INTERNATIONAL TELECOMMUNICATION UNION

CCITT

THE INTERNATIONAL
TELEGRAPH AND TELEPHONE
CONSULTATIVE COMMITTEE

YELLOW BOOK

VOLUME II - FASCICLE II.3

INTERNATIONAL TELEPHONE SERVICE

NETWORK MANAGEMENT, TRAFFIC ENGINEERING

RECOMMENDATIONS E.401-E.543

VIITH PLENARY ASSEMBLY
GENEVA, 10-21 NOVEMBER 1980

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[1] "Telematic services" is used provisionally.

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[1] "Telematic services" is used provisionally.

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Part I – Recommendations E.401 to E.427

International telephone network management and checking of service quality

Part II – Recommendations E.500 to E.543

Traffic engineering

MODIFICATIONS TO THE SERIES E RECOMMENDATIONS

1 *Reorganization of Volume II.2*

Volume II.2 of the *Orange Book*, (Geneva, 1977) has been divided into two fascicles in the *Yellow Book*:

– Fascicle II.2 – International telephone service; Operation. (Recommendations E.100 to E.323 and Supplements 1 to 6.)

– Fascicle II.3 – International telephone service; Network management and Traffic engineering. (Recommendations E.401 to E.543 and Supplements 1 to 7.)

2 *Modifications to the list of contents of the Series E Recommendations*

2.1 The following Recommendations and Supplements did not appear in Volume II.2 of the *Orange Book*, and are for the most part, new:

Recommendations

E.122	E.210
E.130	E.211
E.132	E.426
E.182	E.427
E.200	E.543

Supplements

– in Fascicle II.2: Supplement No. 6

– in Fascicle II.3: Supplement No. 5
Supplement No. 6
Supplement No. 7

2.2 The following Recommendations and Supplements, which appeared in Volume II.2 of the *Orange Book*, have been revised in the Study Period 1977-1980:

Recommendations

E.100 [1]	E.163 (E.161) [2]
E.115	E.171
E.120 (E.113)	E.180
E.121 (E.130)	E.181
E.123 (E.162)	E.410
E.125 (E.425)	E.421
E.131 (E.165)	E.422
E.141	E.500
E.149	E.502
E.150 (E.402)	E.541
E.161	

Supplements

– in Fascicle II.2: Supplement No. 1 (No. 10)
Supplement No. 5 (No. 9)

Note – The number in parentheses indicates a change in the numbering of the Recommendation or Supplement, and refers to the previous number in Volume II.2 of the *Orange Book*.

2.3 The following Recommendations, which were included in Volume II.2 of the *Orange Book*, have been deleted from the Series E Recommendations and transferred to the Series D Recommendations in the *Yellow Book* (Fascicle II.1). The appropriate Series D Recommendations are shown in parentheses:

E.118	(D.9)	E.271	(D.171)
E.200	(D.100)	E.272	(D.172)
E.201	(D.101)	E.273	(D.173)

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1) Teletraffic definitions (§§ 18 to 22) were transferred to the new Supplement No. 7 in Fascicle II.3.

2) The revision of Recommendation E.161 resulted in its division into two separate Recommendations, E.161 and E.163.

E.205 (D.105)	E.275 [3] (D.190)
E.206 (D.106)	E.276 [3] (D.176)
E.207 [3] (D.174)	E.290 R (D.390)
E.250 [3] (D.150)	E.291 R (D.391)
E.251 [3] (D.151)	E.292 R (D.392)
E.252 [3] (D.152)	E.330 (D.180)
E.270 [3] (D.170)	

2.4 The following Recommendations and Supplement appearing in Volume II.2 of the *Orange Book* have been discontinued and do not appear in the *Yellow Book*:

Recommendations

E.501 [4]

E.542 [5]

Supplement

No. 3

2.5 The following Recommendations and Supplements appearing in Volume II.2 of the *Orange Book*, have been renumbered in the *Yellow Book*, but have been otherwise unaltered. The number in parentheses refers to the numbering in Volume II.2 of the *Orange Book*:

Recommendations

E.230 (E.202)	E.277 (E.207)
E.231 (E.203)	E.151 (E.208)
E.232 (E.204)	

Supplements

– in Fascicle II.2 : Supplement No. 2 (No. 4)
Supplement No. 3 (No. 5)
Supplement No. 4 (No. 6)

– in Fascicle II.3 : Supplement No. 1 (No. 1)
Supplement No. 2 (No. 2)
Supplement No. 3 (No. 7)
Supplement No. 4 (No. 8)

REMARK

The Questions entrusted to each Study Group for the Study Period 1981-1984 can be found in Contribution No. 1 to that Study Group.

CCITT NOTE

In this fascicle, the expression "Administration" is used for shortness to indicate both a telecommunication Administration and a recognized private operating agency.

3) Only the titles of these Series E Recommendations have been retained, while the texts have been transferred to the Series D Recommendations.

4) Relevant text of Recommendation E.501 has been included in Recommendation E.500.

5) Relevant text of Recommendation E.542 has been included in Recommendations E.410 and E.541.

PART I

Recommendations E.401 to E.427

INTERNATIONAL TELEPHONE NETWORK MANAGEMENT AND CHECKING OF SERVICE QUALITY

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SECTION 1

INTERNATIONAL SERVICE STATISTICS

Recommendation E.401

STATISTICS FOR THE INTERNATIONAL TELEPHONE SERVICE (NUMBER OF CIRCUITS IN OPERATION AND VOLUME OF TRAFFIC)

(Statistics exchanged by Administrations)

Administrations exchange each year, *in February*, statistics showing the number of circuits used and the volume of traffic monitored in the preceding year, as well as estimates of the number of circuits which will be required three years and five years later. These statistics shall be drawn up in the form indicated below.

A copy of the statistics shall be sent to the CCITT Secretariat for information.

ANNEX A

(to Recommendation E.401)

How to fill in the table on international telephone traffic statistics

Column 1	Designation of the connection by giving the name of the outgoing exchange first and then the name of the incoming exchange. Two-way connections will be shown in alphabetical order.
Columns 2 and 3	Number of circuits in operation as on *31 December* of the year of the statistics. The number will be shown in column 2 when it refers to outgoing circuits and in column 3 when it refers to both-way circuits.
Columns 4 and 5	Number of circuits which would have been required during the year of the statistics.
Column 6	Method of operation. The following abbreviations will be used: A for automatic, SA for semiautomatic, M for manual, A + SA for automatic and semiautomatic.
Column 7	Destination of traffic. Each relation will be shown in this column on a separate line. In the example given, the traffic routed over the Zürich-København circuits is destined for Denmark (terminal), Sweden, Norway and Finland (transit). In this case, the data for each destination will be shown in columns, 8, 9, 10 and 11. The total traffic figure, however, should not be omitted. These data will be bracketed together. If the connection handles traffic only to the country in which the incoming exchange is situated, only the word "terminal" will appear in column 7.

Columns 8 and 9 — Busy-hour traffic, expressed in *erlangs*. (See Supplement No. 7 at the end of this fascicle.)

The traffic measured during the busiest month of the year of the statistics is given in column 9. For two-way circuit groups the total amount of incoming and outgoing traffic should be given. In column 8 the month of the year during which the traffic was measured should be indicated in roman numerals.

Column 10 — Busy hour (UTC).

This refers to the busy hour as defined in Supplement No. 7 at the end of this fascicle.

Column 11 — Annual increase, in %. Each Administration should insert in this column the annual traffic increase rate with respect to the previous year.

Columns 12 and 13 — Columns 12 and 13 should show the estimated number of circuits required to route traffic in three and five years' time, respectively. For example, if the statistics relating to 1982 are drawn up in February 1983, column 12 will give the estimated number of circuits required in 1986 and column 13 those required in 1988.

International telephone traffic statistics

Year: ....

Circuits	Number of circuits in service		Number of circuits required		Method of operation	Destination of traffic	Busy-hour traffic		Start of busy-hour (UTC)	Annual traffic increase	Estimated number of circuits		Observations
	Outgoing	Both-way	Outgoing	Both-way			Month	Erlangs			In three years	In five years	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
(Examples)													
Zürich-København	24	—	20	—	SA	Terminal	X	8	10.00	15%			
						Sweden [a]	X	4	10.15	12%			
						Norway	X	2	09.45	13%			[a] Overflow traffic on Zürich-Stockholm connection
						Finland	X	1	10.30	7%			
						Total	X	15	10.00	14%	28	32	
Zürich-Stockholm	12	—	11	—	SA	Terminal	IX	5.5	10.15	12%	13	15	

SECTION 2

INTERNATIONAL NETWORK MANAGEMENT

Recommendation E.410

INTERNATIONAL NETWORK MANAGEMENT – PLANNING AND OPERATING PROCEDURES

1 Introduction

1.1 *General*

In recent years the demand for international telephone service has increased substantially. This demand has been met by advances in both technology and operational techniques. The growth of traffic has also required the development of larger international transmission systems and switching centres to provide economically the capacity to meet the required grades of service.

A number of localized events arise which have a detrimental effect on the management of the international telephone service. Among such events are:

- failures of international or national transmission systems,
- total or partial failures of international or national switching centres,
- planned outages of transmission systems and switching centres, which affects service,
- abnormal increases in traffic demand. The events which give rise to such traffic demand may be foreseen (e.g. national holidays, international sporting events) or unforeseen (for example, natural disasters, political crises),
- difficulties in meeting the requirements of international traffic resulting from, for example, delays in the provision of additional circuits or equipment.

These events lead to congestion which, if uncontrolled, may spread and thus degrade the service in other parts of the international network. Considerable benefits can be derived for the international network as a whole if prompt action is taken to control the effect on service of such localized events.

With the continuing growth of the international automatic service, direct supervision and control over telephone traffic has decreased since operators are no longer involved in establishing the majority of calls. Alternative means must therefore be provided to supervise and, where necessary, control the traffic carried by the automatic telephone network.

The above considerations have led to the concept of "international network management", which encompasses all the activities necessary to reduce the effect on service of any situations affecting unfavourably the international telephone network.

1.2 *Definition of* **international network management**

F: gestion du réseau international

S: gestión de la red internacional

International network management is the function of supervising the international network and taking action to control the flow of traffic so as to ensure the maximum utilization of the network in all situations.

Network management requires "real-time" monitoring and measurement of network status and performance, and the ability to take prompt action to control the flow of traffic when necessary.

1.3 *Objective of international network management*

The objective of international network management is to enable as many calls as possible to be successfully completed. This objective is met by maximizing the use of all available equipment and facilities in any situation which may occur by, for example, the following means:

- utilizing all available international circuits (for example, by exploiting idle capacity due to time zone differences);
- keeping all available international circuits filled with traffic which has a high probability of resulting in effective calls;
- when all available international circuits are in use, giving priority to calls requiring a minimum number of international circuits to form a connection (for example, where direct circuits are available to a particular destination, by inhibiting traffic from using routings involving two or more international circuits in tandem),
- restricting switching congestion and preventing its spread.

Note – International network management requires that the international network be adequately engineered to meet the normal levels of traffic, the requirement for which is described in Recommendations E.171 [1], E.510, E.520, E.522, E.540 and E.541.

1.4 *Network management functions*

The following are considered to be the main functions of international network management:

a) monitor the status and performance of the international network on a real-time basis;

b) collect and analyze network performance data; [1)]

c) detect abnormal network conditions;

d) investigate and identify the reasons for abnormal network conditions; [1)]

e) initiate corrective action and/or control; [1)]

f) cooperate and coordinate actions with other centres, both domestic and international, on matters concerned with international network management and service restoration;

g) issue reports of abnormal network situations, actions taken and results obtained to higher authority and other involved departments and Administrations, as required;

h) provide advance planning for known or predictable network situations.

1.5 *Benefits derived from international network management*

Among the benefits to be derived from international network management are:

1.5.1 Service to the customer is improved. This can lead, in turn, to:

- improved customer relations,
- stimulation of customer calling rate,
- increased revenue.

1.5.2 More efficient use of the planned international network. This can result in:

- an improvement in the ratio of effective to ineffective calls,
- an increased return on the capital invested in the international network.

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1) These functions are covered by network analysis points and network management points as described in Recommendations M.720 [2] and M.722 [3].

1.5.3 Greater awareness of the actual status and performance of the international network. Such awareness can lead to:

- a basis by which network management and maintenance priorities can be established,
- improved network planning information,
- improved information on which future capital investment in the international network can be decided.

1.5.4 Protection of essential services at all times and particularly during "catastrophic" network situations.

2 Information requirements

2.1 Network management requires information of where and why difficulties are occurring or are likely to occur in the network. This information is essential to identify the source and effect of a difficulty at the earliest possible time, and will form the basis for any network management action which is taken.

2.2 The information relating to current difficulties can be obtained from:

a) real-time surveillance of the status and performance of the network as detailed in § 3;

b) feedback from telephone operators as to where they are experiencing difficulties;

c) transmission system failure and planned outage reports (these reports need not relate to just the network local to one Administration, but should reflect the whole international network);

d) international or national switching centre failure and planned outage reports;

e) news media reports detailing unforeseen events which stimulate traffic (for example, natural disasters).

2.3 The information relating to difficulties which are likely to occur in the future will be obtained from:

a) reports of future planned outages of transmission systems,

b) reports of future planned outages of international or national switching centres,

c) knowledge of special events (for example, international sporting events, political elections),

d) knowledge of national holidays and festivals (e.g. Christmas Day, New Year's Day).

2.4 The system availability information point, defined in Recommendation M.721 [4], will provide a ready source for much of the information indicated above.

3 Data collection and processing

3.1 In order to identify difficulties as they occur in the network and to supervise the effect of any network management action which may have been taken, data will be required which will measure the performance and indicate the status of the network. Such data will require real-time collection and processing.

3.2 The status data should relate to the following:

- switching centre equipment status,
- status of all routes available to each destination,
- status of circuits on each route.

Status information should be provided to show:

a) when the available network is fully utilized, by indicating:

- when all circuits on a route are busy,
- when all routes available to a destination are busy.

This would indicate that congestion is imminent.

b) the availability of the network for service, by indicating, for example:

- the percentage of circuits on each route that are available for service,
- the percentage of key items of common control equipment that are available for service.

This information could highlight a cause of difficulty or give advanced warning that difficulties will arise as the demand for these items increased.

3.3 The performance data should relate to the following:

- switching centre equipment performance,
- traffic performance on each route,
- traffic performance to each destination.

This data is derived from bids, seizures, answer signals, clears and the times of their occurrence (see Annex A for the definitions of these terms). Data can be collected by various devices ranging from electromechanical counters read manually when required (e.g., during periods of heavy traffic or special events) to more sophisticated equipment which provide data automatically.

Data collection should be based on a system of measurement which is either continuous or of sufficiently rapid sampling rate to give the required information. For example, for common equipment the sampling rate may need to be as frequent as every second.

3.4 The performance data is generally expressed in parameters which assist the identification of difficulties in the network. Among these parameters are:

3.4.1 **percentage overflow (% OFL)**

F: pourcentage de débordement (% DBM)

S: porcentaje de desbordamiento (% DBM)

% OFL indicates the relationship between the total bids offered to a route or destination, in a specified period of time, and the quantity of bids not finding a free circuit. It will, therefore, give an indication of the overflow from one route to another, or the bids which fail due to all routes to a destination being busy.

$$\% \text{ OFL} = \frac{\text{Overflow bids one route to another (or to busy signal)}}{\text{Total bids for the route (or all routes)}} \times 100$$

3.4.2 **bids per circuit per hour (BCH)**

F: tentatives de prise par circuit et par heure (TCH)

S: tentativas de toma por circuito y por hora (TTCH)

BCH is an indication of the average number of bids per circuit, in a specified time interval. It will therefore identify the demand and, when measured at each end of a both-way operated route, will identify the direction of greater demand.

$$\text{BCH} = \frac{\text{Bids per hour}}{\text{Quantity of circuits available for service}}$$

It is not necessary to accumulate data for an hour to compute BCH.

3.4.3 **answer seizure ratio (ASR)** [2)]

F: taux de prises avec réponse (TPR)

S: tasa de tomas con respuesta (TTR)

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2) ASR is the same as "efficiency rate".

ASR gives the relationship between the number of seizures that result in an answer signal and the total number of seizures. This is a direct measure of the effectiveness of the service being offered and is usually expressed as a percentage as follows:

$$ASR = \frac{\text{Seizures resulting in answer signal}}{\text{Total seizures}} \times 100$$

Measurement of ASR may be made on a route or on a destination code basis.

3.4.4 **seizures per circuit per hour (SCH)**

F: prises par circuit et par heure (PCH)

S: tomas por circuito y por hora (TCH)

SCH is an indication of the average number of times, in a specified time interval, that each circuit in a route is seized. When related to the expected values of average call holding times and effective call/seizure rate for the route, it will give an indication of the effectiveness of the service being offered.

$$SCH = \frac{\text{Seizures per hour}}{\text{Quantity of circuits available for service}}$$

It is not necessary to accumulate data for an hour to compute SCH.

3.4.5 **occupancy**

F: occupation

S: ocupación

Occupancy can be represented in many units [for example, erlangs, hundred-call-seconds (CCS)] or as a percentage. It can be measured as a total for a destination or for a route and as an average per circuit on a route. Its use for network management purposes is to show usage and to identify unusual traffic levels. When measured at each end of a both-way operated route, it will normally identify the direction of greater demand.

3.4.6 **mean holding time per seizure**

F: durée d'occupation moyenne par prise

S: tiempo medio de ocupación por toma

This is the total holding time divided by the total number of seizures and can be calculated on a route basis or for switching equipment.

3.4.7 *Common control equipment and switching unit performance*

These parameters have not yet been identified. They will depend on the switching technology employed by each Administration. However, the type of performance data required will fall into the following categories:

- load measurements, for example: bid and occupancy data for key switching equipment,
- delay measurements, for example: measurements of bids encountering delay in accessing common control switching equipment,
- switching loss measurements. Switching losses may be due to internal conditions in the switching equipment itself (for example, equipment malfunction or congestion) or due to external conditions such as incorrect incoming signalling or final route congestion.

Note – International networks contain one-way and both-way operated circuits and their traffic flow characteristics are inherently different. This difference needs to be taken into account when calculating BCH and SCH either by:

i) multiplying the number of one-way circuits by 2 to derive an equivalent number of both-way circuits, or

ii) dividing the number of both-way circuits by 2 to derive an equivalent number of one-way circuits.

When BCH and SCH data are exchanged between Administrations, it is essential that agreement be reached on the method to be used.

3.5 The parameters which it is possible or necessary for a particular Administration to calculate will depend upon a number of factors. These will include:

a) the data available at an international switching centre,

b) the particular routing arrangements employed (for example, SCH and BCH relate to route performance only, whereas ASR and % OFL can relate to route or destination performance),

c) the interrelationships which exist between the parameters (for example, SCH can give similar indications to ASR – see § 3.4.4 above).

4 Criteria for action

4.1 The basis for the decision whether any network management action should be taken will depend upon real-time information on the status and performance of the network. It is advantageous if the output of this information can be initially restricted to that which is required to identify possible difficulties in the network. This can be achieved by setting threshold values for performance parameters (see § 3.4) and for the percentage of circuits and common control equipment which are in service [see § 3.2, b)] such that when these threshold values are violated, network management action can be considered. These threshold values will represent some of the criteria by which decisions are reached.

Threshold values, other criteria and their use are under study. Until such studies are completed, Administrations should establish criteria as appropriate.

4.2 Indications of threshold violations and of "all circuits on a route are busy" and "all routes to a destination are busy" [see § 3.2, a)] may be used to direct attention to the particular area of the network for which detailed performance information will then be required. Considerable advantage can be achieved if these indications are prominently displayed.

4.3 The decision on whether or not to take network management action and what action to take is the responsibility of the network management personnel. In addition to the criteria mentioned above, this decision will be based on a number of factors which could include:

- a knowledge of the source of the difficulty,
- detailed performance and status information,
- any predetermined plans that exist (see § 5),
- experience and knowledge of the network,
- routing plan employed,
- local traffic patterns,
- ability to control the flow of traffic (see § 6).

5 Plans and arrangements

5.1 For known or predictable events which will affect service, predetermined network management plans should be developed and agreed between Administrations. The degree of detail of any plans will depend on the type of event to be covered. For example, a known event such as Christmas Day or New Year's Day may be planned for in great detail.

When unforeseen situations arise for which predetermined plans do not exist, ad hoc arrangements will need to be agreed at the time.

5.2 Whether network management actions result from a negotiated plan or an ad hoc arrangement, it is essential that agreement be reached between the Administrations concerned before such actions are actually implemented.

6 Network management actions

6.1 *General*

Network management actions fall into two broad categories:

a) "protective" actions, which are designed to remove traffic from the network which has a low probability of resulting in successful calls;

b) "expansive" actions, which are designed to make available lightly loaded parts of the network to traffic experiencing congestion on its normal route(s).

Normally, the first choice response to a network problem would be an expansive action. Protective actions would be used when expansive actions were not available or not effective.

Network management actions may be taken:

- according to plans which have been mutually agreed between involved Administrations prior to the event;
- according to "ad hoc" arrangements agreed between involved Administrations at the time of an event;
- by an individual Administration in the case of reducing its traffic entering the international network.

6.2 *Protective actions*

Protective actions involve removing traffic from the network which has a low probability of resulting in successful calls. Such traffic should be removed as close as possible to its origin, thus making more of the network available to traffic which has a higher probability of success.

Examples of protective actions are:

a) Temporary removal of circuits from service (circuit busying). This action may be taken when a distant part of the network is experiencing serious congestion.

   Note – In the case of both-way circuits, it may only be necessary to inhibit one direction of operation.

b) Special instructions to operators. For example, such instructions may require that only a limited number of attempts (or none at all) be made to set up a call via a congested route or switching centre, or to a particular destination experiencing congestion.

c) Special recorded announcements. Such announcements may be connected at an international or national switching centre and, when there is serious congestion within part of the network, would advise customers (and operators) to take appropriate action.

d) Inhibiting overflow traffic. This action prevents traffic from overflowing onto routes or into distant switching centres which are already experiencing congestion.

e) Inhibiting traffic to a particular switching centre (code blocking). This action may be taken when it is known that a distant part of the network is experiencing congestion.

In general, protective network management actions can be made available at international switching centres of all technologies with little or no changes to existing equipment arrangements.

6.3 *Expansive actions*

Expansive actions involve the rerouting of traffic from routes experiencing congestion to other parts of the network which are lightly loaded with traffic because of, for example, time zone differences.

Examples of expansive actions are:

a) establishing temporary alternative routing arrangements in addition to those normally available;

b) in a country where there is more than one international switching centre, temporarily reorganizing the distribution of outgoing (or incoming) international traffic;

c) where speech interpolation systems, e.g. TASI, are used, enhancing the advantage of these systems such that the number of circuits available on a congested route is increased;

d) in exceptional cases, passing traffic from operator-to-operator (manually) over circuits normally used for the semiautomatic service;

e) establishing alternative routes into the national network for incoming international traffic;

f) establishing alternative routes in the national network to an international exchange for originating international traffic.

The protective action of inhibiting one direction of operation of both-way circuits [see § 6.2, a)] can have an expansive effect in the other direction of operation.

In general, expansive network management actions can only be made available by specially engineered changes to existing route or equipment arrangements. For example, such arrangements could be provided as prewired additional routings and introduced under key control as required. In some instances, switching centres of modern design (e.g., stored programme controlled) have incorporated the capability of exercising direct control over the flow of traffic, including some of the expansive actions mentioned above.

6.4 In general, network management actions will be invoked under manual control. However, it may be possible upon receipt of appropriate network management signals (see § 7.3) to arrange for equipment to initiate certain network management actions automatically. Such automatic responses must be the subject of prior agreement between the Administrations concerned.

7 Exchange of information

7.1 An essential factor in international network management is the timely exchange of network management information between Administrations both for information and action purposes. To aid understanding, such messages should be in an agreed format. Until such time as CCITT makes suitable Recommendations, it will be necessary for the Administrations concerned to agree on the message format to be used.

7.2 The content of messages should include the following as appropriate:

i) identity of the origin and destination(s) of the message,

ii) date and time of the message (if appropriate to the media used),

iii) date and time of the information,

iv) network management information (see §§ 3.2 and 3.4),

v) action proposed (e.g. agreed plans to be invoked) and/or action already taken.

Suitable message acknowledgements will be required.

The network management information to be given in such messages will include that mentioned in § 2, namely, performance data, status information and other immediate information. In some cases, it may only be necessary to exchange threshold violation information initially.

7.3 The exchange of network management information messages may be:

i) *man-to-man*

- by such manual means as service circuits, public telephone or telex networks;

ii) *man-to-machine, machine-to-man, machine-to-machine*

- by such means as "network management signals" via common channel or other signalling systems.

