest;

static int     pr_sock, msgsock;
static char    buffer[MAX_BUFLEN+1];
static int     buflen = 0;
/**********************************************************************************************
*                               MAIN
* Listen for incoming IP calls and read any incoming messages on
* the first call established.
*
* 1. Ignore SIGPIPE signals. These are generated if a connection
*    is lost. By default they cause a program to terminate.
* 2. Set-up a listening socket for incoming msgs (SetupService)
* 3. Accept the first call received (AcceptConnection)
* 4. Read any messages on this connection (RecvData)
* 5. Close the call and close the listening socket.
**********************************************************************************************/
main(int argc, char *argv[])
{

signal (SIGPIPE,SIG_IGN);

SetupService();
AcceptConnection();
RecvData();
```

```
close(msgsock);
/* shutdown(pr_sock,1) */
close(pr_sock);
}
/**********************************************************************************************
*                                   SETUP SERVICE
* Listen for calls on a given Service/Port.
* 1. Create a socket
* 2. Set the socket KEEPALIVE option.
*    This enables the automatic periodic transmission of "check"
*    messages to be sent on the connection. If the destination
*    does not respond then it is considered broken and this process
*    is notified (by SIGPIPE or end-of-file)
* 3. Set the socket REUSEADDR option. Enable quicker restarting of
*    terminated processes.
* 4. Bind the socket to the required Service/Port
* 5. Start listening for calls.
**********************************************************************************************/
static void SetupService()
{
int        on = 1;
int        rc;
/* adjust the TCP receive buffer size
int        buffsize = MAX_MSGSIZE; */

memset ((char *)&dest, 0, sizeof dest);
dest.sin_addr.s_addr = INADDR_ANY;
dest.sin_family = AF_INET;
dest.sin_port = SERVICE;

pr_sock = socket (AF_INET, SOCK_STREAM, 0);
if (pr_sock < 0) {
  printf("sock error\n");
  exit(1);
  }

 rc = setsockopt(pr_sock,SOL_SOCKET,SO_KEEPALIVE,(char *)&on,sizeof(on));
 if (rc != 0) {
   printf("keepalive error\n");
   exit(1);
   }
 rc = setsockopt(pr_sock,SOL_SOCKET,SO_REUSEADDR,(char *)&on,sizeof(on));
 if (rc != 0) {
   printf("reuse error\n");
   exit(1);
   }
/* adjust the TCP receive buffer size
rc = setsockopt(pr_sock,SOL_SOCKET,SO_RCVBUF,(char *)&buffsize,sizeof(buffsize));
 if (rc != 0) {
   printf("unable to set send receive size\n");
   }
*/
rc = bind(pr_sock,(struct sockaddr *)&dest,sizeof dest);
if ( rc < 0) {
  printf("bind error\n");
  exit(1);
  }

rc = listen(pr_sock,1);
if ( rc < 0) {
  printf("listen error\n");
  exit(1);
```

```
    }

printf("listening\n");
}
/********************************************************************************************
*                              ACCEPT CONNECTION
* Wait for an incoming call (accept).
* Return the socket of the call established.
********************************************************************************************/
static void AcceptConnection()
{
int          addrlen;

printf("waiting connection\n");

addrlen = sizeof(sockaddr_in);
msgsock = accept (pr_sock,&dest,&addrlen);
if ( msgsock < 0) {
  printf("accept error\n");
  exit(1);
  }
printf("connected\n");
}


/********************************************************************************************
*                              RECV DATA
* Read data from the message/call socket.
* Extract GTS messages from this data.
* Keep reading until the sender drops the call or there is an error.
********************************************************************************************/
static void RecvData()
{
int          numr = 1;
int          rc = 0;

while (numr > 0 && rc >= 0) {
   numr = read(msgsock,buffer+buflen, MAX_BUFLEN-buflen);
   if (numr > 0) {
     buflen += numr;
     buffer[buflen] = '\0';
     printf("buffer = %s\n",buffer);
     rc = ExtractMsg(buffer,&buflen);
     }
  }
}
/********************************************************************************************
*                              EXTRACT MSG
*   DESCRIPTION
*   This function accepts a buffer of data on input, along with the
*   amount of data in the buffer, and extracts GTS messages from this
*   buffer.
*
*   Messages that are in the buffer are identified as follows...
*
*   - The first 8 bytes of the message buffer HAVE to be a message
*     length in character format.
*     If the length exceeds the GTS defined maximum message size, or
*     does not consist of numeric characters, then an error is returned
*     (lost synchronization).
*
*   - Immediately following the message length is a 2 character
*             Message Type: "AN" = Alphanumeric, "BI" = binary, "FX" = Fax
```

```
*
*   - The GTS message begins with a SOH character, and is terminated
*     with a ETX character, if this does not occur, then an error is
*     returned (lost synchronization).
*
*   - If a GTS message is identified, then it is extracted and the
*     message is shifted out of the buffer.
*
*   - As there may be more than 1 message in the buffer, this function
*     will loop (extracting messages) until either and
*     error or incomplete message is detected.
*
*
*   RETURNS    = 0  - Not a complete message in the buffer.
*                < 0  - Fatal error in the format of the buffer.
*                > 0  - Success, the message(s) have been extracted
**************************************************************************************************************/
static int ExtractMsg(char *buffer, int *buflen)
{
int          rc, msglen;
char         msg[MAX_MSGSIZE+1];

/* FIND THE FIRST MESSAGE IN THE BUFFER */
rc = FindMessage (buffer, *buflen, &msglen);

/* WHILE A VALID MESSAGE LENGTH IS FOUND IN THE MESSAGE BUFFER... */
while ( rc > 0 ) {

  /* ENSURE THAT THE FIRST CHARACTER AFTER THE MESSAGE LENGTH IS
     A 'SOH' CHARACTER, AND THE LAST CHARACTER AS INDICATED BY
     THE MESSAGE LENGTH IS AN 'ETX' CHARACTER. */
  if ( (rc = CheckMsgBoundaries (buffer, msglen)) < 0 )
    continue;

  /* PRINT THE EXTRACTED MESSAGE */
  memcpy(msg,buffer+GTS_SOCKET_HEADER,msglen);
  msg[msglen] = '\0';
  printf("GTS MSG = \n%s\n",msg);

  /* SHIFT THE JUST INJECTED MESSAGE OUT OF THE MESSAGE BUFFER,
     AND LOOP BACK TO LOOK FOR A NEW MESSAGE. */

  ShiftBuffer (buffer, buflen, msglen);

  /* FIND THE FIRST MESSAGE IN THE SHIFTED BUFFER */
  rc = FindMessage (buffer, *buflen, &msglen);

  }

return (rc);
}
/***************************************************************************************************************
*                            FIND MESSAGE
* Check that the complete message is at the start of the buffer.
* 1. Check the first 8 characters which are the message length
* 2. Check the next 2 characters - Message Type
* 3. Check that the complete message, as defined by the "message length"
*    field, is in the buffer.
* Return codes:
*    0 = message incomplete
*    1 = message complete
*   -1 = error
**************************************************************************************************************/
```