At the present time, voice communication is the most readily available medium, with telex or similar media used as support and to transmit reports, data and to confirm verbal agreements.

In the future, a variety of "network management signals" may be transmitted to centres which may take action to alleviate congestion or react to failures. These signals need only be transmitted to the appropriate international switching centres. Further retransmission within the national network should be at the discretion of the Administration.

Network management signals could be arranged to indicate degrees and types of difficulties so as to communicate the need for network management actions to be applied either manually or automatically (see § 6.4). For example, signals indicating "all circuits busy on a route" are suitable for use in this context.

The specific signals to be used must depend on their availability and the stage of development of network management in the Administrations concerned.

Generally, network management signals should be restricted to immediate information, long-term information being transferred by other means.

ANNEX A

(to Recommendation E.410)

Terminology for network management

A.1 circuit

F: circuit

S: circuito

A circuit connects two switching centres. A national circuit connects two switching centres in the same country. An international circuit connects two international switching centres situated in different countries. (Based on Recommendation D.150 [5] and Recommendation F.68 [6].)

A.2 route

F: voie d'acheminement

S: ruta

A collection of circuits uniquely identifiable for engineering, routing or traffic purposes.

A.3 destination

F: destination

S: destino

A country in which the called subscriber is located or an area or other location that may be specified within that country. A destination can be identified by the digits used for routing the call.

A.4 bid

F: tentative de prise

S: tentativa de toma

An attempt to obtain a circuit in a route. A bid may be successful or unsuccessful in seizing a circuit in that route.

A.5 seizure

F: prise

S: toma

A seizure is a bid for a circuit in a route which succeeds in obtaining a circuit in that route.

A.6 **answer signal**

F: signal de réponse

S: señal de respuesta

A signal sent in the backward direction indicating that the call is answered. (Based on Recommendation Q. 254 [7].)

A.7 **holding time**

F: durée d'occupation

S: tiempo de ocupación

The time interval between seizure and release of a circuit or switching equipment.

References

[1] CCITT Recommendation *International routing plan*, Vol. II, Fascicle II.2, Rec. E.171.

[2] CCITT Recommendation *Network analysis point*, Vol. IV, Fascicle IV.1, Rec. M.720.

[3] CCITT Recommendation *Network management point*, Vol. IV, Fascicle IV.1, Rec. M.722.

[4] CCITT Recommendation *System availability information point*, Vol. IV, Fascicle IV.1, Rec. M.721.

[5] CCITT Recommendation *New system for accounting in international telephony*, Vol. II, Fascicle II.1, Rec. D.150.

[6] CCITT Recommendation *Establishment of the automatic intercontinental telex network*, Vol. II, Fascicle II.4, Rec. F.68.

[7] CCITT Recommendation *Telephone signals*, Vol. VI, Fascicle VI.3, Rec. Q.254.

SECTION 3

CHECKING THE QUALITY OF THE INTERNATIONAL TELEPHONE SERVICE

Recommendation E.420

CHECKING THE QUALITY OF THE INTERNATIONAL TELEPHONE SERVICE GENERAL CONSIDERATIONS

The methods of measuring the quality of service are as follows:

1) service observations;

2) test calls (simulated traffic);

3) customer interviews;

4) automatic observations of the outgoing international circuits.

Administrations are recommended to draw up a programme for observations and tests designed for assessment of circuits and equipment, supervision of operators and evaluation of the quality of service given to subscribers. It would be desirable if telephone Administrations were to exchange ***statistics on quality of service*** directly, and immediately after they have been made out, in accordance with Tables 1/E.422, 1/E.423 and 1/E.424.

Table 1/E.422 relates to the observations of outgoing calls on the quality of international automatic and semi-automatic service. It provides in particular a check of the percentage of unsuccessful calls due to technical faults (equipment shortages or failures).

Table 1/E.423 relates to observations on traffic set up by operators. It provides, in manual and semi-automatic service, a means of determining the efficiency of international circuits, of assessing the work of operators and the quality of transmission.

Table 1/E.424 is used to record the results of test calls undertaken especially when the observations shown in Table 1/E.422 make it clear that the percentage of faults is too high.

The use of customer interviews as a method of measuring telephone service quality is the subject of Recommendation E.125 [1] which is particularly concerned with the determination of sources of user difficulty which may arise when making an international automatic telephone call.

Recommendation E.426 contains a general guide to the expected percentage of effective international call attempts.

Table 1/E.427 may be used to supplement the information contained in Table 1/E.422 when the observations shown in that table make it clear that the percentage of faults due to customer difficulties is too high or the outcome of the application of Recommendation E.125 [1] demonstrates the need for additional information.

Reference

[1] CCITT Recommendation *Inquiries among users of the international telephone service*, Vol. II, Fascicle II.2, Rec. E.125.

SERVICE QUALITY OBSERVATIONS

1 Definitions

1.1 service observation

F: observation de la qualité de service

S: observación de la calidad del servicio

Monitoring to obtain a complete or partial assessment of the quality of telephone calls, excluding test calls.

1.2 manual observation

F: observation manuelle

S: observación manual

Monitoring of telephone calls by an observer without using any automatic data-recording machine.

1.3 automatic observation

F: observation automatique

S: observación automática

Monitoring of telephone calls without an observer.

1.4 semiautomatic observation

F: observation semi-automatique

S: observación semiautomática

Monitoring of telephone calls using equipment which records some data automatically. For example, equipment in which information such as exchange being observed, number dialled by the subscriber, metering pulses and time of call are recorded automatically on some means suitable for data processing. The observer merely has to key in a code indicating the condition observed.

2 Relative merits of manual, automatic and semiautomatic observations

2.1 The three methods mentioned above in 1.2, 1.3 and 1.4 are not exclusive, for example: automatic observations may be used to supplement observations taken by an operator. It was considered in 1968 that the need for automatic observations would increase in view of the heavy cost associated with manual or semiautomatic observations on the rapidly expanding international network. It was also considered that automatic observations would not entirely supersede observations taken by an observer within the foreseeable future.

The relative merits of the three methods can be assessed as follows:

2.2 *Manual observation*

Provides all the data required in Tables 1/E.422 and 1/E.423.

Observations can be carried out with a minimum of equipment.

Observations can permit the detection of a number of abnormalities which cannot be detected automatically, e.g. very poor speech transmission (item 5.2 of Table 1/E.422), or difficulty with audible tones encountered in the international service item 6.4 of Table 1/E.422).

2.3 *Automatic observation*

Operating cost is minimum (staff reduction).

Continuous observation is possible.

It is possible to have a larger sample.

Human error is eliminated.

Automatic processing of data is facilitated.

Conversational privacy is ensured.

Control of the time at which observations are made is facilitated.

2.4 *Semiautomatic observation*

Provides all the data required in Tables 1/E.422 and 1/E.423.

There is a saving in staffing costs compared with manual observation.

Greater accuracy compared with manual observation is possible due to the fact that there is an automatic recording of the number dialled, the time of the call, etc.

It is possible for the observer to give more attention to the more critical conditions being checked during observations of calls.

The results are produced in a form suitable for subsequent mechanized analysis.

Owing to the reduction of costs it is possible to obtain a larger sample for the same expenditure.

Semi-automatic equipment may be converted, during certain hours of the day, to automatic operation.

3 Time of observations

The results of all observations taken over the whole day should be recorded in Table 1/E.422.

In the case where observations are not taken over the whole day the observation period is recorded under the heading "Time of observations" and should include the three busiest hours of the day.

4 Observation access points

4.1 Observations for Table 1/E.422 should be carried out from access points as close as possible to the outgoing international exchange.

The following access points can be considered:

i) outgoing relay set of an international circuit ("exchange" side), i.e. *international circuit access point* [1];

ii) incoming relay set of a national circuit;

iii) link circuits of the international exchange.

Observations will be made only while the call is being set up, and a few seconds after the called subscriber's reply.

When the circuit access point [1] is used for observation of international calls it is possible that the service quality of the international exchange may not be checked by either international or national observation programmes.

Preferably, and where technically feasible for the most complete results, observations for Table 1/E.422 should be carried out as close as possible to the international exchange on the national side. This would be more representative of service to the subscriber, and allows observation of call failure at the outgoing international exchange. Where it is not possible to make the distinction between failures in the outgoing international exchange, and failures beyond this exchange, or where there is a meaningful advantage in doing so, observations should be taken on the outgoing side.

It is necessary to state in Table 1/E.422 the access point where the observations have been made, as observations obtained at each one of the three access points mentioned above are not comparable.

4.2 Observations for Table 1/E.423 must be carried out from access points on the operators' positions.

[1] For definitions of test access points see Recommendation M.700 [1]. See also Recommendation M.110 [2].

5 Number of observations

5.1 Service observing programmes should be established in such a manner that statistical results obtained be as reliable as practicable bearing in mind the cost of obtaining large samples.

5.2 According to the studies carried out by the CCITT in 1964-1968, the quantities shown below are considered the *minimum* quantities to provide a general indication of the quality of service.

5.2.1 *Table 1/E.422*

The minimum number of observations per outgoing circuit group for Table 1/E.422 should be 200 per month when more than 20 circuits are included in a group, 200 per quarter when there are between 10 and 20 circuits in a group and 200 per year if there are less than 10 circuits in a group.

5.2.2 *Table 1/E.423*

The minimum number of observations for Table 1/E.423 should be 200 per quarter when there are more than 20 circuits in the group, 200 per semester when there are between 10 and 20 circuits and 200 per year when there are less than 10 circuits in the group.

5.2.3 *Transit traffic*

Where an outgoing circuit group also carries transit traffic it is desirable to obtain data for each destination country reached via this circuit group. In principle, the number of observations for each destination should be obtained as indicated above. To accomplish this, one should use for each destination country its corresponding number of erlangs and derive from these erlangs a theoretical number of circuits.

However, where only a very small amount of traffic is handled, e.g. less than 5 erlangs, each Administration may wish either to make a smaller number of observations or (e.g. in case of no complaints) no observations at all and rely on the information obtained at the transit exchange.

5.3 The number of observations specified above will provide a general indication of results on quality of service in certain broad categories. Administrations may desire more accurate results especially for the individual categories in Table 1/E.422.

Attention is drawn to Table 1/E.421 which gives the number of observations required to obtain a certain degree of accuracy.

TABLE 1/E.421

Expected percentage rate of failure	Number of observations of a random sample required to predict with 95% confidence the true percentage of failure with an accuracy of:					
	± 25%	± 30%	± 35%	± 40%	± 45%	± 50%
2	3136	2178	1600	1225	1030	880
4	1536	1067	784	600	500	440
6	1003	696	512	392	330	290
8	736	511	376	288	245	215
10	576	400	294	225	195	170
12	469	326	239	183	150	132
14	393	273	201	54	128	112
16	336	233	171	131	112	98
18	292	202	149	114	95	80
20	256	178	131	100	85	70
30	149	104	76	60	50	42
40	96	67	50	38	30	24
50	64	44	33	25	20	16

Annex to Table 1/E.421

Examples of use of Table 1/E.421

Example 1 – It is estimated from previous results that a particular type of failure occurs on about 4% of calls. If it is required to confirm, with 95% confidence, that the existing failure rate is between 3% and 5% (i.e. ± 25% of 4%), then observations must be made on a random sample of 1536 calls.

Example 2 – For an expected failure rate of 2%, observations must be made on a random sample of about 1200 calls (1225 in the table) to predict, with 95% confidence, that the true percentage is between 1.2% and 2.8% (i.e. ± 40% of 2%). This means that when 200 observations are taken over a period it is necessary to take the "rolling average" of conditions over six periods. The rate of failure for a number of categories important from the maintenance point of view is expected to be about 2%.

Example 3 – After observations have been taken and the rate of failure in the sample has been calculated, the table may be used in a "backward" direction to give a rough indication of the accuracy of the result.

Suppose that out of a sample of 1000 observations, there were 29 failures due to cause "X" and 15 failures due to cause "Y". The rates of failure in the sample due to X and Y, respectively, are then 2.9% and 1.5%. From the table, it is apparent from this sample of 1000 calls that the true rate of failure due to X has an accuracy of about ± 35% (i.e. is between 1.9% and 3.9%), and that due to Y has an accuracy of about ± 50% (i.e. is between 0.8% and 2.3%).

6 Exchange and analysis of the results of observations

6.1 *Exchange of the results of observations*

The following periodicities are proposed for the exchange of results between Administrations:

Table 1/E.422 – a monthly exchange is desirable;

Table 1/E.423 – a quarterly exchange is desirable.

Nevertheless, in the case of small groups of circuits (less than 20 circuits) the information should be exchanged after 200 observations have been made but never later than one year in any case; attention is drawn to Table 1/E.421, which shows that less than 200 observations are of little value.

Results of observations will be reported without delay:

- to the Administrations and the network analysis point of the country where observations are carried out;
- to the Administrations and the network analysis point of the other country (including transit Administrations and their network analysis point when involved).

The benefits to be derived from service observations tend to decrease if there is any increase in the time taken to make the results available to those who can take action to bring about an improvement. The results of service observations according to Tables 1/E.422 and 1/E.423 should therefore be made available to the Administration in the countries of destination as soon as possible after completion of the observation period and in any case within six weeks and when possible to the CCITT Secretariat for centralized processing.

6.2 *Analysis of observation results*

An analysis of the results should be carried out in the country of origin. However, analysis may also be performed in the country of destination or on a centralized basis.

Some Administrations have found it useful to distribute to other Administrations concerned, service observation statistics in the form of graphs.

Statistics are also available on an anonymous basis from the CCITT Secretariat as a result of centralized processing.

7 Centralized processing of service observation results

A manual processing of the service observation results was carried out, in 1968-1972, and the conclusions of this first series of field trials were that:

"The results achieved are both useful and helpful. The first series of field trials have provided service observation data not heretofore available and, in the absence of automatic methods of monitoring the quality of international telephone service, enables more effective use to be made of the rather small samples available from manual service observations. The participating Administrations also see the trials as an important means of hastening the standardization of quality of service observation procedures and definitions."

These field trials were continued in Study Period 1973-1976. In view of the results obtained centralized processing has become permanent.

Centralized processing is expected to provide the participating Administrations with better information, enabling each of them, for the matters which concern it, to have consistent and sustained information on the performance of the worldwide telephone network and the degree to which it satisfies users.

The results of centralized processing, presented in synoptic form (see § A.6) may also be of interest to the World Plan Committee.

Administrations are urged to take an active part in the centralized processing of observation results for this service. Annex A describes the processing method to be applied.

ANNEX A

(to Recommendation E.421)

Instructions for processing the service observation results

A.1 *General*

To simplify the work of Administrations, it is suggested that observations [recorded in accordance with Recommendation E.422 (Table 1/E.422)] should be sent to the CCITT. The observations should be submitted quarterly for centralized processing. Observations should be received by the CCITT not later than four weeks after the observation period. Processing the observations within the CCITT should be completed within two weeks.

A.2 *Confidentiality of the processing procedures*

The names of participating Administrations will be kept confidential to avoid any possibility of a leak to persons not directly concerned in the supervision of service quality in international traffic.

The following procedure will be followed:

- each participating country will be designated by a key letter;
- all countries not participating will be jointly designated by one key letter;
- these letters will be communicated to each official personally appointed by a participating country and will be kept secret by him in any way he thinks fit. No official documents mentioning a country will be distributed by the CCITT.

A.3 *Sending of data to the CCITT Secretariat*

A.3.1 The observation results should be sent to:

CCITT Secretariat
2, rue de Varembé
1211 – Geneva 20, Switzerland.

A.3.2 An information directory of the names of the officials appointed by participating Administrations will be published as a contribution of Study Group II at the beginning of each new study period.

A.4 *Processing by the CCITT of data contained in Table 1/E.422*

A.4.1 *Assembly of information recorded in Table 1/E.422*

The information received for Table 1/E.422 should be *assembled* in accordance with the categories of that table. No subheading is required.

Category 1 – Successful calls
Category 2 – No answer
Category 3 – Busy or congestion
Category 4 – Unsuccessful calls indicated by visual signal, tone or recorded announcement
Category 5 – Other unsuccessful calls
Category 6 – Incorrect handling by the caller
Category 7 – Number of calls monitored
Category 9 – Successful calls with defects

A.4.2 *Signalling systems*

Administrations will have advised the CCITT of the signalling system used for each relationship for which service observation results are being submitted. This information must be correlated with the observations received for Table 1/E.422.

A.4.3 *Processing of assembled information for Table 1/E.422*

For each incoming country the total observations for each of the categories 1-7 of § A.4.1 above should be obtained for each of the CCITT signalling systems used. 1-6 should then be calculated as a percentage of category 7. No calculation is made for item 9 of Table 1/E.422.

The use of the ITU computer will not be justified unless the volume of data to be processed is sufficient.

A.5 *Results of processing*

The information resulting from the processing described above will be presented in tabular form for all countries for each signalling system used.

A.6 *Synoptic table*

The processing described above will be completed by establishing a synoptic table showing the overall quarterly results weighted for the different headings listed in § A.4.1 of this annex.

A.7 *Dissemination of results*

A.7.1 The CCITT should send the information detailed in §§ A.5 and A.6 above to each of the countries participating in the centralized processing. The synoptic table should be available also at every Study Group II meeting and at every Working Party meeting dealing with quality control of the international telephone service.

A.7.2 The information processed will be communicated to the officials appointed by participating Administrations.

References

[1] CCITT Recommendation *Definitions for the maintenance organization*, Vol. IV, Fascicle IV.1, Rec. M.700.

[2] CCITT Recommendation *Circuit testing*, Vol. IV, Fascicle IV.1, Rec. M.110.

Recommendation E.422

OBSERVATIONS ON INTERNATIONAL OUTGOING TELEPHONE CALLS FOR QUALITY OF SERVICE

1 Objectives concerning Table 1/E.422

1.1 The purpose of service observation in the international service is to assess the quality of service obtained by the calling subscriber. Consequently, it is essential to have factual or objective recording of observations (i.e., successful and unsuccessful calls), and to present them in the form of a table (see Table 1/E.422). The table should be constructed so as to avoid the necessity of the observer having to interpret the meaning of the indications obtained through the observing equipment.

TABLE 1/E.422

Observations of international outgoing telephone calls for quality of service

Country of origin .... Point of access:

Outgoing international exchange .... National side ....

Group of circuits .... Link circuits ....

Service { automatic [a)] semi-automatic [a)] Outgoing side ....

Period: from .... to .... Time of observations ....

Category	Number		Percentage	
	Subtotal	Total	Subtotal	Total
1. Calls successfully put through (see note 1)		. . .		. . .
2. Ring tone received but no answer		. . .		. . .
3. Unsuccessful calls: *Positive* indication of congestion, including subscriber busy, from beyond the outgoing international exchange. Visual signal, tone or recorded announcement		. . .		. . .
3.1 Subscriber busy/congestion indicated by visual signal	. . .		. . .	
3.2 Subscriber busy/congestion indicated by busy/congestion tone .	. . .		. . .	
3.3 Congestion indicated by a recorded announcement	. . .		. . .	
4. Unsuccessful calls: Other visual signals, tones or recorded announcements, not positively identified as category 3 or 8		. . .		. . .
4.1 Visual signal received	. . .		. . .	
4.2 Tone received	. . .		. . .	
4.3 Recorded announcement received	. . .		. . .	
5. Unsuccessful calls for other technical reasons		. . .		. . .
5.1 Wrong number obtained	. . .		. . .	
5.2 Abandoned due to very poor speech transmission	. . .		. . .	
5.3 No tone, no answer after waiting ..... seconds	. . .		. . .	
5.4 Reception of answer signal when the called party does not reply	. . .		. . .	
5.5 Other failures of a technical kind	. . .		. . .	
6. Unsuccessful calls due to incorrect handling by the calling party . .		. . .		. . .
6.1 Wrong number dialled	. . .		. . .	
6.2 Incomplete number	. . .		. . .	
6.3 Call prematurely abandoned before receipt of signal, tone or announcement (within less than ..... seconds)	. . .		. . .	
6.4 Call prematurely abandoned after receipt of ring tone (within less than 30 seconds)	. . .		. . .	
6.5 Other failures due to incorrect handling	. . .		. . .	

a) Delete whatever is inapplicable.

TABLE 1/E.422 *(continuation)*

Category	Number		Percentage	
	Subtotal	Total	Subtotal	Total
7. *Total calls monitored* (categories 1-6)		. . .		100
8. Unsuccessful calls: *Positive* indication of failure from outgoing international exchange		. . .		
8.1 Congestion on outgoing international circuits	. . .			
8.2 All other indications	. . .			
9. Successful calls with defects. These calls are included in category 1 .		. . .		
9.1 Non-reception of answer signal on chargeable calls	. . .			
9.2 Call with impaired intelligibility but not abandoned	. . .			
9.3 Other calls with defects but not abandoned	. . .			

Note 1 — A successful call is one that reaches the wanted number and allows conversation to proceed. All successful calls are entered in category 1. However, a successful call may or may not have noticeable defects. Successful calls with noticeable defects should also be entered in category 9.

Note 2 — With the exception noted above for categories 1 and 9, the results of one call observation should be entered under one category only, namely the most appropriate one from (1) to (6).

Note 3 — Administrations should periodically exchange necessary information to interpret the observation data recorded under categories 4.1, 4.2 and 4.3.

1.2 The table should be capable of being completed through the use of a wide range of observation facilities, i.e. from the simple to the sophisticated.

1.3 Specialized training of observers should be kept to a minimum.

1.4 The table should be self-explanatory so that reference to detailed how-to-complete instructions is unnecessary.

1.5 The major categories should be selected so that they:

- identify the major factors adversely affecting the quality of service;
- are suitable for the centralized processing of observation results.

1.6 To permit the orderly collection of data for human factors studies to identify sources of difficulty in customer use of the international (automatic) telephone service, Recommendation E.427 contains an additional table to Table 1/E.422.

2 Comments concerning the use of Table 1/E.422

2.1 Table 1/E.422 summarizes observations made on outgoing automatic and semiautomatic traffic, on a country of origin to a country of destination basis. A separate form should be used for each country of destination, and if required, for each group of circuits to which traffic to the country of destination has access at the outgoing international exchange (or exchanges).

2.2 For an explanation of the point of access, see Recommendation E.421, § 4.1.

2.3 The result of each call observed should be entered only under the most appropriate category. In the case of several faults on one call, the most significant cause of failure should be entered.

2.4 In completing Table 1/E.422 reference should be made to the following explanations.

3 How to fill in Table 1/E.422

Category 1 – To ensure objective recording and to avoid producing a biased sample resulting from the exclusion of calls which require subjective assessment, the successful call is defined as a call that reaches the wanted number and allows conversation to proceed. All non-abandoned calls are entered into category 1 and of these calls those which are subjectively adjudged to be defective are also entered into category 9. Thus it is required of the observer to make *two* entries for successful calls with noticeable defects.

Enter in category 1 then, calls successfully put through. This includes answered calls for which a clearback signal is received after some words have been spoken, without knowing for what reason the call is abandoned. If it is observed that the caller has dialled a wrong number, the call will be entered under 6.1. Category 1 will also include calls put through correctly to operator positions, information services, or to machines replying in place of the subscriber or to their equivalents.

Category 2 – Enter in this category calls on which ring tone was heard but the subscriber did not answer before the attempt was abandoned, the caller having waited at least 30 seconds after commencement of ring tone before clearing forward. (See category 6.4 if the call was abandoned *less* than 30 seconds after ring tone commenced.)

Category 3 – Enter in this category all unsuccessful calls in which a *positive* indication of subscriber busy or congestion beyond the outgoing international exchange had been encountered, either by visual signal, tone or recorded announcement. Congestion encountered on common control equipment should be entered in this category as well (e.g. no "proceed-to-send" signal). Where a positive indication of these conditions has *not* been received, enter in category 4.

Categories 3.1, 3.2 and 3.3 are entered for the specific indication received.

When more than one indication is received, e.g. visual signal and audible tone, only one entry should be made. In this case, the preferred order of entry should be tone, announcement, visual signal.

Category 4 – Enter in this category all other indications on unsuccessful calls whether by visual signal, tone or recorded announcement that cannot be positively identified and entered in category 3 or 8.

Categories 4.1, 4.2 and 4.3 are entered for the specific indication received.

When more than one indication is received, e.g. visual signal and audible tone, only one entry should be made. In this case, the preferred order of entry should be tone, announcement, visual signal.

Category 5 – Enter in this category those calls which fail for technical reasons not included in categories 3, 4 and 8. Category 5 subdivides as follows:

Category 5.1 – Calls on which the wrong number was obtained, although the caller dialled correctly.

Category 5.2 – Calls abandoned by the caller because of very poor speech transmission, although the answer signal was received. (See category 9.2 if speech transmission is poor but the call is not abandoned.) In some countries observers may be required to cease listening immediately after conversation is established, thus reducing the number of calls that would be reported in this category.