```
static int  FindMessage (char *buffer, int buflen, int *mlen)
{
  char  charlen[GTS_LENFIELD+1];
  int   intlen;

  *mlen = 0;

  /* IF THE LENGTH OF THE PASSED MESSAGE BUFFER IS NOT GREATER THAN
     10 CHARACTERS THEN RETURN 'INCOMPLETE'. */
  if ( buflen < GTS_SOCKET_HEADER ) {
    return (0);
    }

  /* CHECK THAT THE MESSAGE TYPE IS VALID */
       if   (strncmp(buffer+GTS_LENFIELD,"AN",2)   &&   strncmp(buffer+GTS_LENFIELD,"BI",2)   &&
strncmp(buffer+GTS_LENFIELD,"FX",2)) {
    printf("ERROR: Message Type field invalid");
    return (-1);
    }

  /* EXTRACT THE MESSAGE LENGTH */
  strncpy (charlen, buffer, GTS_LENFIELD);
  charlen[GTS_LENFIELD] = '\0';

  /* CHECK THAT THE MESSAGE LENGTH CHARACTER STRING COMPRISES
     ENTIRELY OF DIGITS. RETURN AN ERROR IF THIS IS NOT THE CASE. */
  if ( strspn (charlen, "0123456789") != strlen (charlen) ) {
    printf("ERROR: length not numeric");
    return (-1);
    }

  /* CONVERT THE MESSAGE LENGTH CHARACTER STRING TO AN INTEGER. */
  intlen = atoi (charlen);

  /* CHECK THAT THE LENGTH EXTRACTED FROM THE BUFFER IS NOT GREATER
     THAN THE GTS DEFINED MAXIMUM MESSAGE SIZE - RETURN AN ERROR IF
     THIS IS THE CASE. */
  if ( intlen > MAX_MSGSIZE ) {
    printf("ERROR: message overlength");
    return (-1);
    }

  /* CHECK IF THE ENTIRE MESSAGE HAS BEEN RECEIVED. RETURN IF NOT */
  if ( buflen < intlen + GTS_SOCKET_HEADER ) {
    return (0);
    }

  *mlen = intlen;
  return (1);
}
/*********************************************************************************************************
*                        CHECK MSG BOUNDARIES
* Confirm the first character after the Socket Header is
* a SOH, and the last character in the message (given by the message
* length) is an ETX.
*********************************************************************************************************/
static int  CheckMsgBoundaries (char *buffer, int msglen)
{

  /*  CHECK THAT THE FIRST CHARACTER (AFTER THE MESSAGE LENGTH
     FIELD) IS AN SOH CHARACTER - RETURN AN ERROR IF IT ISN'T. */
  if ( buffer[GTS_SOCKET_HEADER] != SOH ) {
```

```
      printf("ERROR: SOH not found\n");
      return (-1);
      }

  /*  CHECK THAT THE LAST CHARACTER (ACCORDING TO THE MESSAGE LENGTH
      FIELD) IS AN ETX CHARACTER - RETURN AN ERROR IF IT ISN'T. */
  if ( buffer[msglen+GTS_SOCKET_HEADER-1] != ETX ) {
    printf("ERROR: ETX not found\n");
    return (-1);
    }

  return (1);
}
/*******************************************************************************************************
*                            SHIFT BUFFER
* Shift the leading message in the buffer out of the buffer. This may
* either empty the buffer, or move all or part of a new message to the
* start of the buffer.
*******************************************************************************************************/
static void  ShiftBuffer (char *buffer, int *buflen, int msglen)
{
  int  shiftlen;

  /* CALCULATE THE AMOUNT OF DATA TO BE SHIFTED OUT OF THE BUFFER. */
  shiftlen = msglen + GTS_SOCKET_HEADER;

  /* SHIFT THE 'PROCESSED' DATA  OUT OF THE BUFFER BY MOVING THE
     UNPROCESSED DATA OVER THE TOP OF IT.
     CALCULATE THE NEW AMOUNT OF DATA IN THE BUFFER. */
  *buflen = *buflen - shiftlen;
  memcpy (buffer, buffer + shiftlen, *buflen);
}
```

APPENDIX 4

SOME SECURITY ARRANGEMENTS FOR SMALL GTS CENTRES

This Appendix provides information on low-cost measures to secure GTS centres, when they are connected to the Internet. The traditional GTS with Message Switching Systems passing bulletins over point-to-point circuits is inherently secure, while the Internet is inherently insecure. So, it is important to prevent Internet users from being able to traverse GTS links, where they may be able to cause damage to neighbouring centres.

Security policy

In a mixed Internet/GTS environment, a security hole at a GTS centre may compromise other GTS segments. It is very likely that sooner or later, most of the GTS centres will be connected to the Internet, so a solution for the security aspects must be found, which are practical for all Centres and especially, small centres. Different levels of network security can be achieved with the tools available today at costs that vary from a few dollars (freeware) to expensive proprietary solutions.

There are, however, other important aspects besides costs. Technical expertise and strong management support are indispensable elements to implement and enforce an effective security policy. Without them, no protection will be achieved, even with the best and most expensive firewall systems.

Coexistence of Internet and dedicated GTS links

There are many options for the general configuration of systems in small Centres. Figure A4.1 shows an arrangement where separate routers are used to provide access to Internet and GTS.
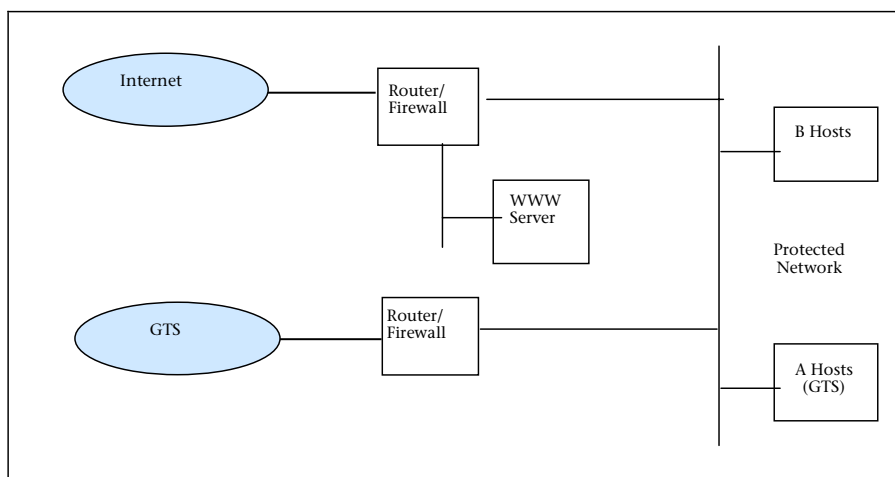
2009 edition

Figure A4.1. Coexistence of GTS and Internet – separate access routers

To achieve cost reduction, GTS centres, may wish to consolidate the GTS and Internet networks, whilst still providing a level of security for their GTS systems. Figure A4.2 depicts a low cost configuration that may meet this objective.
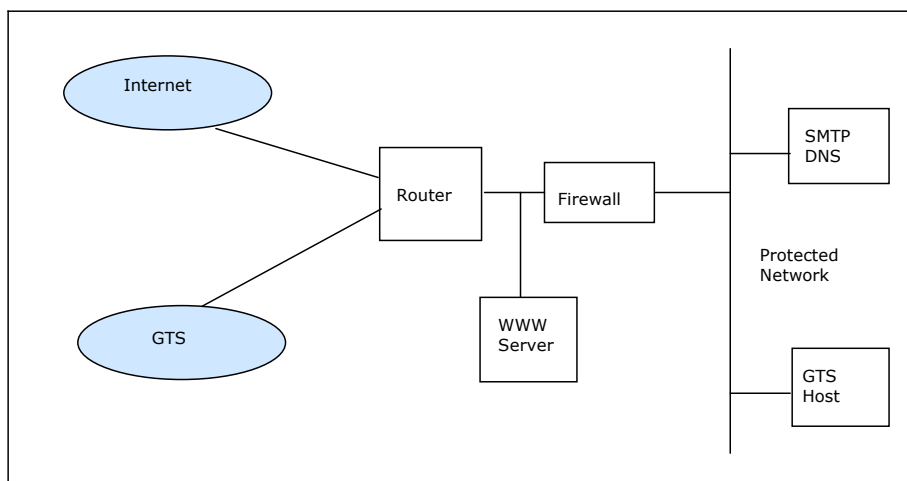

Figure A4.2. Coexistence of GTS and Internet – common access router

Protecting the GTS links from the Internet

It is important that the exterior router(s), connected to both GTS and Internet links be securely passworded, and protected so that it may not be configured via the Internet. Additionally, no Internet traffic should be allowed to propagate down GTS links, nor GTS traffic be sent to the Internet unless specifically intended to do so. This can be achieved by carefully filtering routing updates.

There should be a definite separation between general Internet services (www/http, e-mail access) and the GTS system (e.g. Message Switch). They should be in separate machines. Additionally, use of firewalling technology should be undertaken to limit general Internet access to the GTS Centre internal network, possibly restricting incoming connections to SMTP on the mail server, HTTP on the web server and DNS on the Domain Name servers.

In between the exterior router and critical systems, a firewall should be deployed. This firewall must have the capacity to limit, proxy or redirect access to internal hosts in order to protect them. Several brands of firewall are on the market, with ranges of capabilities. In most cases because of the simple nature of the network in small centres, a simple firewall may be deployed.

When connecting to the Internet, deploying some sort of firewall is virtually mandatory. The risks for internal data and systems would justify this. In order to allow the access control some low-cost options are available.

Linux computers

Linux Operating system is free, and runs on a variety of hardware platforms, notably on PCs. The newest versions of Linux (Kernel version 2.2) come with firewalling software called ipchains. Additionally, they support routing protocols through a routing program called gated. Centres with some experience with UNIX will be able to get a working firewall setting up Linux from scratch.

Windows NT

A variety of commercial packages exist. The familiarity with the Windows and relatively low cost of PC hardware is seen as main advantage.

Free Toolkits

A company called TIS (Trusted Information Systems) has released a set of source code, mainly for UNIX/Linux hosts, which is freely available. This requires access to UNIX/Linux machines, compilers, and requires good knowledge of Internet security issues.

Routers

Many routers have packet filtering capabilities. It is possible to deploy one of these as firewall, although they aren't very flexible. Smaller centres may want to consider this.

Desirable solution

Some firewall vendors have been providing firewall solutions, based on their hardware. Cisco's IOS firewall is a notable example. This type of solution is depicted in Figure A4.3.
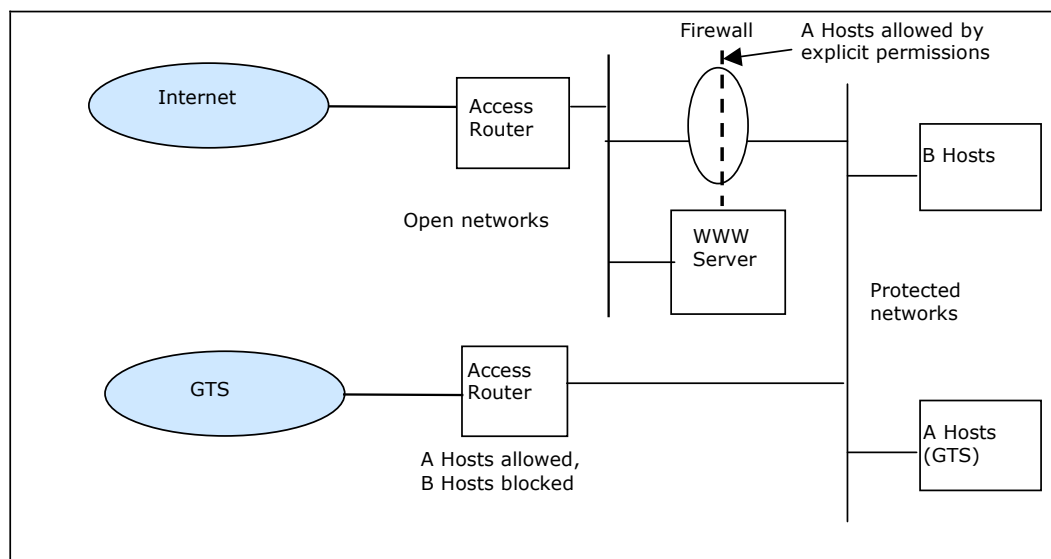
Figure A4.3. Coexistence of GTS and Internet – separate access routers plus firewall

GTS using the Internet

There will be situations where GTS centres will use Internet to transport data and products. Security concerns are also applicable here. The arrangement shown below in Figure A4.4 represents a simple and safe way to use the Internet to connect neighbouring GTS centres that may become popular in small centres in future. Firewalling is done using access lists.
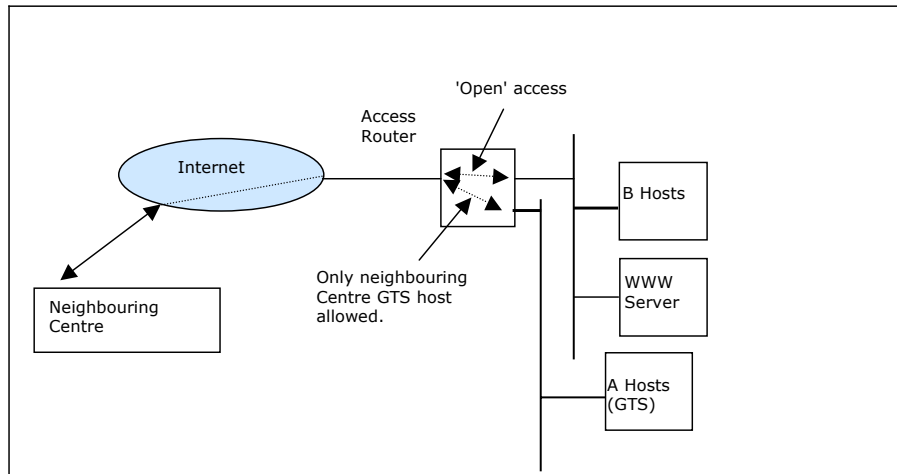
Figure A4.4. The use of Internet between neighbouring GTS Centres

Virtual private network – secure GTS connections over the Internet

A virtual private network (VPN) is a private network implementation among organizations to communicate over a publicly accessible network. VPN message traffic can be carried over the Internet on top of the standard TCP/IP protocols. Secure VPNs use cryptographic tunneling protocols to provide the sender authentication, message integrity and confidentiality to achieve privacy. This is considered suitable for use for the transmission and exchange of meteorological data among centres.

The most common Secure VPN protocol is IPSec. IPSec is designed to provide interoperable high quality, cryptographically-based security for IP. The set of security services offered includes access control, connectionless integrity, data origin authentication, protection against replays, as well as confidentiality.

IPSec is an end-to-end security protocol: all the functionality and intelligence of the VPN connection reside at the end points, either in a gateway or in the end-host. Through IPSec, it is possible to establish a tunnel between two gateways. An IPSec gateway would typically consist of an access router, a firewall or a VPN gateway on which the IPSec protocol is implemented. The IPSec gateway locates between the user's private network and the carrier's shared network.

IPSec tunnels are established dynamically and released automatically when they are not in use. To establish an IPSec tunnel, two gateways must authenticate themselves and define which security algorithms and keys they will use for the tunnel. The entire original IP packet is encrypted and wrapped inside IPSec authentication and encryption headers. Figure A4.5 shows an implementation of a VPN connection using IPSec between two GTS centres.