Category 5.3 – Calls on which the dialling information was correctly and completely sent, but the caller received no signal, tone or announcement before abandoning the call, having waited for at least the specified period before clearing forward.

The value of this time period left open under this category should be filled in by the Administrations of the originating country according to its experience in this matter. The prescribed value may differ depending on the international destination. It is, however, recommended to limit the number of such different quoted periods to a maximum of three values (e.g. 10, 20 or 30 seconds or any other value considered pertinent by the Administrations concerned).

Category 5.4 – Calls on which an answer signal was received, although the called subscriber did not answer.

Category 5.5 – Call failures due to technical reasons which are unable to be entered in categories 5.1 to 5.4. These should be very few, if any, and this category is provided in case they do arise. All possible information about these failures should be supplied as an attachment to the summary of the table. This category includes calls abandoned due to reception of a clear-back signal while connecting with the extension number (PBX).

Category 6 – Enter in this category all unsuccessful calls which have failed due to incorrect handling by the caller (subscriber or operator). Category 6 subdivides as follows:

Category 6.1 – Calls on which it was determined that the number which should have been dialled was different from the number actually dialled.

Category 6.2 – Calls on which it was determined that the number dialled had insufficient digits to be successful.

Category 6.3 – Calls on which the digital information was correctly and completely sent, but the caller abandoned the call without receiving any signal, tone or announcement, and without waiting for at least the specified period.

The value of the time period left open under this category should be filled in by the Administrations of the originating country according to its experience in this matter. The prescribed value may differ depending on the international destination. It is, however, recommended to limit the number of such different quoted periods to a maximum of three values (e.g. 10, 20 or 30 seconds or any other value considered pertinent by the Administration concerned).

The value quoted under category 6 must be the same as that quoted under category 5.

Category 6.4 – Calls prematurely abandoned after receipt of the ringing tone on which the caller disconnected less than 30 seconds after the ringing tone commenced. (See category 2 if the call was abandoned after ***more*** than 30 seconds had elapsed from the time of commencement of ringing tone.)

Category 6.5 – Calls which failed due to incorrect handling by the caller which cannot be classifed under categories 6.1 to 6.4. All possible information about these failures should be supplied as an attachment to the summary of the table. As in categories 5.5, these should be very few, if any.

Category 7 – Enter in category 7 the number of calls monitored (categories 1-6).

Category 8 – Category 8 will be useful for those Administrations which observe on the national side of the outgoing international exchange. (See Recommendation E.421, § 4.1.) Positive indications of failure, congestion or other, are to be entered here. They are not to be included with categories 1-6, which give the data for calls monitored for category 7.

Thus, when category 8 is viewed with categories 3 and 4 a more complete picture is provided of quality of service received by the caller.

Category 9 – Entries in category 9 are for successful calls (entered in category 1) which encountered defects, but which were not abandoned. They are thus automatically included in the total of category 7.

Category 9.1 – Enter here chargeable calls for which no answer signal was received. If abandonment should be detected on such calls, enter in category 5.5.

Category 9.2 – Enter here calls on which poor speech transmission was observed, but the call was not abandoned. (See category 5.2 if the call was abandoned.) All possible information about these calls should be supplied as an attachment to the summary of the table. Note that in some countries observers may be required to cease listening immediately after conversation was established, thus reducing the number of calls that would be reported under this category.

Category 9.3 – Enter here calls encountering switching, signalling or transmission defects, but which were not abandoned and which cannot be classified under categories 9.1 or 9.2.

Recommendation E.423

OBSERVATIONS ON TRAFFIC SET UP BY OPERATORS

1 Comments concerning the use of Table 1/E.423

1.1 This table summarizes observations relating to manual and semi-automatic outgoing traffic originated by operators. These observations will be made, if possible, during the whole call duration.

1.2 Administrations should, if possible, make a distinction between the different types of call, e.g. station-to-station, personal and collect calls; they should use a separate column for each under the heading "Type of call".

TABLE 1/E.423

Observations on traffic set up by operators

International outgoing exchange: ....

Circuit group: ....

Service { semi-automatic [a)]
manual [a)]

Period from .... to ....

Category	Type of call [b)]			
	Ordinary	Personal		
1. Mean call duration – in seconds				
2. Mean chargeable duration – in seconds				
3. Mean holding time of circuits for manœuvres and preparation of calls – in seconds				
4. Number of effective calls observed				
5. Mean number of times the international circuit was seized per effective call				
6. Mean number of "attempts" per effective call				
7. Percentage of calls set up at the first "attempt"				

8. Time-to-answer by operators	Total number of calls answered and unanswered		Calls answered						Calls unanswered (abandoned calls)			
	Num-ber	Mean waiting time in seconds	under 15 seconds		in 15 to 30 seconds		after 30 seconds		within 30 seconds		after 30 seconds	
Operators:			No.	%	No.	%	No.	%	No.	%	No.	%
— incoming operator (code 11)												
— delay operator (code 12)												
— assistance operator												
— information operator												

9. Quality of transmission from the subscriber's viewpoint:	Number	%	10. Comments
— good			
— defective			
Total		100	

a) Delete whichever is inapplicable.
b) In accordance with § 1.2.

1.3 For collect calls, the times to be recorded will be those observed in the country where the call request was made.

1.4 It is recommended that these observations be spread over the whole day.

1.5 Each outgoing Administration will select the international circuit groups on which observations should be carried out.

1.6 In completing this table, reference should be made to the following explanations:

2 How to fill in Table 1/E.423 (Traffic observations determined by the operators)

Category 1 – This category should show the mean duration of calls observed which are successful and have been charged for ("effective" calls).

Category 2 – This category will show the mean *chargeable* duration of all effective calls observed.

Category 3 – This category will show, for each type of observed call, the average time per effective call during which the international circuit has been occupied for manoeuvres or for call preparation.

This average should be based on the time during which the international circuit is held:

a) to obtain information concerning the called number;

b) to obtain information about routing and trunk codes;

c) to call operators, in the incoming international exchange;

d) to exchange information on how to set up the call;

e) to (or attempt to) obtain the called number even when it is engaged or does not reply;

f) to (or attempt to) obtain the called person (in personal calls);

g) between replacement of the receiver by the called person and release of the circuit;

h) because the operator is holding the circuit (whether she is on the line or not) and for any other reasons for which the circuit is engaged.

The times listed above, which exclude the conversation time, should be added together. This total should be divided by the number of effective calls observed during the period in question to obtain the value to be entered in Table 1/E.423.

Category 4 – The number of effective calls observed considered in category 1.

Category 5 – The mean number of times the international circuit was seized per effective call (see category 3). This number is usually obtained by meter recordings.

Category 6 – The mean number of *attempts* (as specifically defined hereafter from the operating point of view to set up a call. Should the operator try several times to set up a call while continuously occupied on that call, all these operations must be considered as being one attempt. Similarly, if the operator makes several tries to set up a call and each time encounters a congestion or busy condition and if, after the last try, she informs the caller, only one attempt must be entered. Calls to information services or to obtain routing particulars, and all calls not directly related to the establishment of a call or to information required by the caller, should not be considered as attempts and should not be included.

The total number of attempts during the period of observation should be divided by the number of effective calls observed in the same period to obtain the mean number of attempts per call.

The total number of attempts is usually determined from markings or notations on call tickets.

Category 7 – The data for this category will be taken from all tickets prepared for the relation concerned, during the period of observation or a comparable period.

Category 8 – The mean waiting time for outgoing operators to receive an answer will be indicated in seconds. This average will include both answered and unanswered calls.

An outgoing operator waits on the circuit (waiting time) for the period:

a) until the incoming operator answers, or

b) until she abandons the attempt, should the incoming operator not answer.

Thus while mean waiting time relates to the outgoing operator it is also a measure of the performance of the incoming operators.

Category 9 – It will be difficult to obtain absolutely comparable results from all observers for this category. However, the observer should consider the quality of transmission from the subscribers' viewpoint, taking into account comments made in this respect by subscribers and the number of requests for conversation to be repeated.

Category 10 – This category should include any comments likely to explain the probable cause of difficulties frequently noted during the observations.

Recommendation E.424

TEST CALLS

1 General

Test calls carried out manually or automatically to assess the functioning of international circuits or connections are of four types:

a) *Type 1 test call*

A test call conducted between two directly connected international centres to verify that the transmission and signalling on an international circuit of a given group are satisfactory.

b) *Type 2 test call*

A test call conducted between two international centres not directly connected to verify transit operational facilites of an intermediate international centre.

c) *Type 3 test call*

A test call from an international centre to a subscriber type number in the national network of the distant country, generally as a result of a particular kind of fault.

d) *Subscriber-to-subscriber type test call*

A subscriber-to-subscriber type test call is a test call from a test equipment having the characteristics of an average subscriber line in one national network to a similar equipment in the national network of a distant country.

Test calls types 1, 2, 3 and subscriber-to-subscriber test calls must not interfere with customer traffic. If, however, test calls contributing a significant load on a part of a network are to be made, prior advice should be given to the other Administration(s) concerned. Types 1 and 2 test calls for preventive maintenance should be conducted during light load periods. Types 1 and 2 test calls should be conducted as and when required for the investigation and clearance of faults.

Type 3 test calls should be conducted only after adequate testing has been done by means of type 1 or 2 test calls and after the distant Administration has made the necessary check in its national network. Type 3 test calls should be conducted during light load periods.

In order to find faults in last-choice equipment, it may be necessary for tests to be carried out at the time when the traffic load approaches the full capacity of the route under test. The agreement of the distant network analysis point will be necessary before this test is carried out.

Subscriber-to-subscriber type test calls can be made by agreement of the network analysis point in the countries concerned.

Normally, unless there is a specific agreement between the Administrations concerned, subscriber-to-subscriber type test calls would be considered for fault location after:

1) verifying that there are no evident faults in the international switching centres involved that would cause the poor quality of service or subscriber complaint being investigated;
2) verifying that type 1 or type 2 test calls have been made on the international circuits that might have been involved;
3) verifying that there are no evident faults in the national network from the outgoing exchange to the international centre in the originating country;
4) verifying that there are no evident faults in the national network in the distant country, from the international centre to the called exchange.

When subscriber-to-subscriber type test calls are made, the network analysis point in the two countries should consider such factors as:

i) the expected nature of the fault;
ii) international accounting agreements;
iii) the need for making the test calls in the busy hour;
iv) the possibility of causing or aggravating congestion at the time the calls are made.

The responding equipments used for subscriber-to-subscriber type test calls could be those used for maintenance of the national network.

2 **Results of test calls** (see Table 1/E.424)

3 Comments concerning the use of Table 1/E.424

3.1 Table 1/E.424 summarizes tests carried out manually or automatically to assess the functioning of the international circuit or connection.

3.2 It is essential to indicate clearly the way in which the tests have been carried out and to give full information about the testing apparatus used.

3.3 Administrations may insert additional categories in Table 1/E.424 as they see fit.

TABLE 1/E.424

Results of test calls

International outgoing exchange: ....

Circuit group: ....

Service { semi-automatic [a)]/ automatic [a)]

Period from .... to ....

Type of test call
Type 1 [a)]
Type 2 [a)]
Type 3 [a)]
Sub-to-Sub [a)]

Category	Number		Percentage	
	Subtotal	Total	Subtotal	Total
1. Satisfactory tests		...		...
2. Signalling and charging faults		...		...
2.1 Wrong number	...		...	
2.2 No tone, no answer	...		...	
2.3 Absence of a backward line signal	...		...	
2.4 Other faults	...		...	
3. Transmission faults		...		...
3.1 Conversation impossible	...		...	
3.2 Call overamplified or underamplified	...		...	
3.3 Noise	...		...	
3.4 Fading	...		...	
3.5 Crosstalk	...		...	
4. Congestion		...		...
5. Other faults	... ...	...	... ...	...
Tests carried out		...		100
Test procedure followed (apparatus used, destination of calls, etc.)				

a) Delete whichever is inapplicable.

GENERAL GUIDE TO THE PERCENTAGE OF EFFECTIVE ATTEMPTS WHICH SHOULD BE OBSERVED FOR INTERNATIONAL TELEPHONE CALLS

(Geneva, 1980)

1 General considerations

1.1 The success of call attempts is fundamental to an automatic international telephone service of high quality.

1.2 The periodic observation of efficiency rates [1] and the categorization of failures to destination countries together with the exchange of such information between countries are valuable to establish and/or maintain a high service quality.

1.3 The call efficiency rate of the national network of a given country, as manifested through its international switching centre(s), affects the efficiency of operation of all countries routing traffic to that country.

1.4 Call efficiency rate information can be provided either internally in an SPC international switching centre or externally at the level of the outgoing international circuits in any international switching centre in which access to the circuits is provided for the purpose of establishing the disposition of call attempts.

1.5 The availability, flexibility and capacity of minicomputers provides an economically attractive method of obtaining call efficiency rate information with extreme accuracy. This includes the observation of tones when suitable interfaces with the minicomputer are provided.

2 A guide to the proportion of effective call attempts

2.1 A general guide for the expected percentage of effective call attempts during the mean busy hour and its two immediately adjacent hours, as observed at the originating international switching exchange, is indicated below. An effective call attempt is defined, for this purpose, as one for which an answer is received at the originating international exchange. Faults caused by the originating international exchange shall be excluded to the extent feasible. All attempts which succeed in seizing an international circuit shall be included in the results:

a) low level of effective call attempts: less than 30%;

b) medium level of effective call attempts: 30% to 60%;

c) high level of effective call attempts: more than 60%.

2.2 When an originating country notes a downward change in the level of effective call attempts towards any destination, the originating, destination or transit Administrations should initiate investigations to determine and alleviate the underlying causes (e.g. network provisioning, subscriber behaviour). The objective of this action is to avoid degradation of the effective call attempts to a lower category.

[1] The efficiency rate is the percentage of call attempts which receive an answer signal.

COLLECTION AND STATISTICAL ANALYSIS OF SPECIAL QUALITY OF SERVICE OBSERVATION DATA FOR MEASUREMENTS OF CUSTOMER DIFFICULTIES IN THE INTERNATIONAL AUTOMATIC SERVICE

(Geneva, 1980)

This Recommendation is provided to permit the orderly collection of data required for special studies to identify sources of difficulty in customer use of the international automatic telephone service.

When calls are made to points outside a customer's home country, many different sets of ringing and busy tones are encountered. In order to measure the effect of unusual sounding ringing tones and busy tones on customer behaviour, it has been decided to collect data on how long customers listen to such foreign tones as well as to their national tones in order to compare them.

The data are to be collected in the same manner as those required for the completion of Table 1/E.422. These data are an extension of those collected for Table 1/E.422, and, as an aid to subsequent analysis, a copy of the current version of that table should be used with the table of this Recommendation.

Table 1/E.427 contains questions numbered 1-9. Their relationship to the questions of Table 1/E.422 is shown in parentheses.

A preferred set of analyses for identifying the statistical significance of differences between data collected from subscribers when setting up national calls and the corresponding data collected from subscribers when setting up international calls is given below.

1 Determine the percentage change in any measure by use of the formula:

$$\text{Change } (C_i) = \left[\frac{f_{ij}}{N_j} - \frac{f_{iH}}{N_H} \right] \times 100 \qquad j = \text{A, B, C}$$

$$i = 0\text{-}2,\ 2\text{-}5\ \ldots > 30$$

where

f_{ij} is the observed frequency of calls of category i in the country j,

N_j is the total number of observations in the country j sample,

f_{iH} is the observed frequency of calls of category i in the home country H, and

N_H is the total number of observations in the home country sample.

2 Compare the central location of the distributions by use of the Kruskal-Wallis One-Way Analysis of Variance [1].

3 Compare the "forms" or "shapes" of the distribution by means of the chi-square test [2].

4 Compare changes in single valued variables, e.g. percentage incomplete-trunk-code, by use the chi-square test.

TABLE 1/E.427
(Supplement to Table 1/E.422)

Observations of international outgoing telephone calls for quality of service
Additional details regarding subscriber dialled calls

Outgoing international exchange: ....

Group of circuits: ....

Period from .... to ....

Category	Number		Percentage	
	Subtotal	Total	Subtotal	Total
Details of dialled calls [a)b)c)]				
1. Calls with errors in the dialled number [d)]				
1.1(6.1) Wrong number dialled		...		100
1.1.1 Wrong country code	...		...	
1.1.2 National trunk prefix (e.g. "0") wrongly included	...		...	
1.1.3 Wrong trunk code	...		...	
1.1.4 Wrong subscriber number	...		...	
1.2(6.2) Incomplete number dialled		...		100
1.2.1 National (significant) number not dialled or incomplete	...		...	
1.2.2 Trunk code not dialled or incomplete	...		...	
1.2.3 Subscriber number not dialled or incomplete	...		...	
2. (5.3) (6.3) Calls abandoned prematurely before receipt of a tone or announcement		...		100
Interval from end of dialling to disconnect [e)]:				
0- 5 s	...		...	
5-10 s	...		...	
10-20 s	...		...	
20-30 s	...		...	
30-50 s	...		...	
> 50 s	...		...	
3. Post dialling delay on all calls that are maintained beyond the start of a tone or announcement		...		100
Interval from end of dialling to tone or announcement:				
0- 5 s	...		...	
5-10 s	...		...	
10-20 s	...		...	
20-30 s	...		...	
30-60 s	...		...	
60-90 s	...		...	
> 90 s	...		...	
Average excluded portion [f)] ...				
4. Calls that encounter ringing tones [g)]				
4.1(1) Completed calls		...		100
Interval from beginning of tone to answer:				
0-10 s	...		...	
10-20 s	...		...	
20-30 s	...		...	
30-50 s	...		...	
> 50 s	...		...	
4.2(2.6.4) Incomplete calls		...		100
Interval from beginning of tone to disconnect:				
0-10 s	...		...	
10-20 s	...		...	
20-30 s	...		...	
30-50 s	...		...	
> 50 s	...		...	

Category	Number		Percentage	
	Subtotal	Total	Subtotal	Total
5. (3.2) Calls that encounter busy/congestion tones [g]		...		100
Interval from beginning of tone to disconnect:				
0- 2 s	...		...	
2- 5 s	...		...	
5-20 s	...		...	
20-30 s	...		...	
> 30 s	...		...	
6. (4.2) Calls that encounter tones that the observer cannot identify		...		100
Interval from beginning of tone to disconnect:				
0- 2 s	...		...	
2- 5 s	...		...	
5-10 s	...		...	
10-30 s	...		...	
> 30 s	...		...	
7. (3.3, 4.3) Calls encountering recorded announcements		...		100
Interval from beginning of announcement to disconnect:				
0-10 s	...		...	
10-20 s	...		...	
20-30 s	...		...	
> 30 s	...		...	
8. List types of errors in dialling and tone interpretation which could not be categorized				
....				
....				
9. List restrictions on subscriber sample [h]				
....				
....				
....				

a) The term "calls" throughout this table refers to circuit seizures by outgoing traffic.

b) The data for each called country should be collected separately and not combined with other countries.

c) The interpretation of these results cannot be made adequately except by comparing them with similar results on national calls.

d) The practicability of putting the observation in category 1 will depend upon the observation access point and knowledge of the national numbering plan of the outgoing country and of the destination country.

e) 0- 5 s implies $0 \leq t \leq 5$.
5-10 s implies $5 < t \leq 10$.

f) The "post-dialling delay" measurements may not represent the actual delay from the time the subscriber finishes dialling to the receipt of tone. To the extent that this measurement as observed on the trunk excludes the time from completion of dialling to seizure of trunk, the average duration of this excluded time should be reported.

g) Identification of tone categories should be made by service observers who are trained to identify the tone categories reliably.

h) If access to the trunks being observed is restricted to some specified population of subscribers, e.g., heavy users, non-coin users, or residents of large urban centres, such restrictions should be noted and reported with the service observations.

References

[1] MARASCUILO (L. A.), McSWEENEY (M.): Non-Parametric and Distribution-Free Methods for the Social Sciences, *Wadsworth Publishing Co.*, California, 1977.

[2] SIEGEL (S.): Non-Parametric Statistics for the Behavioural Sciences, *McGraw Hill*, New York, 1956.

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PART II

Recommendations E.500 to E.543

TRAFFIC ENGINEERING

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SECTION 1

MEASUREMENT AND RECORDING OF TRAFFIC

Recommendation E.500

MEASUREMENT AND RECORDING OF TRAFFIC

1 Introduction

1.1 Traffic measurements provide the data base from which the planning, operation, management and in some cases accounting for transit considerations of the telephone network are carried out. Different applications may exist for the same traffic measurement. The various Recommendations of the E.500 Series, plus Recommendation E.410 in effect describe these applications.

1.2 This Recommendation and Recommendation E.502 describe the acquisition and preparation of traffic data needed to implement the other Recommendations mentioned. In particular, this Recommendation defines the load levels with which grade of service standards are to be associated, specifies the data which must be collected and describes the computation of the standard load levels from the collected data.

1.3 For the trunking (international) network, it is necessary to measure for individual circuit groups:

- traffic flow, bids and overflow/blocked bids,
- or seizures by individual groups.

The number of bids and preferably also the traffic flow should also be determined by individual relations (destinations). Data so obtained are applied as follows:

- in operations: for the activation of circuit groups;
- in planning: for dimensioning of circuit groups; routing exchanges, establishment of new links.

1.4 Exchanges are complex combinations of interacting components. As a consequence bids, seizures and overflow/blocked bids, queue lengths and traffic flow may have to be measured by individual equipment component groups as dictated by the structure of the exchange. These data are applied as follows:

- in operations: for loading and balancing;
- in planning: for routine and major additions to and rearrangement of equipment quantities in response to growth.

1.5 In the longer term, the planning of the establishment of new exchanges makes use of both circuit and exchange measurements.

1.6 The measurements required for network management are generally similar to those described above, but are defined in Recommendation E.410. They will in general require a variable and shorter reporting interval.

2 Normal and high load levels

Traffic measurements must provide base data for calculating the following parameters:

1) "normal" and "high" load traffic flow, and

2) number of call attempts,

For estimating future circuit group and exchange requirements.

Using time consistent busy hours normal and high load are defined [1] in Tables 1/E.500 and 2/E.500.

TABLE 1/E.500

Circuit groups

Parameter	Normal load	High load
Traffic flow	Mean of the 30 highest working [a] days during a 12-month period	Mean of the five highest days in the same period as normal load
Number of bids	Mean of the same 30 days on which the traffic flows are highest	Mean of same five days on which the traffic flows are the highest

[a] Usually working days are used, but Administrations may also require other measurements to provide for particular cases as described in § 3.

TABLE 2/E.500

Exchanges

Parameter	Normal load	High load
Traffic flow	Mean of the ten highest days during a 12-month period	Mean of the five highest days in the same period as normal load
Number of bids	Mean of the ten highest days (not necessarily the same as the highest traffic flow days) during a 12-month period	Mean of the five highest days (not necessarily the same as the highest traffic flow days) in the same period as normal load

Where appropriate, all traffic engineering Recommendations should have a reference to these load level definitions.

Where continuous measurements are available, the base data corresponding to normal and high load parameters can be selected directly from the full year's data. Where limited sample measurements are used, the base data must be derived from the measurement results (under study during the 1981-1984 Study Period.)

In some circumstances, such as with noncontinuous measurements, actual values of high day loads are not available. In such cases, various Administrations use standard ratios of high to normal load for forecasting for design or planning purposes. Such ratios depend on the environment in which the exchange will operate. In particular, the size and type of the exchange and the definitions of high and normal load should be considered.

[1] These definitions are tentative and will be evaluated during the 1981-1984 Study Period.

For example, as a general order of magnitude, the following ratios of high to normal load may be used as a guide for a healthy network:

Parameter	*Circuit groups*	*Exchanges*
Traffic flow	1.2	1.1
Number of bids	1.4	1.2

3 Measurement of traffic flow, bids and overflow/blocked bids or seizures

Traffic statistics should be measured for the significant period of each day of the whole year by automatic measuring and recording equipment capable of running continuously, if possible. The significant period may in principle be 24 hours of the day.

3.1 *Continuous measurements*

The base measurements for computing normal traffic load should be the 30 highest days in a fixed 12-month period. Normally these will be working days, but in some cases separate weekend or tariff-related period measurements should be examined so that Administrations can agree bilaterally on appropriate measures to maintain a reasonable grade of service (GOS) for weekends and tariff-related periods. Recurring exceptional days (e.g. Christmas, Mother's Day, etc.) should be excluded for planning purposes although the data should be collected for network management purposes (Recommendation E.410). This method gives traffic information of relatively high accuracy and is suitable for circuit groups operated automatically or semiautomatically.

3.1.1 *Traffic measurements for different types of groups*

The traffic-recording device is required particularly to collect carried-traffic statistics. As a general rule, carried-traffic measurements will refer to the whole of a group of circuits between two exchanges. Such circuits may carry one-way or both-way traffic.