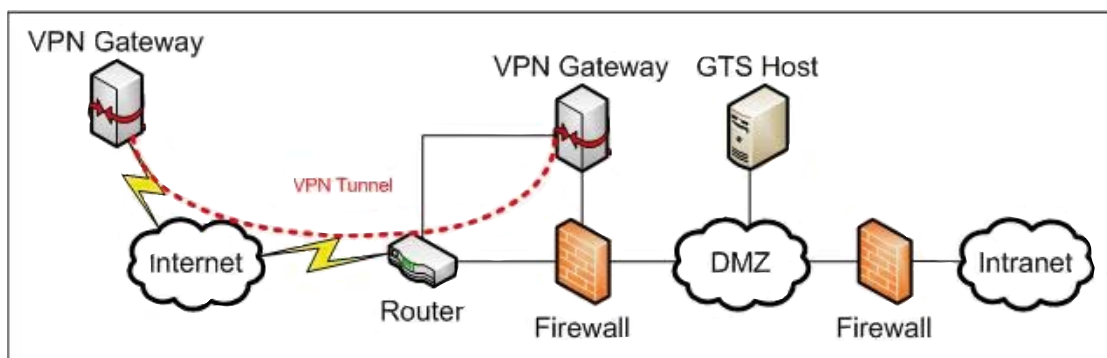

Figure A4.5. The use of VPN over the Internet to connect two GTS Centres

The VPN gateway is connected to a firewall and a router. The VPN gateway can establish a VPN tunnel with other VPN gateways through the interface of the router. The flow of traffic into the internal network will be through the firewall and will be controlled by an access list defined by the user.

IPSec makes use of the Authentication Header (AH) and the Encapsulation Security Payload (ESP) to achieve data integrity and confidentiality.

The most common encryption algorithm used in ESP is Triple Data Encryption Standard (3DES) and Advanced Encryption Standard (AES). They have encryption key sizes from 128 bits to 256 bits, providing sufficient protection for data traffic along the trunk.

Further details on VPN implementation can be found in the Guide on Virtual Private Network (VPN) via the Internet between GTS centres. This Guide is available on the WMO web page at http://www.wmo.int/web/pages/prog/manuals.html.

APPENDIX 5

REFERENCE MATERIAL

GENERAL REFERENCES ON TCP/IP

1. Internetworking TCP/IP Vol. 1 (2/E) – Douglas Comer – Prentice Hall
2. TCP/IP Illustrated Vol. 1. – Stevens – Addison-Wesley
3. TCP/IP Architecture, Protocols and Implementation – Feit – McGraw Hill
4. TCP/IP and Related Protocols - Black - McGraw Hill
5. TCP/IP Running a Successful Network – Washburn and Evans – Addison-Wesley
6. TCP/IP and ONC/NFS (2/E) – Santifaller – Addison-Wesley
7. Inside TCP/IP – Arnett et. al. – New Riders Publishing
8. Teach Yourself TCP/IP in 14 days – Parker – SAMS
9. Introduction to TCP/IP – Davidson – Springer

REFERENCES ON SECURITY

1. Firewalls and Internet Security – Cheswick & Bellovin – Addison-Wesley
2. Building Internet Firewall – Chapman – O'Reilly
3. Practical Unix Security – Garfinkel & Spafford – O'Reilly
4. Internet RFC 2196 (Site security Handbook)
5. http://www.computersecuritynow.com: a website with a lot of reference documents on implementing security

APPENDIX 6

SUGGESTED PASSWORD MANAGEMENT PRACTICES

Passwords are the system's first line of defence against unauthorized intrusion. While it is possible to violate system security without logging in, a poorly protected or chosen password can make a hacker's task a lot easier.

GOOD PASSWORDS:

1. Have both upper-case and lower case letters, and/or
2. Have digits and/or non-alphanumeric characters.
3. Are 6 to 8 characters long.
4. Should consist of at least 2 words or groups of characters.
5. Should not be shared or used by more than one user.
6. Should not be used on more than one computer.
7. Should be changed regularly, e.g. monthly.
8. Can be typed quickly and easily, so that an observer cannot follow the keystrokes.
9. Are easy to remember – so that they should not have to be written down. (e.g. use first letter of words in a well known phrase).

BAD PASSWORDS:

1. The name of: yourself, your spouse, your children, your parents, your pet, your friends, your favourite film stars/characters, anyone associated with you, your workstation or its host.
2. The number of: your telephone, your car's license plate, your user ID, any part of your credit cards' numbers, or any number associated with you.
3. The birthday of yourself or anyone associated with you.
4. Any word from any dictionary, any place name, any proper noun.
5. The name of a well known public identity such as a sporting hero, entertainer or well known fictional character.
6. Simple patterns: aaaaaaa, qwerty.
7. Any of 1 - 6 spelled backwards.
8. Any of 1 - 6 preceded or followed by a digit.
9. Any password that has been written down and left in an unlocked drawer or unsecured computer file.
10. Any password that has been on a machine that may have been successfully hacked (except as part of authorized exercises).
11. Any password on a machine that has been left unattended when any user is logged on.

APPENDIX 7

IP ADDRESSES FOR USE ON THE GTS

INTRODUCTION

The current "Recommended practices and procedures for the implementation, use and application of the Transmission Control Protocol/Internet Protocol (TCP/IP) on the GTS" (also known as "Guide on Use of TCP/IP on the GTS"), as given in this Attachment, describe guidelines and a procedure for assigning IP addresses to GTS links which are no longer adequate. In particular, it is stated that a number of official class C IP addresses were available through the WMO Secretariat to be assigned for GTS links. These sets of IP addresses are no longer officially available, as a consequence of a strict application of Internet standards (RFCs) by Internet Authorities and Services Providers, and unfortunately cannot be used on the GTS, as they may now be assigned to other organizations on the Internet. The WMO Secretariat has therefore been instructed to discontinue the assignment of such IP addresses.

The Expert Team on Communication Techniques and Structure (ET-CTS) has been tasked to provide alternate solutions to solve this issue.

This document is a provisional description of the available options and related guidance to mitigate this problem and assist Members in their implementation. The included guidelines only concern the IP addressing. They do not change the existing recommendations on how IP relates to X.25 or other IP functionality.

The ET-CTS will proceed with developing the proposed amendments to this Attachment to reflect the new recommended practices for allocating IP addresses.

WHO CAN PROVIDE OFFICIAL IP ADDRESSES?

In order to build a network that interconnects many organizations from various countries in the world, it is essential to maintain a standard in the addressing scheme, and to maintain uniqueness in the allocation of addresses to the various organizations. The Internet community has identified this basic principle and created some official bodies to coordinate the distribution of official IP addresses. Today, this responsibility belongs to the Internet Assigned Numbers Authority (IANA), and its regional delegates, the relevant Regional Internet Registries:

AfriNIC (African Network Information Centre) – Africa region
APNIC (Asia Pacific Network Information Centre) – Asia Pacific region
ARIN (American Registry for Internet Numbers) – Americas and Southern Africa
LACNIC (Regional Latin-American and Caribbean IP Address Registry) – Latin America and some Caribbean islands
RIPE NCC (Réseaux IP Européens Network Coordination Centre) – Europe and surrounding areas

These organizations further delegate the allocation of addresses to their regional Internet and telecommunications suppliers through national Internet registries.

In this scheme, it is not the WMO's responsibility to allocate IP addresses. Since the GTS is not built as a unique network under the complete authority of a single organization, the allocation of addresses must therefore go through the respective national Internet registry or the appropriate Regional Internet Registry.

However, several countries now face the issue of the restriction of allocation of IP version 4 (IPv4) addresses and may have difficulty obtaining official addresses. This problem is not an easy one to solve in the short term and provisional measures may have to be taken to allow the further development of the GTS. The following guidelines explain how to interconnect networks with and without the use of official IP addresses.