3.1.1.1 *Direct (point-to-point) circuit groups*

In some cases, the traffic for a particular relation will use an independent group of direct circuits (without overflow facilities) and the traffic measurement should be made according to § 3.1 above.

3.1.1.2 *High-usage and final circuit groups*

Some relations will be served by high-usage routes and by final routes. In such cases, the high-usage and final routes can be measured according to § 3.1 above.

High-usage and final group arrangements form a network; therefore, all measurements for all groups within the network *must* be measured during the *same* time period. This requirement is necessary to develop first route loads (for forecasting and planning).

3.1.2 *Exchange measurements*

Recording equipment should make a record of the traffic flow, bids, overflow/blocked bids or seizures and queue lengths by individual equipment component groups as dictated by the structure of the exchange (see § 2 for time periods to be measured). Busy hours may vary between types of equipment component groups and the traffic flow busy hour may differ from bid busy hour for the same component.

3.2 *Noncontinuous measurements*

A second method which yields information of a lower degree of accuracy may be used by Administrations. This second method allows less control over the day-to-day operation of the network and may involve extra network cost.

This method comprises the taking of measurements in one or more periods of ten consecutive days during the year, of which at least one period is during the busiest season (this busiest season might be determined by use of accounting data or other additional information).

Limited sample measurements will normally be taken on working days, but Administrations may agree bilaterally to measure weekend or reduced tariff periods separately or to exclude certain low-traffic periods from the sample.

As a principle, the results of a noncontinuous measurement should be as close as possible to the results that would be obtained if a continuous measurement were used.

3.3 *Determination of time-consistent busy hour*

To determine the time-consistent busy hour:

- for a number of consecutive days, the carried traffic values observed for the same quarter of an hour each day are added together;
- the time-consistent busy hour is then determined as being the four consecutive quarter-hours which together give the largest sum of observed values [2].

This procedure applies equally both to exchanges and to individual circuit groups. In principle, the time-consistent busy hour may be different for each circuit group and different again for the exchange itself.

3.4 *Notification of mean busy hour traffic, bids and seizures on circuit groups*

All traffic measurement results collected according to § 3.1 above should be communicated to other Administrations concerned.

[2] When more than one mean hour has the same amount of carried traffic flow, due to saturation, offered traffic must be calculated using carried traffic flow, bids and overflow/blocked bids. (Various computational methods will be evaluated in the 1981-1984 Study Period).

SECTION 2

FORECASTING OF TRAFFIC

Recommendation E.502

FORECASTING INTERNATIONAL TELEPHONE TRAFFIC

1 Introduction

In the operation and administration of the international telephone network, proper and successful development depends to a large degree upon estimates for the future. Accordingly, for the planning of equipment and circuit provision, and of telephone plant investments, it is necessary that Administrations forecast the traffic the network will carry. In view of the heavy capital investments in the international network, the economic importance of the most reliable forecast is evident.

2 Base data for forecasting

2.1 An international route may carry not only point-to-point traffic between international exchanges of terminal countries, but also transit traffic destined for or arriving from other points in the international network. Therefore forecasts for each of these components are required. The forecasts should be prepared by the Administration originating the traffic jointly where applicable with any other Administration proceeding a transit function for the traffic component, and should be supplied to the destination Administration and any other Administration involved in transit arrangements. It also has to be recognized that certain adjustments between the two ends of a traffic relation may be necessary in arriving at the final forecast.

2.2 There are two different strategies for deriving future international circuit quantities, namely the *direct Erlang forecasting strategy* which is based on forecasting the offered busy-hour Erlang traffic and which is a more direct method where the necessary data is available, and the *composite forecasting strategy* which is based on forecasting monthly paid minutes and various traffic-dependent conversion factors.

2.3 With direct Erlang forecasting, the traffic carried (in Erlangs) for each relation would be regarded as base data in forecasting traffic growth.

2.4 Composite forecasting uses two sets of base data:

- historical international accounting data of monthly paid minute traffic, and
- a number of factors which are used for converting a paid-minutes forecast on the basis of the accounting data into busy-hour Erlang forecasts.

2.5 Administrations planning installation of traffic measuring equipment are advised to ensure that this equipment records the data in computer-legible form (punched paper tape, magnetic tape, etc.). This greatly facilitates computer processing and makes it easier to analyze more frequent measurements.

3 Length of forecast period

For normal extensions of switching equipment and additions of circuits, a forecast period of about six years is necessary. However, a longer forecast period may be necessary for the planning of new cables or other transmission media, or for major plant installations. Estimates in the long term would necessarily be less accurate than short-term forecasts but that would be acceptable.

4 Methods and models appropriate to international forecasting

4.1 In accordance with the direct Erlang forecasting strategy (§ 2.3), an Administration would at regular intervals measure the level of busy-hour traffic carried for each relation. The carried traffic is converted to offered traffic in accordance with the formula:

$$A = y/(1 - B)$$

where

y is the design date traffic carried, and

B is the design date point-to-point grade of service.

The offered busy-hour traffic levels form the basis for forecasting future offered traffic.

4.2 In accordance with the composite forecasting strategy (§ 2.4) monthly paid-minute traffic demands are forecast using historical international accounting records of monthly paid-minutes. The forecasts are converted to dimensioning busy-hour Erlang forecasts by the application of a number of traffic related conversion factors forecast for each service category. The conversion is carried out in accordance with the formula

$$A = Mdh/60e$$

where

A is the busy hour offered traffic in Erlangs,

M is the monthly paid minutes,

d is day-to-month ratio,

h is the busy hour-to-day ratio, and

e is the efficiency factor.

The formula is described in detail in Annex A.

4.3 In order to prepare a traffic forecast, it is necessary to take into account irregularly recurring features which may have affected past traffic or may affect present traffic. Examples are changes in tariffs, changes in the signalling system, major changes in the structure of the network, removal of bottlenecks in the network, and the substitution of subscriber-to-subscriber dialling methods replacing manual methods of setting up calls. Changes that affect the environment may introduce discontinuities in the traffic profile and may shorten or lengthen the duration of the peak period, i.e. alter the busy-hour/day ratio, to a considerable extent and affect the concentration of traffic in this period. Administrations should develop means of identifying these factors and evaluating them quantitatively (see examples of discontinuities in the graphs of Figures 2/E.502, 3/E.502, 4/E.502 and 5/E.502). From such an evaluation it will be possible to make a modified set of values of past traffic from which a future trend may be extrapolated.

Where such discontinuities are identified, it is advantageous to use the composite forecasting strategy method to aid in the quantitative evaluation of the discontinuities. This is true even where the direct Erlang forecasting method is used for the projections.

4.4 Wherever possible, both the direct and composite forecasting strategies should be used and compared. This comparison may reveal irregularities not evident from the use of only one method. Where these are significant, in particular in the case of the busy hour, the causes for the differences should be identified before the resulting forecast is adopted.

4.5 An adaptive forecasting system using time as an independent variable is recommended for estimates of the future traffic from the values derived in accordance with § 4.3 above. On this basis, the traffic trend is extrapolated by calculating the values of the parameters of some function which is expected to characterize the growth of international traffic. The numerical calculations in curve fitting can be performed by using the least squares method. If the traffic values available cannot be expected to yield mathematically reliable values, a rough survey can be obtained by simply plotting a continuation of the curve of available traffic data.

In view of the historical absence of saturation effects in international communications, and taking account of the prospects for future expansion, a simple exponential or parabolic function may be used to represent the growth of international telephone traffic. The equations of these two functions are given below:

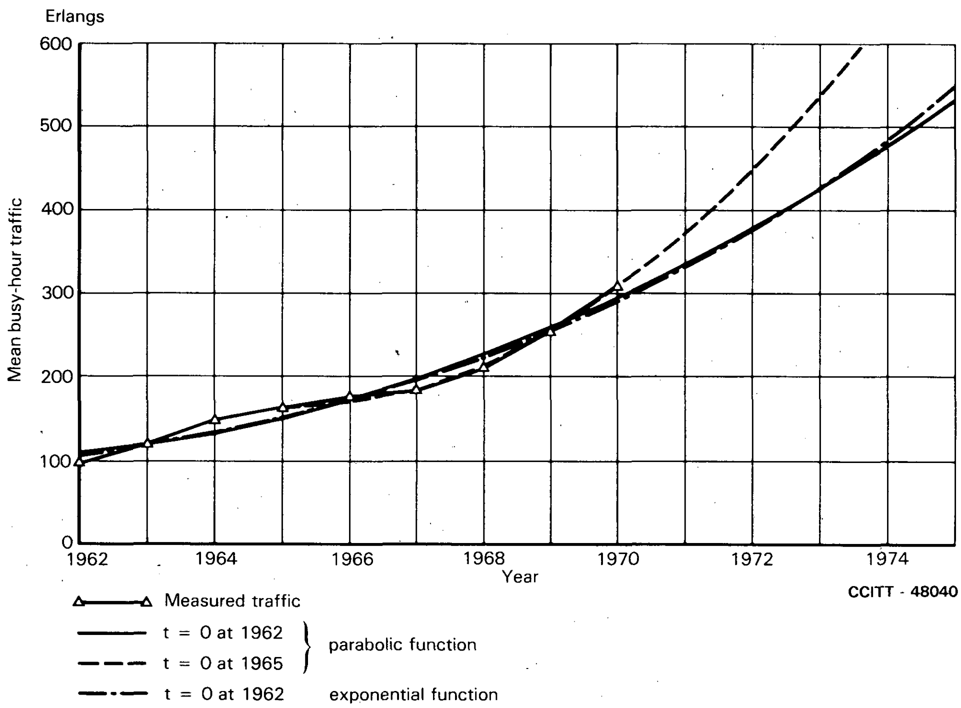
Exponential: $Y_t = Ae^{Bt}$

Parabolic: $Y_t = A + Bt + Ct^2$

In the above equations, Y_t is the traffic after t time intervals, while A, B and C are constants (parameters depending on the route observed). It is found that both these functions can be used for forecasts up to, say, six years, whereas the parabolic function can be applied for longer-term forecasts. However, care must be applied in the use of the parabolic function if the estimate of C is negative.

Examples of curve fitting by means of the method of least squares applied to traffic data from some international telephone relations are given in the graphs of Figures 1/E.502 to 3/E.502. In the examples the growth trends are approximated by the exponential and parabolic functions.

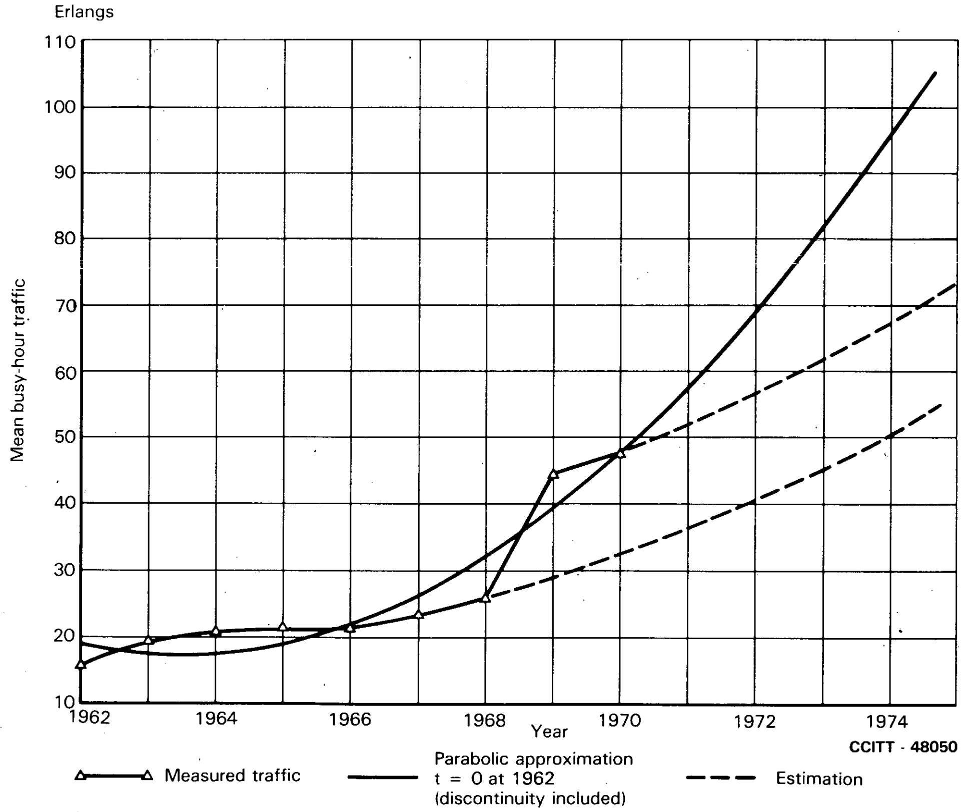
For prediction of changes in factors used for composite forecasting, a linear forecasting model may be sufficient.



Mean busy-hour traffic (Erlangs); 10 consecutive working days, Recommendation E.500, § 3.2.

FIGURE 1/E.502

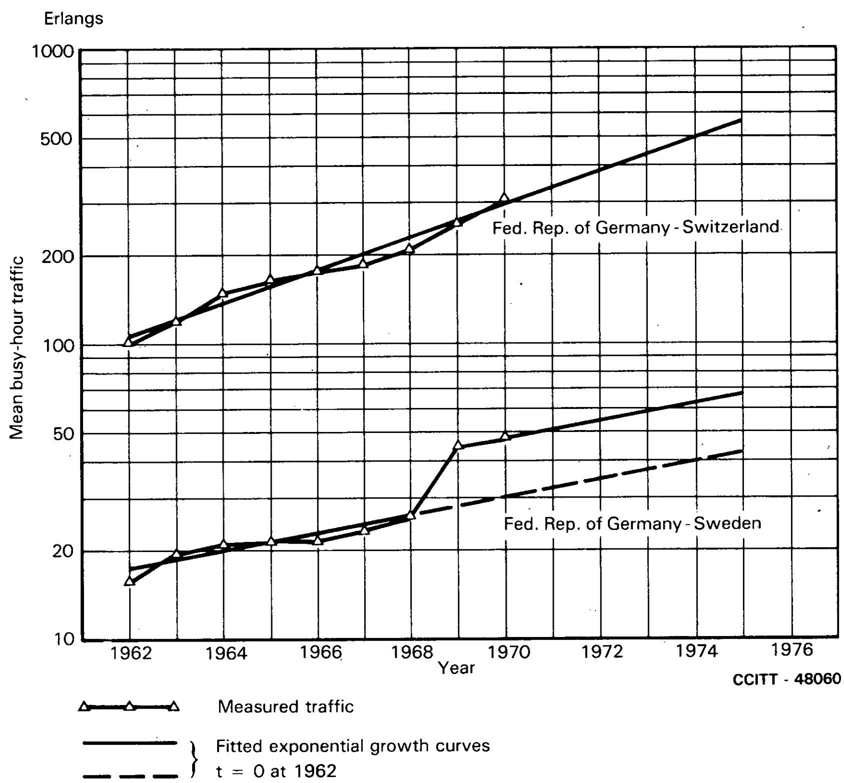
Mean busy-hour traffic Federal Republic of Germany - Switzerland



Mean busy-hour traffic (Erlangs); 10 consecutive working days, Recommendation E.500, § 3.2.

FIGURE 2/E.502

Mean busy-hour traffic Federal Republic of Germany - Sweden



Mean busy-hour traffic (Erlangs); 10 consecutive working days, Recommendation E.500, § 3.2.

FIGURE 3/E.502

Mean busy-hour traffic Federal Republic of Germany - Switzerland and Federal Republic of Germany - Sweden

4.6 By using a smoothing process in curve fitting, it is possible to calculate the parameters of the model to fit current data very well but not necessarily the data obtained a long time ago.

The best known smoothing process is the moving average. The degree of smoothing is controlled by the number of most recent observations included in the average. All observations included in the average have the same weight. In the method of exponential smoothing the weight given to previous observations decreases geometrically with age. The speed with which the effect of past observations is reduced is controlled here by the chosen value of a smoothing constant. Use of smoothing methods is appropriate especially for short-term forecasts.

4.7 The historical data for forecasting purposes must be extended into the past far enough to include a sufficient number of observations for estimating the values of the parameters in the fitting curve or regression function. Historical data are needed for a period which is at least as long as the forecast period.

4.8 The forecasting methods recommended are suitable for computer application.

5 Discontinuities in traffic growth

It may be difficult to assess in advance the magnitude of a discontinuity. The influence of the factors which cause discontinuities often is spread over a transitional period, the discontinuity is then not so obvious. Furthermore, discontinuities arising from the introduction of, for example, international subscriber dialling are difficult to identify accurately, because changes in the method of working are usually associated with other changes (e.g. tariff reductions).

An illustration of the bearing of discontinuities on traffic growth can be observed in the graphs of Figures 2/E.502, 3/E.502, 4/E.502 and 5/E.502.

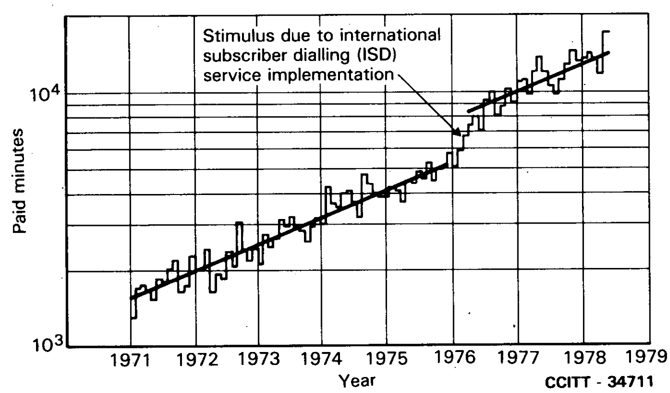


FIGURE 4/E.502

Outgoing telephone paid-minutes from Australia to Sweden

Discontinuities representing the doubling and even more of traffic flow are known. It may also be noted that changes could occur in the growth trend after discontinuities.

In Annex B the experiences of some Administrations with irregularities in traffic growth are presented.

In short-term forecasts it may be desirable to use the trend of the traffic between discontinuities, but for long-term forecasts it may be desirable to use a trend estimate which is based on long-term observations, including previous discontinuities.

In addition to random fluctuations due to unpredictable traffic surges, faults, etc., traffic measurements are also subject to systematic fluctuations, due to daily or weekly traffic flow cycles, influence of time differences, etc.

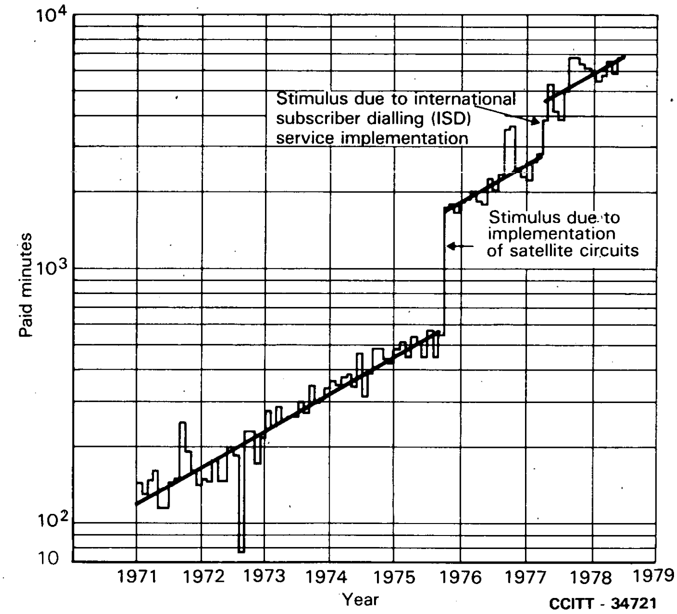
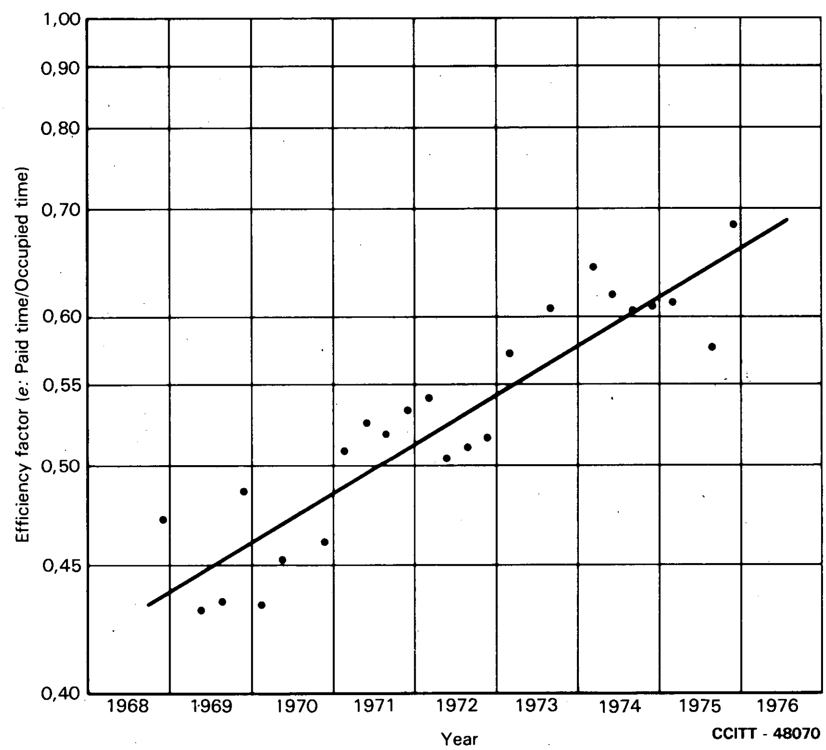


FIGURE 5/E.502

Outgoing telephone paid-minutes from Australia to Sri Lanka



Note 1 – Straight-line graph drawn on basis of least-squares method.

Note 2 – Practical limit for *e* is generally about 0.8 to 0.9.

FIGURE 6/E.502

Efficiency factor for semiautomatic traffic from Australia to United Kingdom

6 Accuracy in forecasting

The accuracy of the forecast depends on the completeness of information, the identification of the causes of past and present conditions and the skill of judgement. It is apparent that particularly in forecasting international traffic the forecasts must of necessity contain a high degree of informed judgement (see § 5 above).

A forecast made for the total outgoing international traffic of a country is usually more accurate than the sum of individual forecasts made for routes or on a point-to-point basis. However, these individual forecasts are necessary. An approach in forecasting both from a "top down" and a "bottom up" concept ensures maximum efficiency and control. If substantial deviations occur between these independently prepared views, the underlying basic assumptions and factors affecting growth should be analyzed and the two views reconciled within a reasonable relationship.

The composite forecasting strategy allows forecasts to be made for traffic on small streams without actual measurement of conversion factors for these streams. Instead, factors for a similar stream from the same or different Administration can be used, e.g. if the paid time/occupied time ratio for a small stream A-B is not available, the factor for a larger stream C-B from another Administration could be used because efficiency is largely independent of origin of call, provided that similar equipment and operating procedures are used.

Because most CCITT signalling systems do not send the country code for the country of origin, it is not currently possible to measure conversion factors for incoming stream traffic. If several Administrations were to measure and exchange the outgoing conversion factors for their larger streams, all Administrations would benefit from this shared data base and the potential accuracy of the composite forecasting method would be more fully realized. Wider availability of measured conversion factors would also enable better insight into the traffic conditions applying.

7 Follow-up of forecasts made

It is essential to make regular comparisons between forecasts made and subsequent observed growth. Reasons for significant differences should be analyzed, and forecasts made should be revised in the light of the result of this analysis. Furthermore, whenever information is received about changes in factors affecting growth, e.g. changes in the tariff structure, forecasts made should be modified.

The foregoing recommendations and observations are intended as a guide and it can be hoped that, with increasing experience, better and more accurate methods will be developed and especially that these can be made, for the most part, suitable for computer implementation. However, some human judgement will always be required in making traffic forecasts.

ANNEX A

(to Recommendation E.502)

The composite forecasting strategy

A.1 *Introduction*

This annex describes a method for forecasting international telephone traffic based on monthly paid-minutes and a number of conversion factors. It demonstrates the method by examining the factors and showing their utility.

The method is seen to have two main features:

1) Monthly paid-minutes exchanged continuously between Administrations for accounting purposes provide a large and continuous volume of data, and graphic and econometric methods can be used for forecasting them.

2) Traffic conversion factors are relatively stable, when compared with traffic growth, and change slowly since they are governed by customers' habits and network performance. By separately considering the paid minutes and the traffic conversion factors, we gain an insight into the nature of traffic growth which cannot be obtained by circuit occupancy measurements alone. Because of the stability of the conversion factors, these may be measured using relatively small samples, thus contributing to the economy of the procedure.

A.2 *Basic procedure*

A.2.1 *General*

The composite forecasting strategy is carried out for each stream, for each direction, and generally for each service category. Essentially, it requires a forecast of monthly paid-minutes to be made, to which are applied forecasts of various conversion factors.

The mean offered busy-hour traffic (in Erlangs) is derived from the monthly paid-minutes using the formula:

$$A = Mdh/60e$$

where

A is the mean traffic in Erlangs offered in the busy hour,

M is the total monthly paid-minutes,

d is the day/month ratio, i.e., the ratio of average weekday paid-time to monthly paid-time,

h is the busy-hour/day ratio, i.e., the ratio of the busy-hour paid-time to the average daily paid-time,

e is the efficiency factor, i.e., the ratio of busy-hour paid-time to busy-hour occupied-time.

A.2.2 *Monthly paid minutes* (M) [1)]

The starting point for the composite strategy is paid minutes. Sudden changes in subscriber demand, for example, resulting from improvements in transmission quality, have a time constant of the order of several months, and on this basis paid minutes accumulated over monthly intervals appear to be optimum in terms of monitoring traffic growth. A longer period (e.g. annually) tends to mask significant changes, whereas a shorter period (e.g. daily) not only increases the amount of data, but also increases the magnitude of fluctuations from one period to the next. A further advantage of the one-month period is that monthly paid-minute figures are exchanged between Administrations for accounting purposes, and consequently historical records covering many years are normally readily available.

It should be recognized, however, that accounting information exchanges between Administrations often takes place after the event, and may take some time to reach full adjustments (e.g. collect call traffic).

A.2.3 *Day/month ratio* (d)

This ratio is related to the amount of traffic carried on a typical weekday compared with the total amount of traffic carried in a typical month. It is convenient to regard a typical month as having 30.42 days (365/12), including 21.73 weekdays and 8.69 Saturdays and Sundays.

Hence $1/d = 21.73 + 8.69 \times r$,

where

$$r = \frac{\text{average non-weekday traffic}}{\text{average weekday traffic}}$$

The relative amount of non-weekday traffic is very sensitive to the relative amount of social contact between origin and destination. (Social calls, are, in general, made more frequently on weekends.) Since changes in such social contact would be very slow, r or d are expected to be the most stable conversion factor, which in general vary only within relatively narrow limits. However, tariff policies such as reduced weekend rates can have a significant effect on r and d. Some typical values are shown below:

Social Contact	*Typical weekend/weekday traffic ratio,* r	*Day-to-Month ratio,* d
Low	0.2	0.0426
Medium	0.5	0.0384
High	1.3	0.0303

1) In situation where only yearly paid-minutes are available, this may be converted to M by a suitable factor.

When r is in the region of 1, the Sunday traffic may exceed the typical weekday level. If this is the case, consideration should be given to dimensioning the route to cater for the additional weekend (Sunday) traffic or adopting a suitable overflow routing arrangement.

A.2.4 *Busy-hour/day ratio* (h)

The relative amount of average weekday traffic in the busy hour primarily depends on the difference between the local time at origin and destination. Moderately successful attempts have been made to predict the diurnal distribution of traffic based on this information together with supposed "degree of convenience" at origin and destination. However, sufficient discrepancies exist to warrant measuring the diurnal distribution, from which the busy-hour/day ratio may be calculated.

Where measurement data is not available, a good starting point is Recommendation E.523. From the theoretical distributions found in Recommendation E.523, one finds variations in the busy-hour/day ratio from 10% for 0 to 2 hours time difference, and up to 13.5% for 7 hours time difference.

A.2.5 *Efficiency factor* (e)

The efficiency factor [ratio of busy-hour paid time to busy-hour occupied time (e)] converts the paid time into a measure of total circuit occupancy. It is therefore necessary to include all occupied circuit time in the measurement of this ratio, and not merely circuit time taken up in establishing paid calls. For example, the measurement of total circuit occupied time should include the occupied time for paid calls (time from circuit seizure to circuit clearance) and, in addition, the occupied time for directory enquiry calls, test calls, service calls, ineffective attempts and other classes of unpaid traffic handled during the busy hour.

As shown in the graph in Figure 6/E.502, there is a tendency for the efficiency to change with time. In this regard, efficiency is mainly a function of operating method (manual, semiautomatic, international subscriber dialling), the B-subscriber's availability, and the quality of the distant network.

Forecasts of the efficiency can be made on the basis of extrapolation of past trends together with adjustments for planned improvements.

The detailed consideration of efficiency is also an advantage from an operational viewpoint in that it may be possible to identify improvements that may be made, and quantify the benefits deriving from such improvements.

It should be noted that the practical limit for e is generally about 0.8 to 0.9 for automatic working.

A.2.6 *Mean offered busy hour traffic* (A)

It should be noted that A is the *mean* offered busy-hour traffic (expressed in Erlangs).

A.2.7 *Use of composite forecasting*

In the case of countries with lower traffic volumes and manual operation, the paid-time factors (d and h) would be available from analysis of call vouchers (dockets). For derivation of the efficiency e, the manual operator would have to log the busy-hour occupied time as well as the paid time during the sampling period.

In countries using stored programme controlled exchanges with associated manual assistance positions, computer analysis may aid the composite forecasing procedure.

One consequence of the procedure is that the factors d and h give a picture of subscriber behaviour, in that unpaid time (enquiry calls, test calls, service calls, etc.) are not included in the measurement of these factors. The importance of deriving the efficiency, e during the busy hour, should also be emphasized.

A.3 *Alternative traffic-based implementation*

As described above, the composite forecasting strategy is implemented as an accounting-based procedure. However, it may be more practical for some Administrations to measure d and h based on occupied time, derived from available call recording equipment.

A.4 *Summary*

The composite forecasting strategy isolates a very volatile aspect of traffic behaviour, namely growth, from traffic characteristics.

By isolating growth from traffic characteristics, attention is focused on a number of significant aspects of traffic behaviour. These aspects are expressed in a number of conversion factors. These factors are seen as being most useful for those Administrations using direct Erlang forecasting because of the insight they give into future traffic behaviour.

As mentioned in § A.2.7 above, where Administrations lack the equipment and procedures enabling these factors to be measured continuously, the factors may be determined from a sample of all vouchers (dockets) and a measurement of busy-hour traffic (occupied time).

If a number of Administrations each builds up a separate data base of conversion factors for its streams, some of the conversion factors can be compared bilaterally and shared among the Administrations. Furthermore, smaller Administrations can make use of comparable conversion factors and gain a better insight into traffic forecasting, even if their measurement resources are limited at present.

ANNEX B

(to Recommendation E.502)

TABLE B-1/E.502

Experience of the Australian Administration with traffic discontinuities

Effects of conversion from HF radio to a high-quality submarine cable system (COMPAC cable)

Stream	Stimulus (%)	Growth rate (%)	
		Before cable	After cable
Australia - New Zealand	84	7.5	28.3
Australia - United Kingdom	168	5.2	30.7
Australia - United States	53	8.5	33.1

Note 1 – Cable working to New Zealand commenced in July 1962 and to UK and USA in December 1963.

Note 2 – The above figures are based on statistics of outgoing paid-minutes over the period 1955-1968 (New Zealand, USA), and 1945-1968 (UK).

TABLE B-2/E.502

Examples of Cable and Wireless Ltd. experience concerning the effects of conversion from HF radio to high-quality wideband systems

Stream	Terminal paid-minutes in preceding year	Stimulus %	Growth rate (%)		Type and date of new system
			Before	After	
Hong Kong - USA					
Outgoing	121 000	116	16	71	Cable, August 1966
Incoming	212 000	69	72	56	
Hong Kong - Indonesia					
Outgoing	57 000	91	9	25	Cable/satellite, August 1970
Incoming	45 000	103	22	38	
Bahrain - United Kingdom					
Outgoing	32 400	0	99	59	Satellite, July 1969
Incoming	13 000	43	56	29	
Bahrain - Dubai					
Outgoing	17 500	60	63	70	Tropospheric scatter, July 1969
Incoming	17 500	50	40	56	
Barbados - Guyana					
Outgoing	11 600	122	22	11	Tropospheric scatter, March 1969
Incoming	12 000	182	4	5	
Antigua - USA					
Outgoing	11 000	117	91	37	Tropospheric scatter/cable, August 1966
Incoming	15 400	137	84	29	
Mauritius - Reunion					
Outgoing	12 500	140	9	38	VHF, October 1971
Incoming	22 000	137	12	47	
Fiji - New Zealand					
Outgoing	2 100	290	18	56	Cable, December 1972
Incoming	2 400	300	5	94	

Note 1 – Growth rates represent the trend over the 12 months before and after conversion, calculated at an annual rate.

Note 2 – The Bahrain - United Kingdom HF route and the Barbados - Guyana route were equipped with Lincompex.

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SECTION 3

DETERMINATION OF THE NUMBER OF CIRCUITS IN MANUAL OPERATION

Recommendation E.510 [1)]

DETERMINATION OF THE NUMBER OF CIRCUITS IN MANUAL OPERATION

1 The quality of an international manual demand service should be defined as the percentage of call requests which, during the average busy hour (as defined later under § 3) cannot be satisfied immediately because no circuit is free in the relation considered.

By *call requests satisfied immediately* are meant those for which the call is established by the same operator who received the call, and within a period of two minutes from receipt of that call, whether the operator (when she does not immediately find a free circuit) continues observation of the group of circuits, or whether she makes several attempts in the course of this period.

Ultimately, it will be desirable to evolve a corresponding definition based on the *average speed* of establishing calls in the busy hour, i.e. the average time which elapses between the moment when the operator has completed the recording of the call request and the moment when the called subscriber is on the line, or the caller receives the advice *subscriber engaged, no reply*, etc. But for the moment, in the absence of information about the operating time in the European international service, such a definition cannot be established.

2 The number of circuits it is necessary to allocate to an international relation, in order to obtain a given grade of service, should be determined as a function of the *total holding time* of the group in the busy hour.

The total holding time is the product of the number of calls in the busy hour and a factor which is the sum of the average call duration and the average operating time.

These durations will be obtained by means of a large number of observations made during the busy hours, by agreement between the Administrations concerned. If necessary, the particulars entered on the tickets could also serve to determine the average duration of the calls.

The average call duration will be obtained by dividing the total number of minutes of conversation recorded by the recorded number of effective calls.

The average operating time will be obtained by dividing the total number of minutes given to operating (including ineffective calls) by the number of effective calls recorded.

3 The number of calls in the busy hour will be determined from the average of returns taken during the busy hours on a certain number of busy days in the year.

Exceptionally busy days, such as those which occur around certain holidays, etc., will be eliminated from these returns. The Administrations concerned should plan, whenever possible, to put additional circuits into service for these days.

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1) This Recommendation dates from the XIIIth Plenary Assembly of the CCIF (London, 1946) and has not been fundamentally revised since. It was studied under Question 13/II in the Study Period 1968-1972 and was found to be still valid.

In principle, these returns will be taken during the working days of two consecutive weeks, or during ten consecutive working days. If the monthly traffic curve shows only small variations, they will be repeated twice a year only. They will be taken three or four times a year or more if there are material seasonal variations, so that the average established is in accordance with all the characteristic periods of traffic flow.

4 The total occupied time thus determined should be increased by a certain amount determined by agreement between the Administrations concerned according to the statistics of traffic growth during earlier years, to take account of the probable growth in traffic and the fact that putting new circuits into service takes place some time after they are first found to be necessary.

5 The total holding time of the circuits thus obtained, in conjunction with a suitable table (see Table 1/E.510), will enable the required number of circuits to be ascertained.

6 In the international manual telephone service, the following Tables A and B should be used as a basis of minimum allocation:

Table A corresponds to about 30% of calls failing at the first attempt because of all circuits being engaged and to about 20% of the calls being deferred.

Table B, corresponding to about 7% of calls deferred, will be used whenever possible.

These tables do not take account of the fact that the possibility of using secondary routes permits, particularly for small groups, an increase in the permissible occupation time.

TABLE 1/E.510

Capacity of circuit groups

(See Supplement No. 2 at the end of this fascicle)

Number of circuits	Table A		Table B	
	Percentage of circuit usage	Minutes of circuit usage possible in the busy hour	Percentage of circuit usage	Minutes of circuit usage possible in the busy hour
1	65.0	39	–	–
2	76.7	92	46.6	56
3	83.3	150	56.7	102
4	86.7	208	63.3	152
5	88.6	266	68.3	205
6	90.0	324	72.0	259
7	91.0	382	74.5	313
8	91.7	440	76.5	367
9	92.2	498	78.0	421
10	92.6	556	79.2	475
11	93.0	614	80.1	529
12	93.4	672	81.0	583
13	93.6	730	81.7	637
14	93.9	788	82.3	691
15	94.1	846	82.8	745
16	94.2	904	83.2	799
17	94.3	962	83.6	853
18	94.4	1020	83.9	907
19	94.5	1078	84.2	961
20	94.6	1136	84.6	1015

Note – Tables A and B can be extended for groups comprising more than 20 circuits by using the values given for 20 circuits.

SECTION 4

DETERMINATION OF THE NUMBER OF CIRCUITS IN AUTOMATIC AND SEMIAUTOMATIC OPERATION

Recommendation E.520

NUMBER OF CIRCUITS TO BE PROVIDED IN AUTOMATIC AND/OR SEMIAUTOMATIC OPERATION, WITHOUT OVERFLOW FACILITIES

This Recommendation refers to groups of circuits used:

- in automatic operation;
- in semiautomatic operation;
- in both automatic and semiautomatic operations on the same group of circuits.

1 General method

1.1 The CCITT recommends that the number of circuits needed for a group should be read from tables or curves based on the classical Erlang B formula (see Supplements Nos. 1 and 2 at the end of this fascicle which refers to full availability groups). Recommended methods for traffic determination are indicated in Recommendation E.500.

For *semi-automatic operation* the loss probability p should be based on 3% during the mean busy hour.

For *automatic operation* the loss probability p should be based on 1% during the mean busy hour.

Semiautomatic traffic using the same circuits as automatic traffic is to be added to the automatic traffic and the same parameter value of $p = 1\%$ should be used for the total traffic.

The values of 3% and 1% quoted above refer to the Erlang B formula and derived tables and curves. The 3% value should not be considered as determining a grade of service because with semiautomatic operation there will be some smoothing of the traffic peaks; it is quoted here only to determine the value of the parameter p (loss probability) to use in the Erlang B tables and curves.

1.2 In order to provide a satisfactory grade of service both for the mean busy-hour traffic and for the traffic on exceptionally busy days, it is recommended that the proposed number of circuits should, if necessary, be increased to ensure that the loss probability shall not exceed 7% during the mean busy hour for the average traffic estimated for *the five busiest days* as specified in Recommendation E.500.

1.3 For *small groups of long intercontinental circuits* with automatic operation some relaxation could be made in respect to loss probability. It is envisaged that such circuits would be operated on a both-way basis and that a reasonable minimum for automatic service would be a group of six circuits. A table providing relaxation in Annex A is based on a loss probability of 3% for six circuits, with a smooth progression to 1% for 20 circuits. The general provision for exceptional days remains unchanged.

For exceptional circumstances in which very small groups (less than six intercontinental circuits) are used for automatic operation, dimensioning of the group should be based on the loss probability of 3%.

2 Time differences

Time differences at the two terminations of intercontinental circuits are likely to be much more pronounced than those on continental circuits. In order to allow for differences on groups containing both-way circuits it will be desirable to acquire information in respect to traffic flow both during the mean busy hour for both directions and during the mean busy hour for each direction.

It is possible that in some cases overflow traffic can be accepted without any necessity to increase the number of circuits, in spite of the fact that this overflow traffic is of a peaky nature. Such circumstances may arise if there is no traffic overflowing from high-usage groups during the mean busy hour of the final group.

3 Both-way circuits

3.1 With the use of both-way circuits there is a danger of simultaneous seizure at both ends; this is particularly the case on circuits with a long propagation time. It is advisable to arrange the sequence of selection at the two ends so that such double seizure can only occur when a single circuit remains free.

When all the circuits of a group are operated on a both-way basis, time differences in the directional mean busy hours may result in a total mean busy-hour traffic flow for the group which is not the sum of the mean busy-hour traffic loads in each direction. Furthermore, such differences in directional mean busy hour may vary with seasons of the year. However, the available methods of traffic measurement can determine the traffic flow during mean busy hour for this total traffic.

3.2 Some intercontinental groups may include one-way as well as both-way operated circuits. It is recommended that in all cases the one-way circuits should be used, when free, in preference to the both-way circuits. The number of circuits to be provided will depend upon the one-way and total traffic.

The total traffic will need to be determined for:

a) each direction of traffic;

b) both-way traffic.

This determination is to be made for the busy hour or the busy hours corresponding to the two cases a) and b) above.

In the cases where the number of one-way circuits is approximately equal for each direction, no special procedure is necessary, and the calculation can be treated as for a simple two-group grading [1].

If the number of one-way circuits is quite different for the two directions, some correction may be needed for the difference in randomness of the flow of calls from the two one-way circuit groups to the both-way circuit group. The general techniques for handling cases of this type are quoted in Recommendation E.521.

ANNEX A

(to Recommendation E.520)

Table A-1/E.520 may be applied to small groups of long intercontinental circuits. The values in column 2 are suitable for a random offered traffic with full availability access.

The table is based on 1% loss probability for 20 circuits and increases progressively to a loss probability of 2% at 9 circuits and 3% at 6 circuits (loss probabilities for these three values being based on the Erlang loss formula: see Supplement No. 1). The traffic flow values obtained from a smoothing curve coincide very nearly with those determined by equal marginal utility theory, i.e. an improvement factor of 0.05 Erlang for an additional circuit.

For groups requiring more than 20 circuits the table for loss probability of 1%, mentioned in Supplement No. 1, should be used.

TABLE A-1/E.520

Number of circuits	Traffic flow (in erlangs)		
	Offered	Carried	Encountering congestion
(1)	(2)	(3)	(4)
6	2.54	2.47	0.08
7	3.13	3.05	0.09
8	3.73	3.65	0.09
9	4.35	4.26	0.09
10	4.99	4.90	0.09
11	5.64	5.55	0.10
12	6.31	6.21	0.10
13	6.99	6.88	0.10
14	7.67	7.57	0.10
15	8.37	8.27	0.11
16	9.08	8.96	0.11
17	9.81	9.69	0.11
18	10.54	10.42	0.11
19	11.28	11.16	0.12
20	12.03	11.91	0.12

Reference

[1] TÅNGE (I.): Optimal use of both-way circuits in cases of unlimited availability, *TELE*, English Edition, No. 1, 1956.

Recommendation E.521

CALCULATION OF THE NUMBER OF CIRCUITS IN A GROUP CARRYING OVERFLOW TRAFFIC

A calculation of the number of circuits in a group carrying overflow traffic should be based on this Recommendation and on Recommendation E.522 dealing with high-usage groups.

The objective grade of service used is that the average blocking during the busy-hour of the 30 busiest days of the year will not exceed 1%.

To determine the number of circuits in a group carrying overflow traffic, three traffic parameters are required: the average traffic offered to the group, the weighted peakedness factor, and the level of day-to-day traffic variations.

The level of day-to-day traffic variations indicates the degree to which the daily busy-hour traffic deviates from the overall mean traffic, and is determined by the sample variance of the 30 busy-hour traffic.

The peakedness factor indicates the degree to which the variability of the traffic deviates from pure chance traffic within a single hour, and in statistical terms is the variance-to-mean ratio of the distribution of simultaneous overflow traffic.

1 Determination of the level of day-to-day traffic variations

Let $M_1, M_2, \ldots, M_{30}$ denote the 30 busy-hour loads of the traffic offered to the final group. Determine the mean traffic M of the daily traffic by

$$M = \frac{1}{30} \sum_{j=1}^{30} M_j$$

Determine the sample variance V_d of the daily traffic by

$$V_d = \frac{1}{29} \sum_{j=1}^{30} (M_j - M)^2$$

Determine the point (M, V_d) on Figure 1/E.521; M on the horizontal axis, and V_d on the vertical axis.

i) If the point (M, V_d) is below the bottom curve, the level of variation is *No.*

ii) If the point is between the lower two curves, the level of variation is *Low.*

iii) If the point is between the upper two curves, the level of variation is *Medium.*

iv) If the point is above the highest curve, the level of variation is *High.*

Default procedures: if the data are not available to compute the variance V_d use the following guidelines:

a) If no more than 25 per cent of the traffic offered to the final group is overflow from other groups, assume the level of day-to-day variation is Low.

b) Otherwise, assume a Medium level of variation.

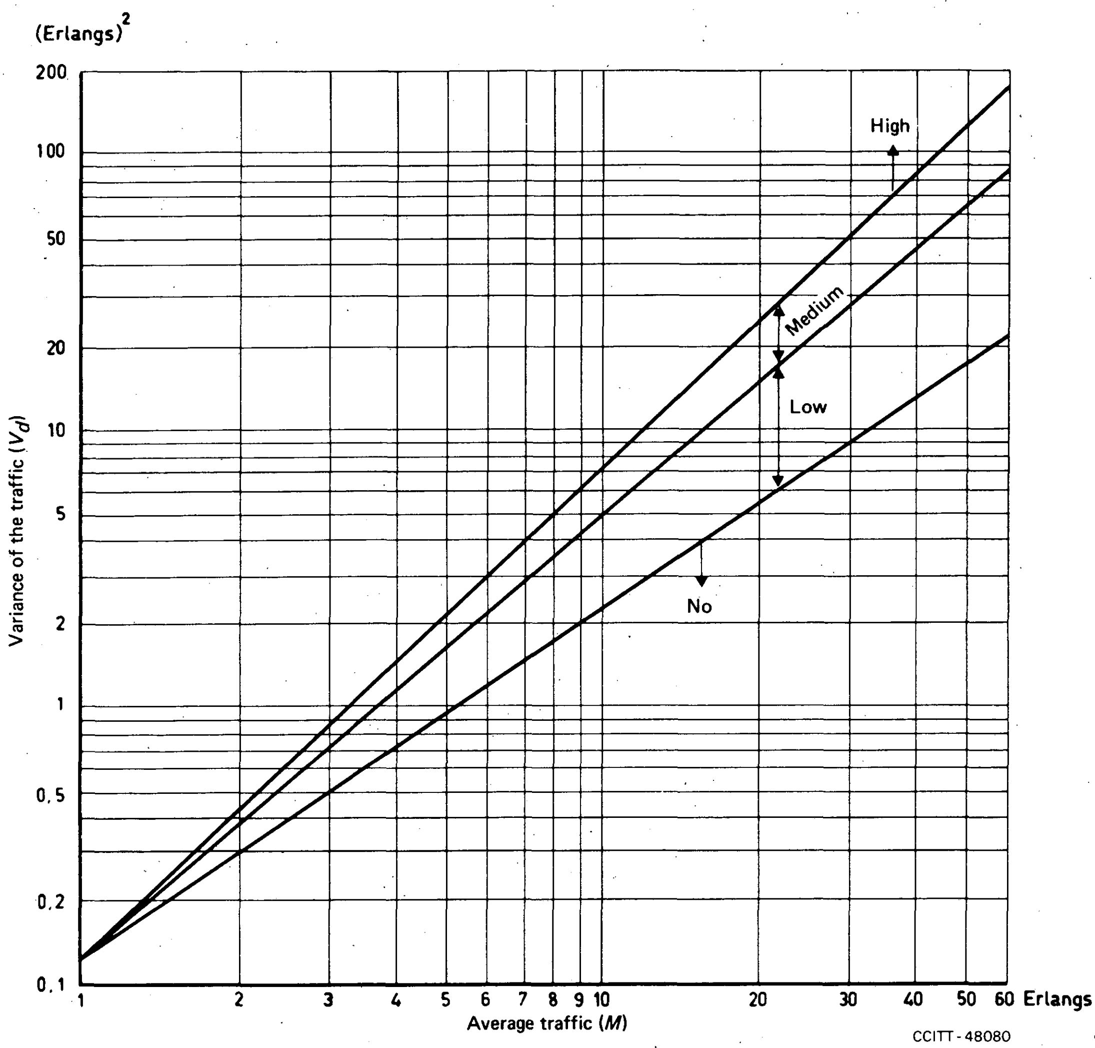

FIGURE 1/E.521
Determination of the level of day-to-day traffic variation

2 Determination of peakedness factor z

Peakedness factors depend principally upon the number of high-usage circuits over which random traffic has access. When the number of such high-usage circuits does not exceed 30, the actual peakedness of the traffic overflowing from a high-usage group will be only slightly below the maximum peakedness values [1), 2)]. The maximum peakedness values are given in Table 1/E.521.