CONNECTING NETWORKS WITH OFFICIAL IP ADDRESSES

Using official IP addresses assigned directly to an organization (e.g. the NMS)

This remains the preferred option if it is feasible. It is basically the main procedure described in the existing "Guide on Use of TCP/IP on the GTS". It follows all the Internet rules and allows an organization to build a coherent network with interconnections to the Internet, GTS and possibly other partner organizations. It is also the easiest configuration to maintain.

In interconnecting two countries to form a GTS link, the two National Meteorological Services should decide which one actually provides the address to the interconnecting link. The decision remains one of practicality for the countries. There are no general rules that would favour one set of addresses over another one.

Using official IP addresses provided by a telecommunications supplier

This option is very similar to the previous one. The addresses supplied would be official and all the rules would of course be followed.

It may require that a common telecommunications supplier be used between the two interconnecting organizations.

This option however has the drawback that a change in telecommunication suppliers may require a change in IP addressing as original incumbent reclaims "his" addresses. Each organization should plan for this possibility ahead of time and evaluate its impact on future operations. If these addresses are only used for link purposes and not for an organization's internal purposes, then this drawback may be of minimal impact.

Using IP version 6 (IPv6) addresses

The new IP version 6 (IPv6) protocol standard was designed in great part to address the shortage of IPv4 addresses. Although the IPv6 protocol is available and supported in many telecommunication equipments available today, its implementation requires much planning. In particular, IPv4 and IPv6 are not compatible without the use of gateways and there are several operational tools still missing to make IPv6 usable for the GTS at this time. Converting to IPv6 would be a major task that can not be imposed on our members until the industry is ready to take this step as a whole.

This option is therefore not available today. It is only mentioned here for completeness and will be further studied over the next years.

CONNECTING NETWORKS WITHOUT OFFICIAL IP ADDRESSES

Using the "ip unnumbered" feature

Several network equipment suppliers (Cisco, 3Com, Juniper) have now introduced a feature in their configurations which allows the implementation of links without the need for allocation of IP addresses. This feature is usually called the "ip unnumbered" feature. For example, Cisco provides a document on "Understanding and Configuring the ip unnumbered Command" (see http://www.cisco.com/warp/public/701/20.html for details).

This feature is not a standard IP protocol feature, so it requires compatible equipment at both ends of the link to work (most frequent situation anyhow).

Routing between the two networks can be accomplished by binding the unnumbered interface to another existing interface in the router (either a real LAN or virtual loopback interface). The use of this feature may introduce limitations in routing flexibility.

Using RFC1918 – Addresses for private internets

The Internet Engineering Task Force (IETF) document "RFC1918 – Addresses for private internets" describes a set of addresses reserved for use by organizations for sole intra-enterprise communications, without any intention to ever directly connect to other enterprises or the Internet itself.

Therefore the use of these addresses does not require official registration. The main purpose of this scheme is to allow a big organization to make use of a larger address space for its internal operations. As soon as the organization needs to exchange with others, a gateway must be traversed to enter an area of officially assigned addresses to maintain overall network coherence. This gateway must translate the internal RFC1918 addresses into official external IP addresses, which must be obtained via the official bodies. The function (usually performed by a router or firewall) that does this translation is called Network Address Translation (NAT). This address translation will also have the effect of concentrating several RFC1918 internal addresses into a very small number of official addresses, thus preserving official address space.

Although this scheme might seem attractive at first for our issue, the GTS is not the network of a single enterprise. At this time, any number of the WMO Member NMHSs and related organizations may already make use of the RFC1918 in their own networks, which may result in conflicting address allocations if the networks interconnect. A recommendation from WMO for the use of RFC1918 is almost an impossible task, as the NMHSs may already be under guidelines of their own government, which might conflict with a directive of WMO. However, interconnecting countries may find adequate address space within RFC1918 in a bilateral agreement.

This option is therefore feasible as long as the following points are carefully considered, planned, maintained and monitored:

1. Great care should be taken in selecting a proper RFC1918 set of addresses for links between organizations. It is important that the selected addresses are not already in use by any of the involved organizations.
2. Great care should be taken to ensure that routing configurations do not allow the leaking of RFC1918 addresses into other organization's network or worse, into the Internet.
3. Although this solution will work quite satisfactorily between a few countries, it cannot be expanded to many directly interconnected countries, as the choice of RFC1918 addresses will get more and more complicated.
4. The IANA has reserved the following blocks in RFC1918.
    10.0.0.0 - 10.255.255.255 (10/8 prefix)
    172.16.0.0 - 172.31.255.255 (172.16/12 prefix)
    192.168.0.0 - 192.168.255.255 (192.168/16 prefix)
Since many organizations already use the 10.0.0.0/8 block internally and since the 192.168.0.0/16 block is often used as default addresses by several equipment manufacturers, it is recommended that GTS links be used out of the 172.16.0.0/12 block only if possible.
5. Furthermore, it is also recommended that the 172.16.0.0/12 be subnetted in a way to maximize the usage of the address space. To that effect, GTS links can be subnetted to /30 bits. This allows 4 hosts per link (leaving the hosts addresses 1 and 2 available to designate the 2 ends of a given link).
6. NMHS that consider using the RFC1918 addresses should consult with all potential NMHS with whom they might establish a link in order to coordinate and plan the use of these subnets ahead of time. In the case of address conflicts, other address schemes within RFC1918 might be used by bilateral agreement. The ET-CTS would like to be informed of such issues if they arise to further develop this recommendation.

The use of RFC1918 addresses should not introduce security problems as long as the above points are well managed.

RECOMMENDATION

All the options described above can be used in the GTS. The order of preference is as follows:

1. Using official IP addresses assigned directly to an organization, e.g. the NMHS (preferred).
2. Using official IP addresses provided by a telecommunications supplier.

3.   Using the "ip unnumbered" feature.
4.   Using RFC1918 – Addresses for private internets.

The use of IPv6 on the GTS is not recommended at this time.

It should be understood that all options that do not require official IP addresses are workarounds to mitigate the shortage of addresses and must be used with care.

CONFIGURATION EXAMPLES

Option 1 – Using existing organization (NMHS) official IP addresses or Option 2 – Using Telecommunication Supplier official IP addresses

This is the standard way to configure an interface between two networks.

Router A:
```
!
interface Ethernet0
ip address 131.238.17.11 255.255.255.0
!
interface Serial0
description 64Kbps leased line to router B
ip address 131.238.18.01 255.255.255.252
encapsulation ppp
bandwidth 64
!
ip route 142.47.43.0 255.255.255.0 131.238.18.2
!
```

Router B:
```
!
interface Ethernet0
ip address 142.47.43.201 255.255.255.0
!
interface Serial0
description 64Kbps leased line to router A
ip address 131.238.18.02 255.255.255.252
encapsulation ppp
bandwidth 64
!
ip route 131.238.17.0 255.255.255.0 131.238.18.1
```

ATTACHMENT II-16

PROCEDURES FOR TRANSMITTING AND COLLECTING METEOROLOGICAL BULLETINS ON THE INTERNET

A   USE OF ELECTRONIC MAIL (E-MAIL)

Background

Electronic mail (e-mail) can be a very simple and cost effective way to exchange meteorological bulletins, in particular for collecting meteorological data bulletins. It should be noted however that e-mail is not an end-to-end service and there is no guarantee of the timely delivery of messages. E-mail is also inherently insecure.

The following guidelines describe practices for sending both data collection bulletins and binary meteorological bulletins via e-mail while minimizing security issues.

Centres implementing this procedure should ensure that meteorological bulletins to be ingested in the GTS follow the standard GTS procedures and formats.

Format of messages for sending meteorological bulletins via electronic mail on the Internet

1. E-mail messages should use only International Alphabet No. 5. It is recommended that the meteorological bulletin should be contained in the main body of the e-mail message; as an option it may be contained in an attachment.

Note: 'Attachments' are a part of an e-mail message that are separate from the main body of the mail message, and that their display/storage is normally contingent upon some further action of the user.

2. It is recommended that only a single bulletin should be sent in each e-mail message. However, receiving centres may agree to accept multiple meteorological bulletins per e-mail message to a maximum of five.

3. The meteorological bulletin(s) can be sent either as text in the main body of the e-mail message, or in the attachment(s) of the e-mail message, but not in both. Binary data can only be sent in the attachment(s).

4. The main body of an e-mail message should follow the following format:
<Meteorological Bulletin>
NNNN

where,

<Meteorological Bulletin> is a standard meteorological bulletin starting with the abbreviated header line, such as

TTAAii CCCC YYGGgg [BBB]

message text

A termination string NNNN is required after every meteorological bulletin.

No other information should be included in the main body of the e-mail message unless agreed by the receiving centre. For example, automatic forward and reply informational text should not be allowed in the body of the message.

Note: The receiving centre shall validate the AHL before processing the meteorological bulletin.

5. The total size of all attachments should not exceed 2 MBytes or as specified in a bilateral agreement. Attachments should be coded in Base64 (MIME standard).

6. The e-mail header "Subject:" field either:
   (a) May contain the AHL if the e-mail message contains a single meteorological bulletin;
   (b) Or a pre-defined <security string>

Security considerations

1. E-mail is inherently insecure. To minimize security issues, all e-mail input should be pre-authorized by means of a list of valid source e-mail addresses at the receiving site. The receiving centre should only

process GTS-related e-mails from the pre-defined list of e-mail addresses. That is, the receiving centre should validate the e-mail message header "From:" field. To avoid problems with e-mail messages containing manipulated "From"-fields, centres may optionally agree to implement <security strings> in the message. If <security strings> are agreed on, and GTS message(s) are included in attachment(s), then the main body of the e-mail message can only contain the <security string>. The receiving centre should validate the "Subject"-field for the AHL or the pre-agreed string.

2.   No automatic acknowledgements or replies should be sent from the receiving centres.

3.   It is recommended to use specific mail accounts for GTS data transfer with bilaterally agreed names and not to receive GTS data in personal mailboxes.

4.   A problem with some mail exchanger applications is that by default they operate as an "open-relay". An open-relay occurs, for example, if site A.COM accepts mail from B.NET destined for C.ORG. This means that spammers can use A.COM's mail system to distribute their e-mails. Centres should ensure that they do not operate as an open-relay.

Example

From: NMCAAAAA <NMCAAAAA@meteo.fr>
To: RTHcollector <RTHcollector@meteo.zz>
Subject: SMFW01 NWBB 270000

Information which is part of the e-mail header

SMFW01 NWBB 270000
AAXX 27004
91753 32481 51008 10331 20259 40078 58017 83202
   333 20263 59018 83816 84078=
91754 01581 51812 10287 20245 40092 58017 60034 70182 85200
   333 20256 59016 60017 85820=
NNNN

Text in the main body of the e-mail message or in the attachment

B   USE OF WEB DATA INGEST

Background

This procedure is intended for use as a simple data collection mechanism by an NMC. It may also be used by an RTH or NMC to ingest meteorological bulletins in the event of failure of a primary access method. This method is expected to have better security, timeliness and reliability than e-mail ingest.

Preliminary requirements

The data provider that intends to send data to an RTH or NMC that offers the Web-based ingest service shall first establish an account with that centre. An authentication mechanism (such as a USERID and PASSWORD combination) shall be established for security purposes. Validating the sending IP address is impractical in most cases due to the routine translating of addresses and the nature of the possible backup scenarios.

Input

The user shall input all mandatory fields in the abbreviated header and input the body of the message. For mandatory fields, drop-down-lists may be provided to reduce the possibility of errors. The body of the message shall conform to WMO standards.

Validation

The Web Bulletin Input Interface should provide a fill-in-the-blank area for a single GTS abbreviated heading line. It should confirm that:

(a) All mandatory fields have been filled with valid information;
(b) All optional fields either have valid information or are left blank;
(c) The CCCC field is valid for the authenticated user of the sending centre;