TABLE 1/E.521

Maximum peakedness factor z_i

Number of high-usage circuits (n_i)	Peakedness factor (z_i)	Number of high-usage circuits (n_i)	Peakedness factor (z_i)
1	1.17	16	2.44
2	1.31	17	2.49
3	1.43	18	2.55
4	1.54	19	2.61
5	1.64	20	2.66
6	1.73	21	2.71
7	1.82	22	2.76
8	1.90	23	2.81
9	1.98	24	2.86
10	2.05	25	2.91
11	2.12	26	2.96
12	2.19	27	3.00
13	2.26	28	3.05
14	2.32	29	3.09
15	2.38	30	3.14

For more than 30 circuits, the peakedness of the traffic overflowing from a high-usage group i of n_i circuits is given by

$$z_i = 1 - \beta_i + \frac{A_i}{n_i + 1 + \beta_i - A_i}$$

where

A_i is the mean (random) traffic offered to the n_i circuits and

β_i is the traffic overflowing.

The overflow traffic β_i is found by employing the standard Erlang loss formula $E_{1,\, n_i}(A_i)$:

$$\beta_i = A_i E_{1,\, n_i}(A_i).$$

The weighted mean peakedness factor z, is then calculated from:

$$z = \frac{\sum_{i=1}^{h} \beta_i z_i}{\sum_{i=1}^{h} \beta_i}$$

for the h parcels of traffic being offered to the final group.

Note that for the traffic directly offered to the final group, the peakedness factor is $z_i = 1$.

---

1) Tables giving:
– the exact mean of the overflow traffic, and
– the difference between variance and mean of the overflow
have been computed and are set out in [1].

2) Curves giving the exact mean and variance of overflow traffic are given in [2]. See also a more detailed description of the method in [3] and [4].

3 Determination of the mean traffic offered to the final group and the number of circuits required

3.1 For planning future network requirements, the traffic overflowing to a final group should be determined theoretically from forecasts of traffics offered to the high-usage groups.

The mean traffic overflowing to the final group from a high-usage group is determined in two steps:

i) the "single-hour" overflow traffic β_i overflowing from n_i circuits is given as above by

$$\beta_i = A_i E_{i,\, n_i} (A_i),$$

when A_i is the forecast of traffic offered to the i^{th} high-usage group;

ii) the average overflow traffic $\bar{\beta}i$ overflowing from the n_i circuits is then determined by adjusting the single-hour traffic β_i for the effect of day-to-day traffic variations.

$$\bar{\beta}_i = r_i \, \beta_i$$

The adjustment factor r_i is given in Table 2/E.521; it is a function of:

- the offered traffic A_i,
- the traffic $A_i E_{i,\, n_i - 1} (A_i) - \beta_i$ carried by the last trunk i, and
- the level of day-to-day variations of the traffic offered to the high-usage group.

This level can be determined using the method described in § 1 above, but applying it to measurements of traffic offered to the high-usage group. If such measurements are not available a *medium* level can be used.

The mean traffic offered to the final group is then the sum of all $\bar{\beta}_i$ over the h parcels of traffic:

$$M = \sum_{i=1}^{h} \bar{\beta}_i$$

It can be assumed that the level of day-to-day traffic variations on the final group remains constant over the forecast time period.

Using the level of day-to-day traffic variation as determined in § 1 above on the final group and the peakedness factor of § 2 above, the appropriate table of Tables 3/E.521 to 6/E.521 is used to derive the number of circuits required.

Note 1 – This method of calculation of the mean traffic offered to the final group is valid only if the overflow traffic due to blocking encountered in the exchange in the attempts to connect to a high-usage, is negligible.

Note 2 – Table 3/E.521 differs slightly from the previous tables published by CCITT, although in Table 3.1/E.521 there is no allowance for day-to-day variations. The new table takes into account a systematic bias in the measurement procedure that is based on a finite period of time (1 hour), instead of an infinite period as was assumed in the previous table [5].

Note 3 – Tables 4/E.521, 5/E.521 and 6/E.521 are based on the calculation of the average blocking from the formula:

$$\bar{\beta} = \int B(m)\; f(m)\, dm,$$

where

$B(m)$ is the single-hour expected blocking and

$f(m)$ is the density distribution of day-to-day traffic (m), assuming a Pearson Type III distribution:

$$\left[f(m) = \frac{(M/V)^{(M^2/V_d)}}{\gamma^{(M^2/V_d)}} m^{[(M^2/V_d) - 1]}\; e^{-M_m/V_d} \right]$$

M and V_d are the mean and day-to-day variance of the traffic as calculated [5] in § 1 above.

TABLE 2 /E.521

Overflow adjustment for high-usage trunk groups

Factor r_i

Offered traffic A_i	Last trunk traffic														
	Low daily variation					Medium daily variation					High daily variation				
	0.25	0.3	0.4	0.5	0.6	0.25	0.3	0.4	0.5	0.6	0.25	0.3	0.4	0.5	0.6
3	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
5	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.0	1.0	1.2	1.2	1.1	1.1	1.0
7	1.0	1.0	1.0	1.0	1.0	1.2	1.2	1.1	1.1	1.0	1.4	1.3	1.2	1.1	1.1
10	1.1	1.1	1.1	1.0	1.0	1.3	1.2	1.2	1.1	1.1	1.5	1.4	1.3	1.2	1.1
15	1.2	1.1	1.1	1.1	1.0	1.5	1.4	1.2	1.2	1.1	1.8	1.6	1.4	1.3	1.1
20	1.2	1.2	1.1	1.1	1.0	1.6	1.5	1.3	1.2	1.1	2.0	1.8	1.5	1.3	1.2
25	1.3	1.2	1.2	1.1	1.1	1.8	1.6	1.4	1.3	1.1	2.3	2.0	1.7	1.4	1.2
30	1.3	1.3	1.2	1.1	1.1	1.8	1.7	1.4	1.3	1.2	2.4	2.1	1.7	1.5	1.3

TABLE 3/E.521

Single-hour capacity, in Erlangs, as a function of the number of trunks and of the peakedness factor

Parameters: – Blockage 0.01;
– *No* allowance for day-to-day variation;
– Weighted mean peakedness factor.

Number of trunks required	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.4	3.8	4.0
1	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.53	0.33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.94	0.69	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	1.42	1.14	0.89	0.67	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	1.97	1.64	1.36	1.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	2.56	2.19	1.86	1.58	1.31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	3.19	2.81	2.44	2.11	1.81	1.53	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	3.83	3.42	3.03	2.67	2.36	2.03	1.75	1.50	0.0	0.0	0.0	0.0	0.0	0.0
10	4.53	4.08	3.67	3.28	2.92	2.58	2.28	2.00	1.75	0.0	0.0	0.0	0.0	0.0
11	5.22	4.75	4.31	3.89	3.53	3.17	2.83	2.53	2.25	1.97	0.0	0.0	0.0	0.0
12	5.94	5.44	4.97	4.56	4.14	3.78	3.42	3.08	2.78	2.47	2.22	0.0	0.0	0.0
13	6.67	6.14	5.64	5.19	4.81	4.39	4.03	3.67	3.33	3.03	2.72	0.0	0.0	0.0
14	7.42	6.86	6.36	5.89	5.44	5.03	4.67	4.28	3.94	3.61	3.28	2.69	0.0	0.0
15	8.17	7.58	7.06	6.58	6.11	5.69	5.31	4.92	4.56	4.19	3.86	3.22	0.0	0.0
16	8.94	8.33	7.78	7.28	6.81	6.36	5.94	5.56	5.17	4.81	4.44	3.81	3.19	0.0
17	9.72	9.08	8.50	8.00	7.50	7.06	6.61	6.19	5.81	5.42	5.06	4.39	3.75	3.44
18	10.50	9.83	9.25	8.72	8.22	7.75	7.31	6.86	6.44	6.06	5.69	4.97	4.31	4.00
19	11.31	10.61	10.00	9.44	8.92	8.44	7.97	7.53	7.11	6.72	6.33	5.58	4.89	4.58
20	12.08	11.39	10.78	10.19	9.67	9.14	8.67	8.22	7.81	7.39	6.97	6.22	5.50	5.17
21	12.89	12.19	11.53	10.94	10.39	9.86	9.39	8.92	8.47	8.06	7.64	6.86	6.11	5.78
22	13.72	13.00	12.31	11.69	11.14	10.61	10.08	9.61	9.17	8.72	8.31	7.50	6.75	6.39
23	14.53	13.78	13.08	12.47	11.89	11.36	10.81	10.33	9.86	9.42	8.97	8.17	7.39	7.00
24	15.36	14.58	13.89	13.22	12.64	12.08	11.56	11.03	10.56	10.11	9.67	8.83	8.03	7.64
25	16.19	15.39	14.67	14.00	13.39	12.83	12.28	11.78	11.28	10.81	10.36	9.50	8.69	8.31
26	17.03	16.22	15.47	14.81	14.17	13.58	13.03	12.50	12.00	11.53	11.06	10.19	9.36	8.94
27	17.86	17.03	16.28	15.58	14.94	14.33	13.78	13.22	12.72	12.22	11.75	10.86	10.03	9.61
28	18.69	17.86	17.08	16.36	15.72	15.11	14.53	13.97	13.44	12.94	12.47	11.56	10.69	10.28
29	19.56	18.69	17.89	17.17	16.50	15.86	15.28	14.72	14.19	13.67	13.19	12.28	11.39	10.94
30	20.39	19.53	18.72	17.97	17.28	16.64	16.06	15.47	14.92	14.42	13.92	12.97	12.08	11.64
31	21.25	20.36	19.53	18.78	18.08	17.42	16.81	16.22	15.67	15.14	14.64	13.69	12.78	12.33
32	22.11	21.19	20.36	19.58	18.89	18.22	17.58	17.00	16.42	15.89	15.36	14.39	13.47	13.03
33	22.97	22.06	21.19	20.39	19.67	19.00	18.36	17.75	17.19	16.64	16.11	15.11	14.17	13.72
34	23.83	22.89	22.00	21.22	20.47	19.81	19.14	18.53	17.94	17.39	16.86	15.86	14.89	14.42
35	24.69	23.75	22.83	22.03	21.28	20.58	19.92	19.31	18.69	18.14	17.61	16.58	15.61	15.14
36	25.58	24.58	23.69	22.86	22.11	21.39	20.72	20.08	19.47	18.89	18.36	17.31	16.31	15.83
37	26.44	25.44	24.53	23.69	22.92	22.19	21.50	20.86	20.25	19.67	19.11	18.06	17.06	16.56
38	27.31	26.31	25.36	24.53	23.72	23.00	22.31	21.64	21.03	20.44	19.86	18.81	17.78	17.28
39	28.19	27.17	26.22	25.36	24.56	23.81	23.11	22.44	21.81	21.19	20.64	19.53	18.50	18.00
40	29.08	28.03	27.06	26.19	25.39	24.61	23.89	23.22	22.58	21.97	21.39	20.28	19.25	18.72
41	29.94	28.89	27.92	27.03	26.19	25.44	24.69	24.03	23.36	22.75	22.17	21.06	19.97	19.47
42	30.83	29.75	28.78	27.86	27.03	26.25	25.53	24.81	24.17	23.53	22.94	21.81	20.72	20.19
43	31.72	30.64	29.61	28.72	27.86	27.08	26.33	25.61	24.94	24.31	23.69	22.56	21.47	20.94
44	32.61	31.50	30.47	29.56	28.69	27.89	27.14	26.42	25.75	25.11	24.50	23.33	22.22	21.69
45	33.50	32.39	31.33	30.42	29.53	28.72	27.94	27.22	26.56	25.89	25.28	24.08	22.97	22.42
46	34.39	33.25	32.19	31.25	30.39	29.56	28.78	28.03	27.33	26.69	26.06	24.86	23.72	23.17
47	35.28	34.14	33.08	32.11	31.22	30.39	29.58	28.86	28.14	27.47	26.83	25.64	24.47	23.92
48	36.17	35.00	33.94	32.97	32.06	31.22	30.42	29.67	28.94	28.28	27.64	26.42	25.25	24.69
49	37.06	35.89	34.81	33.81	32.92	32.06	31.25	30.47	29.75	29.08	28.42	27.19	26.00	25.44
50	37.97	36.78	35.67	34.67	33.75	32.89	32.08	31.31	30.58	29.89	29.22	27.97	26.78	26.19

TABLE 4/E.521

Single-hour capacity, in Erlangs, as a function of the number of trunks and of the peakedness factor

Parameters: – Blockage 0.01;
– *Low* day-to-day variation allowance;
– Weighted mean peakedness factor.

Number of trunks required	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.4	3.8	4.0
1	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.53	0.33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.94	0.69	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	1.39	1.14	0.89	0.67	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	1.89	1.64	1.36	1.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	2.44	2.14	1.86	1.58	1.31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	3.03	2.69	2.42	2.11	1.81	1.53	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	3.64	3.28	2.97	2.67	2.36	2.03	1.75	1.50	0.0	0.0	0.0	0.0	0.0	0.0
10	4.25	3.89	3.56	3.22	2.92	2.58	2.28	2.00	1.75	0.0	0.0	0.0	0.0	0.0
11	4.92	4.53	4.17	3.83	3.50	3.17	2.83	2.53	2.25	1.97	0.0	0.0	0.0	0.0
12	5.58	5.17	4.78	4.44	4.08	3.78	3.42	3.08	2.78	2.47	2.22	0.0	0.0	0.0
13	6.25	5.81	5.42	5.06	4.69	4.36	4.03	3.67	3.33	3.03	2.72	0.0	0.0	0.0
14	6.94	6.50	6.08	5.69	5.33	4.97	4.64	4.28	3.94	3.61	3.28	2.69	0.0	0.0
15	7.64	7.17	6.75	6.33	5.97	5.61	5.25	4.92	4.56	4.19	3.86	3.22	0.0	0.0
16	8.33	7.86	7.42	7.00	6.61	6.25	5.89	5.53	5.17	4.81	4.44	3.81	3.19	0.0
17	9.06	8.56	8.11	7.67	7.28	6.89	6.53	6.17	5.81	5.42	5.06	4.39	3.75	3.44
18	9.81	9.28	8.81	8.36	7.94	7.56	7.17	6.81	6.44	6.06	5.69	4.97	4.31	4.00
19	10.53	10.00	9.50	9.06	8.61	8.22	7.83	7.44	7.08	6.72	6.33	5.58	4.89	4.58
20	11.28	10.72	10.22	9.75	9.31	8.89	8.50	8.11	7.72	7.36	6.97	6.22	5.50	5.17
21	12.03	11.44	10.94	10.44	10.00	9.56	9.17	8.78	8.39	8.03	7.64	6.86	6.11	5.78
22	12.78	12.19	11.67	11.17	10.69	10.25	9.83	9.44	9.06	8.67	8.31	7.56	6.75	6.39
23	13.53	12.94	12.39	11.89	11.42	10.94	10.53	10.11	9.72	9.33	8.94	8.19	7.39	7.00
24	14.31	13.69	13.14	12.61	12.11	11.67	11.22	10.81	10.39	10.00	9.61	8.86	8.03	7.64
25	15.08	14.44	13.86	13.33	12.83	12.36	11.92	11.50	11.08	10.67	10.28	9.50	8.67	8.31
26	15.86	15.22	14.61	14.08	13.56	13.08	12.61	12.19	11.75	11.36	10.94	10.17	9.33	8.94
27	16.64	15.97	15.36	14.81	14.28	13.81	13.33	12.89	12.44	12.03	11.64	10.83	10.00	9.61
28	17.42	16.75	16.14	15.56	15.03	14.53	14.06	13.58	13.14	12.72	12.31	11.50	10.67	10.28
29	18.22	17.53	16.89	16.31	15.78	15.25	14.78	14.31	13.86	13.42	13.00	12.19	11.36	10.94
30	19.00	18.31	17.67	17.06	16.50	16.00	15.50	15.03	14.56	14.11	13.69	12.86	12.06	11.64
31	19.81	19.08	18.44	17.83	17.25	16.72	16.22	15.72	15.28	14.83	14.39	13.56	12.75	12.33
32	20.61	19.89	19.19	18.58	18.00	17.47	16.94	16.47	16.00	15.53	15.11	14.25	13.44	13.03
33	21.39	20.67	19.97	19.36	18.78	18.22	17.69	17.19	16.72	16.25	15.81	14.94	14.14	13.72
34	22.22	21.47	20.75	20.11	19.53	18.97	18.42	17.92	17.44	16.97	16.53	15.67	14.83	14.42
35	23.03	22.25	21.56	20.89	20.28	19.72	19.17	18.67	18.17	17.69	17.22	16.36	15.56	15.11
36	23.83	23.06	22.33	21.67	21.06	20.47	19.92	19.39	18.89	18.42	17.94	17.08	16.25	15.81
37	24.64	23.86	23.14	22.44	21.83	21.25	20.67	20.14	19.64	19.14	18.67	17.78	16.94	16.50
38	25.47	24.67	23.92	23.25	22.61	22.00	21.44	20.89	20.36	19.89	19.42	18.50	17.64	17.19
39	26.28	25.47	24.72	24.03	23.39	22.78	22.19	21.64	21.11	20.61	20.14	19.22	18.33	17.89
40	27.11	26.28	25.53	24.81	24.17	23.53	22.94	22.39	21.86	21.36	20.86	19.94	19.06	18.61
41	27.92	27.08	26.31	25.61	24.94	24.31	23.72	23.14	22.61	22.11	21.61	20.67	19.78	19.31
42	28.75	27.92	27.11	26.39	25.72	25.08	24.47	23.92	23.36	22.83	22.33	21.39	20.47	20.03
43	29.58	28.72	27.92	27.19	26.50	25.86	25.25	24.67	24.11	23.58	23.08	22.11	21.19	20.75
44	30.42	29.56	28.75	28.00	27.31	26.64	26.03	25.44	24.89	24.33	23.83	22.86	21.92	21.44
45	31.25	30.36	29.56	28.81	28.08	27.44	26.81	26.22	25.64	25.11	24.58	23.58	22.64	22.17
46	32.08	31.19	30.36	29.61	28.89	28.22	27.58	26.97	26.42	25.86	25.33	24.33	23.36	22.89
47	32.92	32.03	31.17	30.42	29.69	29.00	28.36	27.75	27.17	26.61	26.08	25.06	24.11	23.64
48	33.75	32.83	32.00	31.22	30.47	29.81	29.14	28.53	27.94	27.39	26.83	25.81	24.83	24.36
49	34.58	33.67	32.81	32.03	31.28	30.58	29.94	29.31	28.72	28.14	27.58	26.56	25.56	25.08
50	35.44	34.50	33.64	32.83	32.08	31.39	30.72	30.08	29.50	28.92	28.36	27.31	26.31	25.83

TABLE 5/E.521

Single-hour capacity, in Erlangs, as a function of the number of trunks and of the peakedness factor

Parameters: – Blockage 0.01;
– *Medium* day-to-day variation allowance;
– Weighted mean peakedness factor.

Number of trunks required	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.4	3.8	4.0
1	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.53	0.33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.94	0.69	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	1.39	1.14	0.89	0.67	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	1.86	1.61	1.36	1.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	2.39	2.11	1.83	1.58	1.31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	2.94	2.64	2.36	2.08	1.81	1.53	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	3.53	3.19	2.89	2.61	2.33	2.03	1.75	1.50	0.0	0.0	0.0	0.0	0.0	0.0
10	4.11	3.78	3.47	3.17	2.86	2.58	2.28	2.00	1.75	0.0	0.0	0.0	0.0	0.0
11	4.72	4.39	4.03	3.72	3.42	3.14	2.83	2.53	2.25	1.97	0.0	0.0	0.0	0.0
12	5.36	4.97	4.64	4.31	4.00	3.69	3.39	3.08	2.78	2.47	2.22	0.0	0.0	0.0
13	6.00	5.61	5.25	4.89	4.56	4.25	3.94	3.67	3.33	3.03	2.72	0.0	0.0	0.0
14	6.64	6.22	5.86	5.50	5.17	4.83	4.53	4.22	3.92	3.61	3.28	2.69	0.0	0.0
15	7.31	6.89	6.47	6.11	5.78	5.42	5.11	4.78	4.47	4.19	3.86	3.22	0.0	0.0
16	7.97	7.53	7.11	6.75	6.39	6.03	5.69	5.39	5.06	4.75	4.44	3.81	3.19	0.0
17	8.64	8.19	7.78	7.36	7.00	6.64	6.31	5.97	5.64	5.33	5.03	4.39	3.75	3.44
18	9.33	8.86	8.42	8.03	7.64	7.28	6.92	6.58	6.25	5.92	5.61	4.97	4.31	4.00
19	10.03	9.53	9.08	8.67	8.28	7.89	7.53	7.19	6.86	6.53	6.19	5.58	4.89	4.58
20	10.69	10.19	9.75	9.33	8.92	8.53	8.17	7.81	7.47	7.14	6.81	6.17	5.50	5.17
21	11.42	10.89	10.42	9.97	9.56	9.17	8.81	8.44	8.08	7.75	7.42	6.75	6.11	5.78
22	12.11	11.58	11.11	10.64	10.22	9.83	9.44	9.06	8.69	8.36	8.03	7.36	6.72	6.39
23	12.83	12.28	11.78	11.33	10.89	10.47	10.08	9.69	9.33	8.97	8.64	7.97	7.33	7.00
24	13.53	13.00	12.47	12.00	11.56	11.14	10.72	10.36	9.97	9.61	9.25	8.58	7.94	7.61
25	14.25	13.69	13.17	12.69	12.25	11.81	11.39	11.00	10.61	10.25	9.89	9.19	8.56	9.19
26	14.97	14.42	13.86	13.39	12.92	12.47	12.06	11.64	11.28	10.89	10.53	9.83	9.17	8.81
27	15.69	15.11	14.58	14.08	13.61	13.14	12.72	12.31	11.92	11.53	11.17	10.44	9.78	9.42
28	16.44	15.83	15.28	14.78	14.28	13.83	13.39	12.97	12.58	12.19	11.81	11.08	10.39	10.06
29	17.17	16.56	16.00	15.47	14.97	14.53	14.08	13.64	13.25	12.83	12.47	11.72	11.03	10.67
30	17.92	17.28	16.72	16.17	15.67	15.19	14.75	14.31	13.92	13.50	13.11	12.36	11.64	11.31
31	18.64	18.03	17.42	16.89	16.39	15.89	15.44	15.00	14.58	14.17	13.78	13.03	12.28	11.94
32	19.39	18.75	18.14	17.58	17.08	16.58	16.11	15.67	15.25	14.83	14.44	13.67	12.92	12.56
33	20.14	19.47	18.86	18.31	17.78	17.28	16.81	16.36	15.92	15.50	15.11	14.33	13.58	13.19
34	20.89	20.22	19.61	19.03	18.50	18.00	17.50	17.06	16.61	16.17	15.78	14.97	14.22	13.86
35	21.64	20.97	20.33	19.75	19.22	18.69	18.19	17.75	17.28	16.86	16.44	15.64	14.86	14.50
36	22.39	21.69	21.06	20.47	19.92	19.42	18.92	18.44	17.97	17.53	17.11	16.31	15.53	15.14
37	23.14	22.44	21.81	21.19	20.64	20.11	19.61	19.14	18.67	18.22	17.81	16.97	16.19	15.81
38	23.89	23.19	22.53	21.94	21.36	20.83	20.31	19.83	19.36	18.92	18.47	17.64	16.86	16.47
39	24.64	23.94	23.28	22.67	22.08	21.56	21.03	20.53	20.06	19.61	19.17	18.33	17.53	17.11
40	25.42	24.69	24.03	23.39	22.81	22.25	21.75	21.25	20.75	20.31	19.86	19.00	18.19	17.78
41	26.17	25.44	24.78	24.14	23.56	22.97	22.44	21.94	21.47	21.00	20.56	19.69	18.86	18.44
42	26.94	26.19	25.50	24.86	24.28	23.72	23.17	22.67	22.17	21.69	21.25	20.36	19.53	19.11
43	27.72	26.97	26.25	25.61	25.00	24.44	23.89	23.36	22.86	22.39	21.94	21.06	20.19	19.81
44	28.47	27.72	27.00	26.36	25.75	25.17	24.61	24.08	23.58	23.08	22.64	21.75	20.89	20.47
45	29.25	28.47	27.78	27.11	26.47	25.89	25.33	24.81	24.31	23.81	23.33	22.44	21.56	21.14
46	30.03	29.25	28.53	27.86	27.22	26.64	26.06	25.53	25.00	24.50	24.03	23.14	22.25	21.83
47	30.81	30.00	29.28	28.61	27.97	27.36	26.78	26.25	25.72	25.22	24.75	23.83	22.94	22.50
48	31.58	30.78	30.03	29.36	28.72	28.11	27.53	26.97	26.44	25.94	25.44	24.53	23.64	23.19
49	32.36	31.56	30.81	30.11	29.44	28.83	28.25	27.69	27.17	26.64	26.17	25.22	24.33	23.89
50	33.14	32.31	31.56	30.86	30.19	29.58	29.00	28.42	27.89	27.36	26.86	25.92	25.03	24.58

TABLE 6/E.521

Single-hour capacity, in Erlangs, as a function of the number of trunks and of the peakedness factor

Parameters: – Blockage 0.01 ;
– *High* day-to-day variation allowance ;
– Weighted mean peakedness factor.

Number of trunks required	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	2.6	2.8	3.0	3.4	3.8	4.0
1	0.06	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.53	0.33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.94	0.69	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	1.36	1.14	0.89	0.67	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	1.86	1.61	1.36	1.08	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	2.36	2.08	1.83	1.58	1.31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	2.89	2.61	2.33	2.06	1.81	1.53	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	3.44	3.14	2.86	2.58	2.31	2.03	1.75	1.50	0.0	0.0	0.0	0.0	0.0	0.0
10	4.03	3.69	3.39	3.11	2.83	2.56	2.28	2.00	1.75	0.0	0.0	0.0	0.0	0.0
11	4.61	4.25	3.94	3.64	3.36	3.08	2.81	2.53	2.25	1.97	0.0	0.0	0.0	0.0
12	5.19	4.83	4.50	4.19	3.89	3.61	3.33	3.06	2.78	2.47	2.22	0.0	0.0	0.0
13	5.81	5.42	5.08	4.78	4.44	4.17	3.86	3.58	3.31	3.03	2.72	0.0	0.0	0.0
14	6.42	6.03	5.67	5.33	5.03	4.72	4.42	4.14	3.83	3.58	3.28	2.69	0.0	0.0
15	7.03	6.64	6.28	5.92	5.61	5.28	4.97	4.69	4.39	4.11	3.83	3.22	0.0	0.0
16	7.67	7.25	6.86	6.53	6.19	5.86	5.56	5.25	4.94	4.67	4.36	3.81	3.19	0.0
17	8.31	7.86	7.47	7.11	6.78	6.44	6.11	5.81	5.50	5.22	4.92	4.36	3.75	3.44
18	8.94	8.50	8.11	7.72	7.36	7.03	6.69	6.39	6.08	5.78	5.47	4.89	4.31	4.00
19	9.58	9.14	8.72	8.33	7.97	7.64	7.31	6.97	6.64	6.33	6.03	5.44	4.89	4.58
20	10.22	9.78	9.36	8.94	8.58	8.22	7.89	7.56	7.22	6.92	6.61	6.00	5.44	5.14
21	10.89	10.42	9.97	9.58	9.19	8.83	8.50	8.14	7.83	7.50	7.19	6.58	6.00	5.69
22	11.53	11.06	10.61	10.22	9.83	9.44	9.08	8.75	8.42	8.08	7.78	7.17	6.56	6.25
23	12.19	11.72	11.28	10.83	10.44	10.06	9.69	9.36	9.00	8.67	8.36	7.72	7.14	6.83
24	12.86	12.36	11.92	11.47	11.08	10.69	10.31	9.94	9.61	9.28	8.94	8.31	7.69	7.39
25	13.53	13.03	12.56	12.11	11.69	11.31	10.94	10.56	10.22	9.89	9.56	8.92	8.28	7.97
26	14.19	13.69	13.22	12.75	12.33	11.94	11.56	11.19	10.83	10.47	10.14	9.50	8.86	8.56
27	14.89	14.36	13.86	13.42	12.97	12.58	12.19	11.81	11.44	11.08	10.75	10.08	9.44	9.14
28	15.56	15.03	14.53	14.06	13.64	13.22	12.81	12.42	12.06	11.69	11.36	10.69	10.03	9.72
29	16.25	15.69	15.19	14.72	14.28	13.86	13.44	13.06	12.69	12.33	11.97	11.31	10.64	10.31
30	16.92	16.36	15.86	15.36	14.92	14.50	14.08	13.69	13.31	12.94	12.58	11.89	11.22	10.92
31	17.61	17.06	16.53	16.03	15.58	15.14	14.72	14.33	13.94	13.56	13.19	12.50	11.83	11.50
32	18.31	17.72	17.19	16.69	16.22	15.78	15.36	14.94	14.56	14.19	13.83	13.11	12.44	12.11
33	18.97	18.42	17.86	17.36	16.89	16.44	16.00	15.58	15.19	14.81	14.44	13.72	13.06	12.69
34	19.67	19.08	18.53	18.03	17.56	17.08	16.67	16.25	15.83	15.44	15.08	14.36	13.67	13.31
35	20.36	19.78	19.22	18.69	18.22	17.75	17.31	16.89	16.47	16.08	15.69	14.97	14.28	13.92
36	21.06	20.47	19.89	19.36	18.89	18.42	17.97	17.53	17.11	16.72	16.33	15.61	14.89	14.53
37	21.75	21.14	20.58	20.06	19.56	19.08	18.61	18.19	17.78	17.36	16.97	16.22	15.50	15.14
38	22.44	21.83	21.25	20.72	20.22	19.72	19.28	18.83	18.42	18.00	17.61	16.86	16.14	15.78
39	23.17	22.53	21.94	21.39	20.89	20.39	19.94	19.50	19.06	18.64	18.25	17.50	16.75	16.39
40	23.86	23.22	22.64	22.08	21.56	21.06	20.58	20.14	19.72	19.31	18.89	18.11	17.39	17.00
41	24.56	23.92	23.33	22.75	22.22	21.75	21.25	20.81	20.36	19.94	19.53	18.75	18.00	17.64
42	25.28	24.61	24.00	23.44	22.92	22.42	21.92	21.47	21.03	20.58	20.19	19.39	18.64	18.29
43	25.97	25.31	24.69	24.14	23.58	23.08	22.58	22.14	21.67	21.25	20.83	20.03	19.28	18.89
44	26.67	26.03	25.39	24.81	24.28	23.75	23.25	22.78	22.33	21.92	21.47	20.67	19.89	19.53
45	27.39	26.72	26.08	25.50	24.94	24.44	23.94	23.44	23.00	22.56	22.14	21.33	20.53	20.17
46	28.08	27.42	26.78	26.19	25.64	25.11	24.61	24.14	23.67	23.22	22.78	21.97	21.17	20.81
47	28.81	28.14	27.47	26.89	26.33	25.81	25.28	24.81	24.33	23.89	23.44	22.61	21.81	21.44
48	29.53	28.83	28.19	27.58	27.00	26.47	25.97	25.47	25.00	24.56	24.11	23.28	22.47	22.08
49	30.22	29.53	28.89	28.28	27.69	27.17	26.64	26.14	25.67	25.19	24.75	23.92	23.11	22.72
50	30.94	30.25	29.58	28.97	28.39	27.83	27.31	26.81	26.33	25.86	25.42	24.58	23.75	23.36

3.2 *Computer implementation*

When computer facilities are available, it is possible to automate the use of Tables 3/E.521. For that purpose, numerical algorithms have been developed and are described in [5].

4 Example

4.1 *Level of day-to-day traffic variations*

If the traffics offered to a final group over the 30 busiest days are given (M_1 to M_{30}) and if the mean load and variance are calculated to be 10 and 20 respectively, then applying Figure 1/E.521, a *high* level of day-to-day traffic variations should be used.

4.2 *Future traffic offered to the final group and peakedness factor*

If the forecast of future traffics indicates that three parcels of traffic will be offered to the final group:

- the overflow from 6 circuits offered 7.8 Erlangs,
- the overflow from 12 circuits offered 10 Erlangs,
- 7 Erlangs offered directly,

then Table 7/E.521 can be developed.

TABLE 7/E.521

Number of parcels of traffic i	Traffic offered to high-usage groups A_i	Number of high-usage circuits n_i	Single-hour overflow β_i	Last trunk traffic	Peakedness factor z_i	$\beta_i z_i$	Adjustment factor r_i	Average overflow $\bar{\beta}_i = r_i \beta_i$
1	7.8	6	2.95	0.69	1.73	5.1	1.0	2.95
2	10.0	12	1.20	0.44	2.19	2.6	1.2	1.44
3	7.0	0	7.0	–	1.0	7.0	1.0	7.00
						14.7		
			$\sum_{i=1}^{h} \beta_i = 11.15$			$z = \frac{\sum_{i=1}^{h} \beta_i z_i}{\sum_{i=1}^{h} \beta_i} = \frac{14.7}{11.15} = 1.3$		$M = \sum_{i=1}^{h} \bar{\beta}_i = 11.39$

Note that the values of r_i are derived from Table 2/E.521 for *medium* level of day-to-day traffic variations; if the 30 busiest day traffics for each of the high-usage groups were available, a more appropriate level could be used for each group.

Now all the information required is available: using the capacity Table 6/E.521 for *high* level of day-to-day traffic variations, the average traffic offered to the final group $M = 11.39$ and a peakedness factor $z = 1.3$ (from interpolating between $z = 1.2$ and $z = 1.4$), it is calculated that 23 circuits are required.

Note that if the measurements used in § 4.1 above were not available, then to determine the level of day-to-day traffic variations it would have been necessary to use the default procedure of § 1 above.

Overflow traffic offered to the final group = 4.15 Erlangs.

Total traffic offered to the final group = 11.15 Erlangs.

The ratio 4.15/11.15 = 0.37 is higher than 0.25 and hence a *medium* level of day-to-day traffic variations would have been used.

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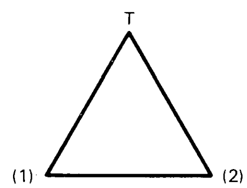
Recommendation E.522

NUMBER OF CIRCUITS IN A HIGH-USAGE GROUP

1 Introduction

For the economic planning of an alternate routing network the number of circuits in a high-usage group should be determined so that the annual charges for the whole network arrangement are at a minimum. This is done under the constraint that given requirements for the grade of service are fulfilled. In the optimum arrangement, the cost per erlang of carrying a marginal amount of traffic over the high-usage route or over the alternative route is the same.



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The optimum number of high-usage circuits, n, from one exchange (1) to another exchange (2) is therefore obtained from the following expression when the overflow traffic is routed over a transit exchange T (route 1-T-2).

$$F_n(A) = A\{E_{1,n}(A) - E_{1,(n+1)}(A)\} = M \times \frac{\text{annual charge (1-2)}}{\text{annual charge (1-T-2)}}$$

A is the traffic flow offered, for the relation "1-2", in the Erlang loss formula for a full availability group. The expression $F_n(A)$ gives the marginal occupancy (improvement function) for the high-usage group, if one more circuit were added; the values $F_n(A)$ are tabulated in the reference cited in [1].

M is the *marginal utilization factor for the final route* "1-T-2" (which has nothing to do with cost ratio), if one additional circuit were provided. The annual charges are marginal charges for adding one additional circuit to route "1-2" and likewise to route "1-T-2".

Planning of an alternate routing network is described in the technical literature (see [2] to [16]).

2 Recommended practical method

2.1 *Field of application*

It must be recognized that the conditions applying to alternative routing will vary widely between the continental network and the intercontinental network. Significant differences between the two cases apply to the length and cost of circuits, the traffic flow and the different times at which the busy hours occur. The method described attempts to take account of these factors in so far as it is practicable to do so in any simplified procedure.

2.2 *Traffic statistics*

The importance of reliable traffic estimates should be emphasized. Traffic estimates are required for each of the relations in question, for both the busy hour of the relation and for the busy hour of each link of the routes to which the traffic overflows. Since this may be affected by the high-usage arrangements finally adopted, it will be necessary to have traffic estimates for each relation covering most of the significant hours of the day. This applies particularly to the intercontinental network where the final routes carry traffic components with widely differing busy hours.

2.3 *Basis of the recommended method*

The method is based on a simplification of the economic dimensioning equations described under 1. Introduction. The simplifying assumptions are:

i) the ratios of the alternative high-usage annual charges are grouped in classes and a single ratio selected as representative for each class. This is acceptable because total network costs are known to be relatively insensitive to changes in the annual charges ratio;

ii) the marginal utilization factor M applicable to the overflow routes is regarded as constant within a range of circuit group sizes;

Size of group (number of circuits)	Value of M
For less than 10.	0.6
For 10 or more	0.8

iii) each high-usage group will be dimensioned against the cheapest alternative route to which traffic overflows. (That is, the effect of parallel alternative routes is ignored.)

Where greater precision is required in either network or individual route dimensioning, more sophisticated methods may be employed. The utility of computers in this work is recognized.

2.4 *Determination of cost ratio*

In continental and intercontinental working, the number of circuits to be provided in high-usage circuit groups depends upon the ratio of the annual charges estimated by the Administrations involved. The annual charge ratio (see Table 1/E.522) is defined as:

$$R = \frac{\text{annual charge of one additional circuit on the alternative route}}{\text{annual charge of one additional circuit on the high-usage route}}$$

The "annual charge of one additional circuit on the alternative route" is calculated by summing:

- the annual charge per circuit of each link comprising the alternative route, and
- the annual charge of switching one circuit at each intermediate switching centre.

The traffic value used should be the value of traffic offered to the high-usage route during the busy hour of the final route. It is likely that some of the busy hours of the circuit groups or links forming an alternative route will not coincide with the busy hour of the relation. Some of these links may therefore receive no overflow necessitating additional circuits and there will be no annual charges for this link of the alternative route. Several hours must be examined to determine the ratio between the annual charges for the alternative and the high-usage route. It is possible that the ratio is less than unity but this case is not shown in the table because the provision of high-usage circuits would then be used for grade of service reasons. Cases of this type can introduce valuable economies but the calculation of the appropriate number of circuits to be provided is best handled by a computer.

The value determined for R should then be employed to select in Table 1/E.522 the precise (or next higher) value of annual charges ratio for use in traffic tables. The value of annual charges ratios may be grouped in the following general sets:

a) Within a single continent or other smaller closely connected land mass involving distances up to 1000 miles, high traffic and frequently one-way operation:

Annual charges ratio: $R = 1.5$; $\underline{\underline{2.0}}$; 3.0 and 4.

b) Intercontinental working involving long distances, small traffic and usually two-way operation:

Annual charges ratio: $R = 1.1$; $\underline{\underline{1.3}}$ and 1.5.

2.5 *Use of method*

High-usage circuit groups carrying random traffic can be dimensioned from Table 1/E.522.

Step 1 – Estimate the annual charges ratio R as described under 2.4 above. (There is little difference between adjacent ratios.) If this ratio is difficult to estimate, the values underlined in a) and b) of § 2.4 above, should be used.

Step 2 – Consult Table 1/E.522 to determine the number of high-usage circuits N.

Note – When two values of N are given the right-hand figure applies to alternative routes of more than 10 circuits, the left-hand figure applies to smaller groups. The left-hand figure is omitted when it is no longer possible for the alternative route to be small.

3 Service considerations

On intercontinental circuits, where both-way operation is employed, a minimum of two circuits may be economical. Service considerations may also favour an increase in the number of direct circuits provided, particularly where the annual charges ratio approaches unity.

Although the dimensioning of high-usage groups is normally determined by traffic flows and annual charges ratios, it is recognized that such groups form part of a network having service requirements relative to the subscriber. The ability to handle the offered traffic with acceptable traffic efficiency should be tempered by the overall network considerations on quality of service.

The quality of service feature, which is of primary importance in a system of high-usage and final circuit groups, is the advantage derived from direct circuits versus multi-link connections. A liberal use of direct high-usage circuit groups, taking into account the economic factors, favours a high quality of service to the subscriber. It is recommended that new high-usage groups should be provided whenever the traffic flow and cost ratios are not conclusive. This practice may result in direct high-usage groups of two circuits or more.

The introduction of high-usage groups improves the overall grade of service and provides better opportunities of handling traffic during surges and breakdown conditions. When high-usage links bypass the main backbone final routes the introduction of high-usage routes can assist in avoiding expenses which might otherwise be incurred in keeping below the maximum number of long-distance links in series. In the future, more measurements of traffic flows may be necessary for international accounting purposes and high-usage circuits should make this easier.

TABLE 1/E.522

Number of high-usage circuits for different values of offered traffic, annual charges ratios and sizes of overflow groups

Traffic offered during network busy hour (erlangs)	Annual charges ratios						Number of circuits if there is no overflow route, for $p = 0.01$
	1.1	1.3	1.5	2.0	3.0	4.0	
	Minimum circuit occupancies for high-usage traffic						
	0.545/0.727	0.46/0.615	0.4/0.53	0.3/0.4	0.2/0.26	0.15/0.2	
	N, number of high-usage circuits A/B, where A is for less than 10 circuits in the overflow group ($M = 0.6$), B is for 10 or more circuits in the overflow group ($M = 0.8$)						
1.5	1/0	1/0	2/1	2/2	3/2	3/3	6
1.75	1/0	2/1	2/1	3/2	3/3	4/3	6
2.0	1/0	2/1	2/2	3/2	4/3	4/4	7
2.25	2/0	2/1	3/2	3/3	4/4	5/4	7
2.5	2/0	3/1	3/2	4/3	5/4	5/5	7
2.75	2/1	3/2	3/2	4/3	5/4	5/5	8
3.0	3/1	3/2	4/3	4/4	5/5	6/5	8
3.5	3/1	4/2	4/3	5/4	6/5	7/6	9
4.0	4/2	4/3	5/4	6/5	7/6	7/7	10
4.5	4/2	5/3	6/4	6/6	7/7	8/7	10
5.0	5/3	6/4	6/5	7/6	8/7	9/8	11
5.5	5/3	6/5	7/5	8/7	9/8	9/9	12
6.0	6/3	7/5	7/6	8/7	9/9	10/9	13
7.0	7/4	8/6	8/7	10/8	11/10	11/11	14
8.0	8/5	9/7	10/8	11/10	12/11	13/12	15
9.0	/6	/8	/9	/11	/12	/13	17
10.0	/7	/9	/10	/12	/14	/15	18
12.0	/9	/11	/12	/14	/16	/17	20
15.0	/12	/14	/16	/18	/20	/21	24
20.0	/16	/19	/21	/23	/25	/27	30
25.0	/21	/24	/26	/29	/31	/33	36
30.0	/26	/29	/31	/34	/37	/38	42

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Recommendation E.523

STANDARD TRAFFIC PROFILES FOR INTERNATIONAL TRAFFIC STREAMS

The worldwide nature of the international telephone network, spanning as it does all possible time zones, has stimulated studies of the traffic streams between countries in different relative time locations. These studies have led to the development of standardized 24-hour traffic profiles which, theoretically based and verified by measurements, would be useful for engineering purposes. In fact, these concepts can be applied to a variety of network situations:

i) variable access satellite working where a large number of traffic streams with possibly differing traffic profiles share the pool of satellite circuits;

ii) combining of traffic streams on groups of terrestrial circuits which may be either high-usage or final choice routes;

iii) detour routing of traffic between origin and destination countries to take advantage of prevailing low load conditions on the detour path.

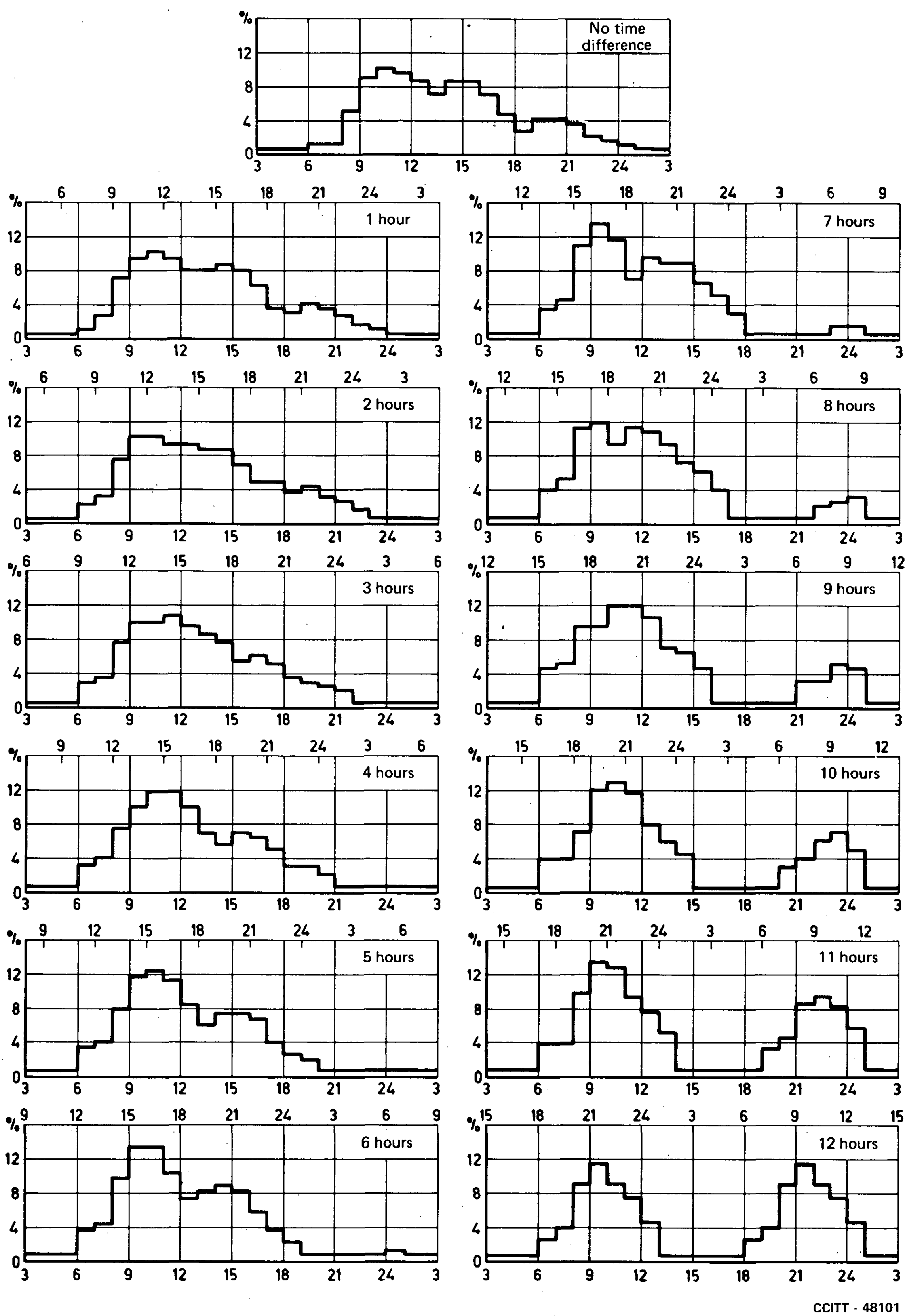
In developing any such applications, account must be taken of the International Routing Plan (Recommendation E.171 [1]) and of accepted accounting principles (Recommendation D.150 [2]).

It must be recognized that the preferred basis for dimensioning consists of traffic profiles based on real traffic. Nevertheless, many countries have found the standard profiles presented in this Recommendation very useful where streams are too small to obtain reliable measurements or where no measurements are available.

For both-way profiles, two equivalent methods of presentation are given in chart and tabular form. In Figure 1/E.523 hour-by-hour traffic volumes are shown in diagrammatically as percentages of the total daily traffic volume; such percentages are particularly convenient for tariff studies. In Table 1/E.523, hourly traffics are expressed as percentages of the busy hour traffic, and this is convenient for engineering purposes. Time zone differences are given in whole hours only. Directional profiles are given in Tables 2/E.523 and 3/E.523.

Although tables are given for both-way and directional traffic streams, it must be emphasized that at this stage only the both-way profiles can be regarded as soundly supported by measurement. The directional profiles are theoretically based and supported by some measurements, but should be used with caution until adequate verification has been achieved.

The theoretical basis for the profiles presented here is contained in Annex A. It depends on a convenience function $f(t)$ which represents the profile of *local* daily traffic, where of course no time zone difference exists. The function $f(t)$ used for computation of the standard profile was derived by mathematical manipulation of measurements of the Tokyo-Oakland and Tokyo-Vancouver streams. Although these results have been supported by other measurements, it leaves open the possibility that the convenience function may vary from one country to another and that, strictly, these should be derived independently and then used to obtain a calculated profile for the international relation. It also seems that the convenience function for the country of destination should be given greater weight than that for the country of origin. These remarks suggest possible refinements, but are not quantified in this Recommendation.



Note – The vertical scale gives the hourly traffic volume as a percentage of the daily traffic volume. The horizontal scales show the local times.