(d) There will be only one bulletin created per Web page entry;
(e) The resulting abbreviated heading line follows all appropriate WMO standards, such as proper alphabet code and proper termination sequences.

Content verification

Before the completed message is ingested, the Web bulletin input interface should display the entire message to the user and ask for confirmation that message is correct. The creator of the message should be given an opportunity to change the message before submission.

Security

For additional security, the use of HTTPS is recommended.

Examples of implemented Web Bulletin Input Pages:

RTH Washington with URL: http://www.nws.noaa.gov/tg/bullguid.html

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PART III

TECHNICAL CHARACTERISTICS AND SPECIFICATIONS OF THE GLOBAL TELECOMMUNICATION SYSTEM

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1. CIRCUIT CHARACTERISTICS OF THE MAIN TELECOMMUNICATION NETWORK

1.1 **The configuration of the Main Telecommunication Network shall be an integrated ensemble of circuits and centres/hubs forming a meshed network. It shall operate on a round-the-clock basis.**

1.2 The World Meteorological Centres and the designated Regional Telecommunication Hubs shall be the centres/hubs of the Main Telecommunication Network.

1.3 **The circuits of the Main Telecommunication Network shall be implemented by using efficient telecommunication services and facilities, including digital- or analogue-dedicated leased circuits, frame relay services and managed data-communication network services, based on relevant ITU-T Recommendations.**

1.4 **Analogue-dedicated leased circuits (i.e. telephone-type circuits) shall be operated with modems in conformity with relevant ITU-T Recommendations.** Modems in conformity with ITU-T Recommendation V.34 are recommended.

1.5 Additional low-speed channels, including a backward supervisory channel, may be established in both directions of a full duplex circuit by agreement between centres/hubs.

1.6 **Where a circuit of the Main Telecommunication Network is of necessity, an HF radio circuit, separate 3-kHz channels for data and facsimile transmissions shall be provided.**

1.7 **HF radio circuits shall be provided with at least two 3-kHz channels.** Where required and technically practicable, up to four 3-kHz channels may be used on HF radio circuits in accordance with ITU-R recommendations.

1.8 **The number of 3-kHz channels required in the radio circuit in order to transmit meteorological information in accordance with the required transit times and relevant times of transmission to meet agreed WMO requirements shall be as agreed bilaterally by the related centres.**

2. ENGINEERING OF WMCs AND RTHs ON THE MAIN TELECOMMUNICATION NETWORK

WMCs and RTHs on the Main Telecommunication Network shall be capable of operating as a node on the MTN and of providing the necessary gateway functions with the relevant regional meteorological telecommunication network.

3. REGIONAL NETWORKS

Regional networks developed by regional associations shall be compatible with the system characteristics (engineering, circuit, transmission) of the Main Telecommunication Network. Compatibility shall be essential, particularly to ensure an efficient flow of traffic over the GTS.

4. NATIONAL NETWORKS

National networks should be developed so as to ensure an efficient flow of traffic over the GTS within the specified time limits.

5. TECHNICAL CHARACTERISTICS OF EQUIPMENT FOR METEOROLOGICAL FACSIMILE (ANALOGUE) TRANSMISSIONS

5.1 Characteristics of the equipment

The technical characteristics given below shall be applied to meteorological facsimile (analogue) transmission facilities used in the international exchange of pictorial information.

5.1.1   Scanning direction

Viewing the document area in a vertical plane, the scanning line direction shall be from left to right, commencing in the left-hand corner at the top of the picture area and finishing in the lower right-hand corner. Each scan shall be adjacent to, and below, the previous scan.

5.1.2   Index of cooperation (IOC)

The index cooperation (M) shall be defined by the formula:

$$M = \frac{LF}{\pi}$$

where L is the length of the scanning line and F is the scanning density (or number of lines per unit length).

Note: The product LF is called factor of cooperation. It is essential to specify the index of cooperation in order to ensure compatibility between the transmitter and the recorder. These may have the scanning lines of different length but if the index is the same, the document will be received without distortion.

The standard index of cooperation shall be 576 or 288.

5.1.3   Dimensions of the equipment

The equipment should be able to accommodate at least documents of 420 x 594 mm, with reference base ISO Format A.2.

5.1.3.1   *Equipment with flat-bed scanning*

The total scanning line length (active sector plus dead sector) shall normally be 477.5 mm.

5.1.3.2   *Equipment with drum scanning*

The diameter of the drum shall be 152 mm. The usable length of the drum should be at least 660 mm.

5.1.3.3   *Dead sector*

The dead sector (that portion of the scanning line which cannot be used for picture signal transmission) shall be 4.5% ± 0.5% of the line scanning length.

The signal transmitted during the passage of the dead sector should, for the most part, correspond to white, but transmission of a black pulse within and not exceeding one half length of the dead sector is permissible.

5.1.4   Scanning line density

The scanning line density is found from the definition of index of cooperation and shall be nominally equal to:

3.8 lines/mm (index 576) and

1.9 lines/mm (index 288).

5.1.5   Scanning frequency

The scanning line frequency, or drum speed, shall be:

60 lines per minute (60 rpm);

90 line per minute (90 rpm);

120 lines per minute (120 rpm);

240 lines per minute (240 rpm).

The scanning line frequency, expressed in lines per minute or revolutions per minute, shall be maintained within $\pm\ 5.10^{-6}$ its nominal value.

Note: This tolerance allows a maximum oblique skew of approximately 1/55 when transmitter and receiver function with combined effect at opposite maximum deviation limits. A smaller tolerance is very desirable so as to reduce maximum oblique skew.

5.2 Remote control signals

5.2.1 Starting device of receiving equipment

Receiving equipment shall be designed to start upon receipt of either the IOC-selection signal (section 5.2.2 below) or the phasing signal (section 5.2.3 below). No other starting signal shall be transmitted.

5.2.2 Selection of index of cooperation

5.2.2.1 The index of cooperation shall be selected by transmission of alternating black and white signals lasting 5–10 s, with frequency:

300 Hz for IOC 576;
675 Hz for IOC 288 (or IOC 576 with alternate line scanning).

5.2.2.2 The envelopes of the signals transmitted shall be approximately rectangular.

5.2.3 Phasing and selection of line scanning frequency (or drum speed)

5.2.3.1 Phasing and selection of line scanning frequency shall be accomplished by a 30-second transmission of alternating white and black signals with the following frequencies:

1.0 Hz for   60 lines per minute (60 rpm);
1.5 Hz for   90 lines per minute (90 rpm);
2.0 Hz for 120 lines per minute (120 rpm);
4.0 Hz for 240 lines per minute (240 rpm).

5.2.3.2 The wave-form should be either symmetrical, i.e. white and black, each lasting half the scanning line, or asymmetrical with the white lasting for 5% and black for 95% of the scanning line.

5.2.3.3 Members publishing details of their facsimile transmissions shall include the description of the wave-form (symmetrical or asymmetrical) of the phasing signal transmitted.

5.2.3.4 Phasing shall be actuated by the leading edge of the white signal. This leading edge shall correspond in phase with the entry of the scanning beam into the dead sector of the net transmission.

5.2.3.5 The envelopes of the signals transmitted shall be approximately rectangular.

5.2.4 Adjustment of recording levels

Automatic adjustment of recording levels, when used, should be effected by reference to the phasing signal (section 5.2.3 above).

5.2.5 Stopping device of receiving equipment

5.2.5.1 The stop signal shall be a five-second transmission of alternating black and white signals at 450 Hz, followed by 10 seconds of signal corresponding to continuous black.

5.2.5.2 The envelopes of the 450 Hz signals shall be approximately rectangular.

5.2.6 Frequency precision of remote control signals

The tolerance for the remote control signals shall be ± 1% for frequencies.

5.3 Modulation characteristics

5.3.1 The modulation characteristics for facsimile (analogue) transmissions shall be as follows:

5.3.1.1 *Amplitude modulation (AM)*

The maximum amplitude of the carrier frequency shall correspond to the transmission of black.

Value of the carrier frequency:

About 1800 Hz for 60, 90 and 120 lines per minute (60, 90 and 120 rpm);
About 2600 Hz for 240 lines per minute (240 rpm).

For 240 lines per minute (240 rpm), transmissions shall be carried out with the vestigial side-band system, with the possible use of an asymmetric filter for transmission.

5.3.1.2 *Frequency modulation (FM)*

Mean frequency	1 900 Hz;
Frequency for black	1 500 Hz;
Frequency for white	2 300 Hz.

The frequencies for black and white shall vary by not more than 8 Hz over a period of 30 seconds and by not more than 16 Hz over a period of 15 minutes.

5.3.2 Power at the transmitter output

For AM transmissions it shall be possible to adjust the power of the "black" signal at the output of the transmitter to between –7 dBm and 0 dBm.

For FM transmissions it shall be possible to adjust the output level of the transmitter to between –10 dBm and 0 dBm.

Whatever the transmission mode used (AM or FM), the contrast ratio for control signals and for black and white picture signals shall be the same and shall be between 12 and 25 dB.

5.3.3 Power at the receiver input

For AM transmissions receiving equipment shall be designed to accept any level between 0 and –25 dBm, this being the level of the "black" signal.

For FM transmissions the input level shall be between 0 and –35 dBm.

5.4 Transmission of intermediate tones (analogue facsimile)

5.4.1   A linear distribution should be observed for the transmission of intermediate tones, on the basis of a number of tones equal to eight, including the "black" and "white" levels.

5.4.2   For amplitude modulation a dynamic range of 20 dB should be observed as follows:

0 dB; –1.2 dB; –2.6 dB; –4.2 dB; –6.3 dB; –9 dB; –13 dB; –20 dB.

5.4.3   For frequency modulation the following distribution should be observed:

1 500, 1 614, 1 729, 1 843, 1 957, 2 071, 2 186, 2 300 Hz.

5.5 Facsimile (analogue) transmission over radio circuits

5.5.1   When frequency modulation of the sub-carrier is employed for the facsimile (analogue) transmission over radio circuits, the following specifications shall apply;

Centre frequency	1 900 Hz;
Frequency corresponding to black	1 500 Hz;
Frequency corresponding to white	2 300 Hz.

5.5.2   When direct frequency modulation (FSK) is employed for the facsimile (analogue) transmission of pictorial information over radio circuits, the following specifications shall apply:

(a) HF (decametric) circuits (3 MHz–30 MHz)
Centre frequency (corresponding to the assigned frequency):	f_o
Frequency corresponding to black:	f_o –400 Hz;
Frequency corresponding to white:	f_o +400 Hz;

(b) LF (low-frequency) circuits (30 kHz–300 kHz)
Centre frequency (corresponding to the assigned frequency):	f_o
Frequency corresponding to black:	f_o –150 Hz;
Frequency corresponding to white:	f_o +150 Hz.

6.   TECHNICAL CHARACTERISTICS OF EQUIPMENT FOR CODED DIGITAL FACSIMILE TRANSMISSIONS

6.1   The technical characteristics given below shall be applied to meteorological coded transmission facilities used for international exchange of pictorial information.

6.1.1   Scanning track

          The message area shall be scanned in the same direction in the transmitter and receiver. Viewing the message area in a vertical plane, the picture elements should be processed as if the scanning direction were from left to right with subsequent scans adjacent to and below the previous scan.

6.1.2   Preferred standard

6.1.2.1   **The following provisions, based on ITU-T Recommendation T.4–Standardization of Group 3 facsimile apparatus for document transmission, applying to an ISO A4 document shall be used:**

(a) **1 728 picture elements along the scan line length of 215 mm ± 1%;**
(b) **A normal resolution and a higher resolution of 3.85 lines/mm ± 1% and 7.7 lines/mm ± 1%, respectively in a vertical direction;**
(c) **A coding scheme as defined in ITU-T Recommendation T.4, paragraph 4.1.**

6.1.2.2   In addition to the basic A4 format specified in paragraph 6.1.2.1, the following characteristics may be used:

(a) Useful line length: 456 mm;
(b) Number of picture elements per line: 1 728, 3 456;
(c) Horizontal resolution: 3.79, 7.58 lines/mm;
(d) Vertical resolution: (1) 3.79 lines/mm (IOC 576);
                                                  (2) 1.89 lines/mm (IOC 288).

6.1.3   Other standards

          The ITU-T Group 4 (G4) standards (Recommendation T.6) may be used as required.

6.1.4   Transmission rate

          The transmission rate over a point-to-point circuit shall be: 2 400, 4 800, 7 200, 9 600 bit/s.

7.   TECHNICAL CHARACTERISTICS FOR THE EXCHANGE OF NON-CODED DIGITAL FACSIMILE

7.1   For the transmission of non-coded digital facsimile the terminal transmitting and receiving equipment should comply with WMO standards for analogue facsimile, using analogue-to-digital converters.

7.2   The remote control signals should conform to the WMO standard (section 5.2 above) and be transmitted through direct conversion into digital form.

7.3   At the ITU-T V.24 interface between analogue-to-digital converters and modems, black picture elements should be coded as bit set to 0 and white picture elements as bit set to 1, according to the following table:

Significant voltage levels in conformity with ITU-T V.28	$V_1 < -3$ volts	$V_1 > +3$ volts
Binary state	1	0
Condition	OFF/mark	ON/space
Picture element	White	Black

7.4   The scanning frequency, index of cooperation and data signalling rate on a discrete channel should be as follows:

Scanning frequency signalling (lines/min)	Number of picture elements in a full line	IOC	Date rate (bit/s)
60	2 400	288	2 400
120	1 200	288	2 400
240	1 200	288	4 800
60	2 400	576	2 400
120	2 400	576	4 800
240	1 800	576	7 200

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