FIGURE 1/E.523

Standard hourly both-way traffic distribution patterns

TABLE 1/E.523

Standard hourly bothway traffic patterns

Time difference (in hours) between two countries \ Local time in the more westerly country	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	BH %
0	5	5	5	5	5	5	10	10	50	90	100	55	85	70	85	85	70	45	25	40	40	35	20	15	10.0
1	5	5	5	5	5	5	10	25	70	95	100	90	80	80	85	80	60	35	30	40	35	25	15	10	10.0
2	5	5	5	5	5	5	20	30	75	100	100	90	90	85	85	65	45	45	35	40	30	25	15	5	10.0
3	5	5	5	5	5	5	25	35	75	100	95	100	95	80	70	50	60	45	35	30	25	15	5	5	10.4
4	5	5	5	5	5	5	25	35	65	85	100	100	85	60	50	60	55	40	25	25	20	5	5	5	11.5
5	5	5	5	5	5	5	25	30	65	95	100	90	70	50	60	60	55	30	20	20	5	5	5	5	12.4
6	10	5	5	5	5	5	25	30	75	100	100	75	55	60	65	60	40	25	15	5	5	5	5	5	13.1
7	10	5	5	5	5	5	25	35	80	100	85	55	70	65	65	50	40	20	5	5	5	5	5	10	13.5
8	25	5	5	5	5	5	35	45	95	100	80	95	90	75	60	50	35	5	5	5	5	5	20	20	11.7
9	40	5	5	5	5	5	35	40	75	80	100	95	85	60	55	35	5	5	5	5	5	25	25	40	12.1
10	40	5	5	5	5	5	35	35	60	95	100	90	65	50	40	5	5	5	5	5	25	30	50	55	12.5
11	40	5	5	5	5	5	30	25	75	100	95	70	55	35	5	5	5	5	5	25	30	65	70	60	12.3
12	40	5	5	5	5	5	20	35	80	100	80	65	40	5	5	5	5	5	20	35	60	100	80	65	11.3

Note 1 – The 24-hour profile of both-way traffic between any two countries is read from left to right from the appropriate row of the table; all time differences can be expressed in the range 0-12 hours. Each entry is expressed as a percentage of the busy hour traffic.

Note 2 – The *more westerly* country of a traffic relation is the one from which we can proceed eastwards to the other through time zones not exceeding 12 hours.

Note 3 – For network planning studies, UTC (Universal Coordinated Time) would normally be used so that all traffic streams are processed time consistently. Clearly if the more westerly country is W hours ahead of UTC (ignoring the international dateline), then the traffic at 0000-0100 UTC is obtained from the row corresponding to the time difference between the two countries at the column headed W. Alternatively, the first entry in the appropriate row gives the relative traffic intensity for the hour (24-W) to (25-W).

Example: For the traffic stream between the U.K. (UTC + 1 hour) and the central zone of USA (UTC + 18 hours), the time difference is 7 hours and the USA is regarded as the more westerly country, hence $W = 18$. Thus from the table, the traffic during 0000-0100 UTC is 5% of the busy hour traffic, and the busy hour is 1500-1600 UTC.

Note 4 – The column headed "BH %" gives the busy hour traffic volume as a percentage of the daily traffic volume.

TABLE 2/E.523

Diurnal distributions of eastbound international telephone traffic

Local time in the more westerly country

Time difference (in hours) between two countries	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0	10	5	5	5	5	5	10	10	50	90	100	95	85	70	85	85	70	45	25	40	40	35	20	15
1	5	5	5	5	5	5	10	30	80	95	100	90	80	80	85	80	60	35	30	40	35	25	15	10
2	5	5	5	5	5	5	25	40	85	100	100	90	90	85	85	60	40	45	35	40	25	20	15	5
3	5	5	5	5	5	5	40	50	90	100	95	100	95	80	65	40	55	45	35	25	20	10	5	5
4	5	5	5	5	5	5	35	50	70	85	100	100	85	60	40	50	50	40	25	20	15	5	5	5
5	5	5	5	5	5	5	30	40	70	95	100	90	65	45	50	50	50	25	20	15	5	5	5	5
6	10	5	5	5	5	5	40	45	85	100	100	65	45	55	55	50	30	20	15	5	5	5	5	5
7	10	5	5	5	5	5	40	50	90	100	75	40	60	55	55	40	30	10	5	5	5	5	5	10
8	25	5	5	5	5	5	55	65	100	100	70	90	85	70	45	35	25	5	5	5	5	5	20	20
9	50	5	5	5	5	5	40	45	70	75	100	100	85	55	50	35	5	5	5	5	5	25	35	60
10	65	5	5	5	5	5	45	45	60	95	100	90	60	45	35	5	5	5	5	5	25	30	75	100
11	65	5	5	5	5	5	40	40	75	90	80	55	40	25	5	5	5	5	5	20	25	80	100	95
12	55	5	5	5	5	5	20	40	65	70	50	40	20	5	5	5	5	5	20	25	70	100	90	80

Note – This table is based on $p = 1.4$, $q = 0.6$ i.e. greater weight is given to the convenience function of the called party (see Annex A).

TABLE 3/E.523

Diurnal distributions of westbound international telephone traffic

Local time in the more westerly country

Time difference (in hours) between two countries	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
0	10	5	5	5	5	5	10	10	50	90	100	95	85	70	85	85	70	45	25	40	40	35	20	15
1	5	5	5	5	5	5	10	20	60	95	100	90	80	80	85	80	60	35	30	40	35	25	15	10
2	5	5	5	5	5	5	15	20	65	100	100	90	90	85	85	70	50	45	35	40	35	30	15	5
3	5	5	5	5	5	5	10	20	60	100	95	100	95	80	75	60	65	45	35	35	30	15	5	5
4	5	5	5	5	5	5	15	20	60	85	100	100	85	60	60	70	60	40	25	30	25	5	5	5
5	5	5	5	5	5	5	20	20	60	95	100	90	75	55	70	70	60	35	20	25	5	5	5	5
6	10	5	5	5	5	5	10	15	65	100	100	85	65	65	75	70	50	30	15	5	5	5	5	5
7	10	5	5	5	5	5	10	20	70	100	95	70	80	75	75	60	50	30	5	5	5	5	5	10
8	20	5	5	5	5	5	15	25	90	100	90	95	95	80	75	65	45	5	5	5	5	5	20	20
9	25	5	5	5	5	5	30	35	80	85	100	95	85	65	60	35	5	5	5	5	5	20	20	25
10	10	5	5	5	5	5	25	25	60	95	100	90	70	55	45	5	5	5	5	5	25	30	25	10
11	15	5	5	5	5	5	10	10	65	95	100	80	65	45	5	5	5	5	5	25	35	40	35	25
12	20	5	5	5	5	5	20	25	70	100	90	80	55	5	5	5	5	5	20	40	65	70	50	40

Note – This table is based on $p = 1.4$, $q = 0.6$ i.e. greater weight is given to the convenience function of the called party (see Annex A).

ANNEX A

(to Recommendation E.523)

Mathematical expression for the influence of time differences on the traffic flow

A telephone call is initiated when a person wishes to call someone else, but both parties have to be on the line before the call is established. It is considered that a telephone call is made at a time which tends to be convenient for both the calling and called parties. The *degree of convenience* for making a telephone call is considered to be a periodical function of time t, whose period is 24 hours. When the time difference between both parties is zero, the degree of convenience is denoted by $f(t)$, where t is local standard time. The graphic shape of the basic function $f(t)$ will be determined by the daily pattern of human activities, and will resemble, or fairly closely coincide with, the hour by hour traffic distribution in the national (or local) telephone network.

It is assumed that the hourly traffic distribution $F_\tau(t)$, when a time difference of τ hours exists between the originating and called locations, is expressed as the geometric mean of convenience functions of two locations τ hours apart:

$$F_{\tau,}(t) = k\left\{f(t) \cdot f(t+\tau)\right\}^{\frac{1}{2}}$$

where

$$k = 1\Big/\int_{24\text{ hours}}\left\{f(t) \cdot f(t+\tau)\right\}^{\frac{1}{2}} dt \qquad \text{(A-1)}$$

The sign of τ is positive when the time at the destination is ahead of, and negative when the time of destination is behind, the reference time.

The distribution of equation (A-1) represents the sum of the outgoing and incoming traffics. Expressions for the one-way hourly traffic distributions can also be obtained by extending the concept of convenience function as follows.

Define convenience functions both for the caller $f_0(t)$ and for the called party $f_i(t)$. Then the one-way traffic distributions of east-bound and west-bound telephone calls, for the case of τ hour time-difference, are similarly expressed as follows:

$$F_{\tau,\text{east}}(t) = k\left\{f_o(t) \cdot f_i(t+\tau)\right\}^{\frac{1}{2}}$$

$$k = 1\Big/\int_{24\text{ hours}}\left\{f_o(t) \cdot f_i(t+\tau)\right\}^{\frac{1}{2}} dt \qquad \text{(A-2)}$$

$$F_{\tau,\text{west}}(t) = k\left\{f_i(t) \cdot f_o(t+\tau)\right\}^{\frac{1}{2}}$$

$$k = 1\Big/\int_{24\text{ hours}}\left\{f_i(t) \cdot f_o(t+\tau)\right\}^{\frac{1}{2}} dt \qquad \text{(A-3)}$$

where

t is the local standard time of the west station and

τ is positive.

It is natural that a caller makes a call considering the convenience of the called person, and therefore the convenience function of the called person f_i contributes more than the convenience of the caller f_0 to the directional distribution F. They can be written as follows:

$$f_i(t) = k_1 \left\{f(t)\right\}^p, \qquad f_0(t) = k_2 \left\{f(t)\right\}^q, \qquad \text{(A-4)}$$

where

$$p > q \quad \text{and} \quad p + q = 2,$$

and where k_1 and k_2 are normalizing coefficients to ensure that:

$$\int_{24\text{ hours}} f_i(t)dt = 1, \qquad \int_{24\text{ hours}} f_0(t)dt = 1.$$

As to the values of p and q in equation (A-4), it has been found empirically that the convenience of the called side p is considerably larger than that of originating side q, and appropriate values are roughly $p = 1.4$ and consequently $q = 0.6$.

References

[1] CCITT Recommendation *International routing plan*, Vol. II, Fascicle II.2, Rec. E.171.

[2] CCITT Recommendation *New system for accounting in international telephony*, Vol. II, Fascicle II.1, Rec. D.150.

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SECTION 5

GRADE OF SERVICE

Recommendation E.540

OVERALL GRADE OF SERVICE OF THE INTERNATIONAL PART OF AN INTERNATIONAL CONNECTION

1 The International Routing Plan envisages that international traffic relations may be served by any of the following routing arrangements:

a) direct circuits;

b) transit operation involving one or more transit centres for all connections,

c) direct high-usage circuits with overflow via one or more transit centres.

In principle there would be merit in dimensioning international facilities to provide the same grade of service for all relations, however served. Practical considerations make it advisable to depart from one universal value.

2 Direct circuit groups are dimensioned, according to Recommendation E.520 on the basis of $p = 1\%$ loss probability during the mean busy hour. An exception is permitted for small groups of very long international circuits for which $p = 3\%$ loss probability is accepted for six or fewer circuits. As the traffic increases the grade of service improves progressively until $p = 1\%$ loss value is reached for 20 circuits.

3 For the relations served exclusively by transit operation the grade of service will deteriorate with the number of transit centres in the connection. Measurements made on congestion in such circumstances suggest that the overall grade of service for up to six links in tandem is less than twice the congestion of any of the six links in the chain. Hence, for a series of routes, each dimensioned for $p = 1\%$, the overall grade of service should seldom exceed 2%. An East-West type of connection would have the advantage of different busy hours on the various links. Corresponding advantage would not apply to North-South circuits.

In the case of relations served by high-usage circuits the overflow traffic will route over at least two links and, hence, will be subject to the same deterioration of service as in the case for transit traffic. However, a substantial part of the traffic will be connected over the high-usage circuits and the overall grade of service will approximate that of the relations served solely by direct circuits.

It is desirable that at least one high-usage circuit should always be provided between a CT3 and its homing CT1, even though the circuit may not be wholly justified on economic considerations alone. However, such a circuit should not be provided unless there is a measurable amount of traffic which exists, or can be foreseen in the busy hour. The provision of such circuits would improve the transmission as well as the grade of service; these considerations should encourage an increase both in traffic and in the revenue-earning capacity of the circuits provided.

The overall grade of service for the international part of a connection is a contributory factor to the overall grade of service from the calling party in one country to the called party in another.

Recommendation E.541

OVERALL GRADE OF SERVICE FOR INTERNATIONAL CONNECTIONS (SUBSCRIBER-TO-SUBSCRIBER)

1 Introduction

1.1 The overall grade of service (subscriber-to-subscriber) on international connections – relating only to the phenomena of congestion in the entire network as a result of the traffic flow – depends on a number of different factors, such as the routing arrangements in the national and international parts of the connection, congestion allowed per switching stage, the methods used to measure traffic and compute the traffic base, and the time differences between the busy hours of the various links involved in the connection.

1.2 The most satisfactory way in which this grade of service could be described would be to give its distribution. The design average grade of service during the busy hour of the complete connection would be the most useful single parameter. However, until such time as continuous traffic measurements are carried out during the busy season in all parts of the network on a routine basis, it is not possible to compute this average grade of service. Therefore, at this stage it cannot be used as a criterion for the dimensioning of the network.

1.3 The only practical way of ensuring an acceptable overall grade of service on international calls is to specify an upper limit on the design loss probability per connecting link in the national network as is done for the links in the international network (see Recommendation E.540).

2 General considerations

2.1 Since the success of the international automatic service is highly dependent on the grade of service of all links involved in the connection from subscriber-to-subscriber, it is desirable that the originating and terminating national network involved in the connection has grade of service standards comparable with those of the international network.

2.2 It is especially important that the links in the country of destination should have a good grade of service for handling the traffic, since high congestion in the terminating national network could have serious effects on the international network. High congestion in the network of the country of destination causes added retrials with consequent increased loading on common switching devices as well as increased occupation of the routes with ineffective calls.

3 Design objectives

3.1 It is recommended that the links in the national network should be designed for a loss probability [1] not exceeding 1 per cent per link in the final choice route during its applicable busy hour. It is recognized, however, that in some countries additional congestion is permitted for the internal switching stages of the transit exchanges. It is also recognized that, where this recommended grade of service is not provided for the national service, it may not be economically feasible to provide it for international relations.

3.2 The maximum number of links in tandem used by an international connection is defined by Recommendation E.171 [1].

3.3 Although the worst overall grade of service would be approximated by the sum of loss probabilities for individual links connected in tandem, on most calls the overall grade of service will be significantly better.

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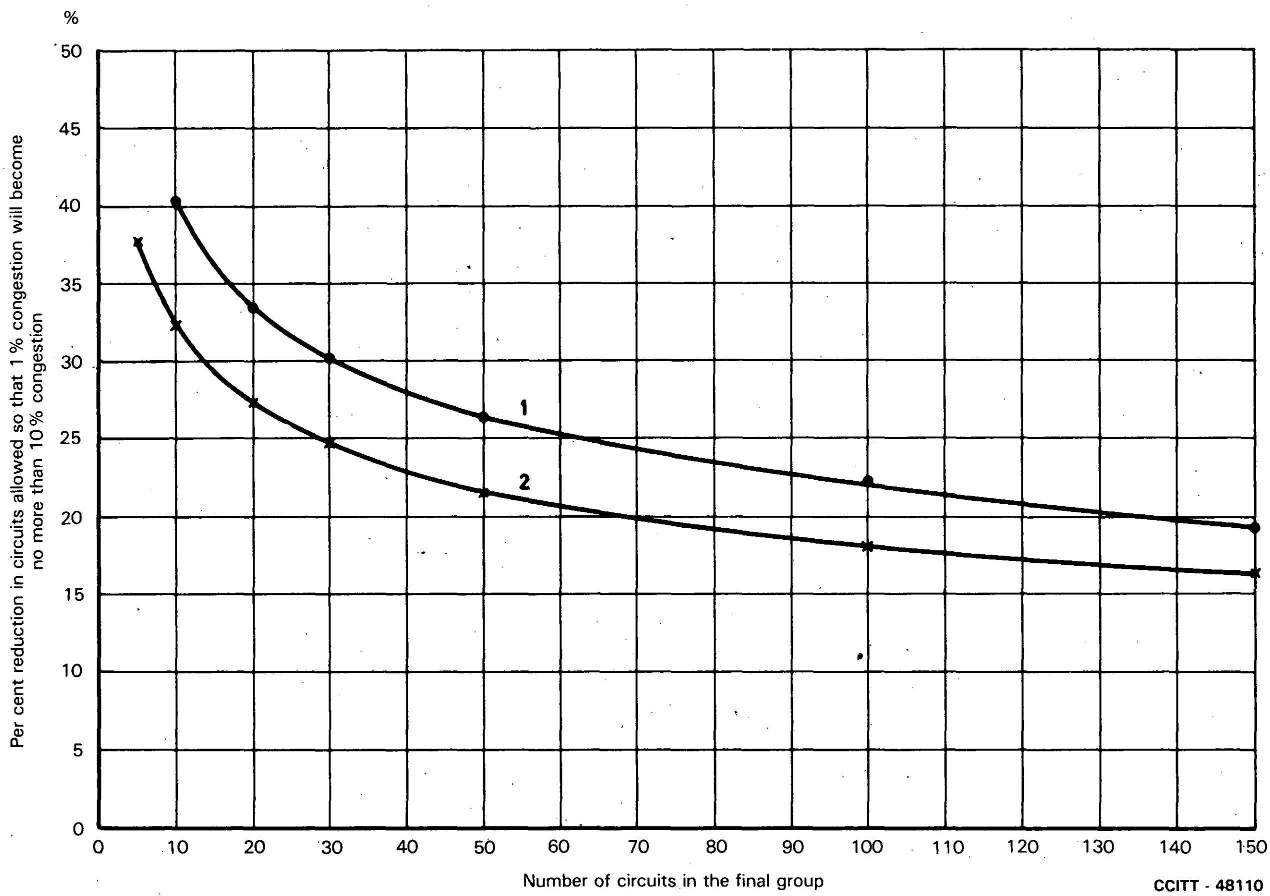
1) The loss probability mentioned refers to busy hour traffic values as defined in Recommendation E.500.

4 Maximum traffic loading

4.1 An acceptable automatic service on a final circuit group is difficult to maintain if the traffic loading on the group exceeds a level corresponding to a calculated Erlang grade of service of 10 per cent. Beyond this traffic loading, service on the route may rapidly deteriorate. This condition will be accentuated under the cumulative effect of repeat attempt calls if these should occur.

4.2 The curves of Figure 1/E.541 indicate the proportionate reduction in circuits that may be tolerated for a short period, 15 minutes for example, under normal busy-hour conditions, on a full-availability circuit group dimensioned for 1 per cent Erlang loss, in accordance with the above traffic overload criterion. Table 1/E.541 gives the figures used to plot the curves.



1: peakedness factor = 2.5
2: random traffic (peakedness factor = 1.0)

FIGURE 1/E.541

Proportionate reduction in the number of circuits in a final group in the event of a breakdown if the calculated Erlang grade of service is not to exceed 10 per cent

TABLE 1/E.541

Percentage reduction in the number of circuits if the calculated Erlang grade of service is not to exceed 10 %

Number of circuits	If originally operating at 1 % congestion, % reduction in circuits allowed to yield 10 % congestion	
	Random traffic (peakedness factor = 1.0)	Peakedness factor = 2.5
5	37.7	–
10	32.3	40.2
20	27.2	33.3
30	24.8	30.1
50	21.7	26.5
100	18.3	22.4
150	16.7	19.7

4.3 The curves of Figure 1/E.541 are intended merely as a guide. If the breakdown occurs during an exceptionally busy hour, the permissible proportionate reduction will be less. Conversely, if the breakdown occurs during an hour of light traffic, a higher proportionate reduction in circuits could be tolerated. A higher reduction might also be acceptable after an appropriate oral announcement has been introduced. In the general case, a knowledge of the circuit occupancy will enable an estimate to be made of the prevailing Erlang loss figure with the reduced number of circuits.

The permissible reduction in the case of large groups should not be exceeded; otherwise very serious congestion can result from repeated attempts.

5 General notes

Note 1 – teletraffic implications for international switching and operational procedures under failure of a transmission facility are discussed in Supplement No. 6 of this fascicle.

Note 2 – alternative routing in the national and in the international networks provides on average a grade of service that is better than that provided in the theoretical final route.

Note 3 – non-coincidence of traffic peaks in the national and international networks will provide reduction in the overall grade of service compared with the sum of the design grade of service values per link.

Note 4 – time differences will also improve the resulting grade of service.

Note 5 – the methods of measuring and calculating the traffic base for provisioning purposes in the national networks may be different in various countries and differ from the methods for the international network given in Recommendation E.500. This means that the national traffic values are not always comparable among themselves or with the values of the international network. Each Administration must estimate how its design traffic level compares with that recommended for the international network.

Note 6 – the design grade of service value of each link will only apply if the traffic at each switching stage is equal to the forecast. In practice, such a situation will seldom occur. Furthermore, the planning procedure normally is such that the specified grade of service should not be exceeded until the end of the planning period. In a growing network, this means that the circuit groups during almost the whole planning period give a better service than the specified critical standard.

In conclusion, the overall grade of service depends on the accuracy of forecasts made and the planning procedure used, i.e. it depends on the interval between plant additions and on the specific traffic value in future to which the grade of service is related.

Reference

[1] CCITT Recommendation *International routing plan*, Vol. II, Fascicle II.2, Rec. E.171.

Recommendation E.543

GRADES OF SERVICE IN ANALOGUE/DIGITAL INTERNATIONAL TELEPHONE EXCHANGES

1 Introduction

1.1 This Recommendation specifies the grade of service (GOS) of common control switching systems – regardless of the technology used – in the international telephone network.

1.2 The grade of service standards of an international telephone exchange defined in this Recommendation are described on the basis of specified load levels assuming that the exchange is fully operative. Only ranges of values are shown at present, pending further study.

2 General concept

2.1 The grade of service standards are specified for an exchange as a whole, i.e. the connecting network as well as the control area. This is done in order to provide the system designers with the maximum flexibility to take advantage of new technologies and achieve the most economical design.

The standards are expressed from the operational rather than from the design point of view. They will apply to *all* call attempts to a given exchange, not just to the first attempts of particular call intents.

2.2 There are two grades of service aspects in an exchange:

– loss in setting up a connection;

– delay in setting up a connection.

Both standards are to be referred to specified load levels. For those the two load levels "normal load" and "high load" given in Recommendation E.500 shall be used.

3 Grade of service standards

The loss and delay grade of service standards are defined as follows:

3.1 *Loss grade of service*

Loss: The probability of failure to build up a connection from an inlet of the exchange to any outgoing trunk group having at least one free trunk.

The loss grade of service is to be met by every pair of incoming and outgoing trunk groups averaged over all inlets of the incoming group.

This approach takes explicit account of the fact that the Administrations will take actions such as the favourable loading of switch blocks in order to balance access to all trunk groups. These actions will minimize the impact of the worst case upon the traffic flow capacity of the switch, by confining the necessary adjustments to localized regions of the switching network.

These actions should ensure that the switching system operates as efficiently as possible within the constraints imposed by this loss standard.

3.2 *Delay grade of service in case of channel-associated signalling*

Incoming response delay: The interval from the instant when an incoming seizure signal has arrived at the incoming side of the exchange to the instant when a proceed-to-send signal is returned to the preceding exchange by the receiving exchange.

The incoming response delay may affect the holding time of the preceding trunks and of the common control equipment in the preceding exchange(s). It may also be perceived by the subscriber as dial-tone delay, in case of special dial tone for international calls in outgoing international exchanges, or may contribute to the post-dialling delay experienced by the subscriber in all other cases. The contribution to post-dialling delay does not necessarily comprise the whole of the incoming response delay.

3.3 *Delay grade of service in case of any combination of channel-associated and common channel signalling*

Exchange call set-up delay: The interval from the instant when the address information required for setting up a call is received at the incoming side of the exchange to the instant when the seizing signal or the corresponding address information is sent to the subsequent exchange.

Through-connection delay: The interval from the instant when the information required for setting up a through-connection in an exchange is available for processing in the exchange to the instant when the switching network through-connection is established between the incoming and outgoing circuits.

4 Ranges of values

Given the definitions of normal and high load of Recommendation E.500 the ranges of values shown in Table 1/E.543 may give an idea of possible figures for the grade of service standards.

TABLE 1/E.543

	Normal load	High load
Incoming response delay Exchange call set-up delay Through-connection delay	$P(>x) \leq y$*)	$P(>x) \leq z$*)
Loss probability	0.001...0.01	Around 0.03

$x = 0.5$ or 1 second
$0.005 \leq y \leq 0.05$
$0.05 \leq z \leq 0.10$

*) The probability that the delay exceeds x must be less than y or z respectively.

PART III

SUPPLEMENTS TO THE SERIES E RECOMMENDATIONS RELATING TO TELEPHONE NETWORK MANAGEMENT AND TRAFFIC ENGINEERING

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TABLE OF THE ERLANG FORMULA

Table of the Erlang loss formula (Erlang No. 1 formula, also called Erlang B formula)

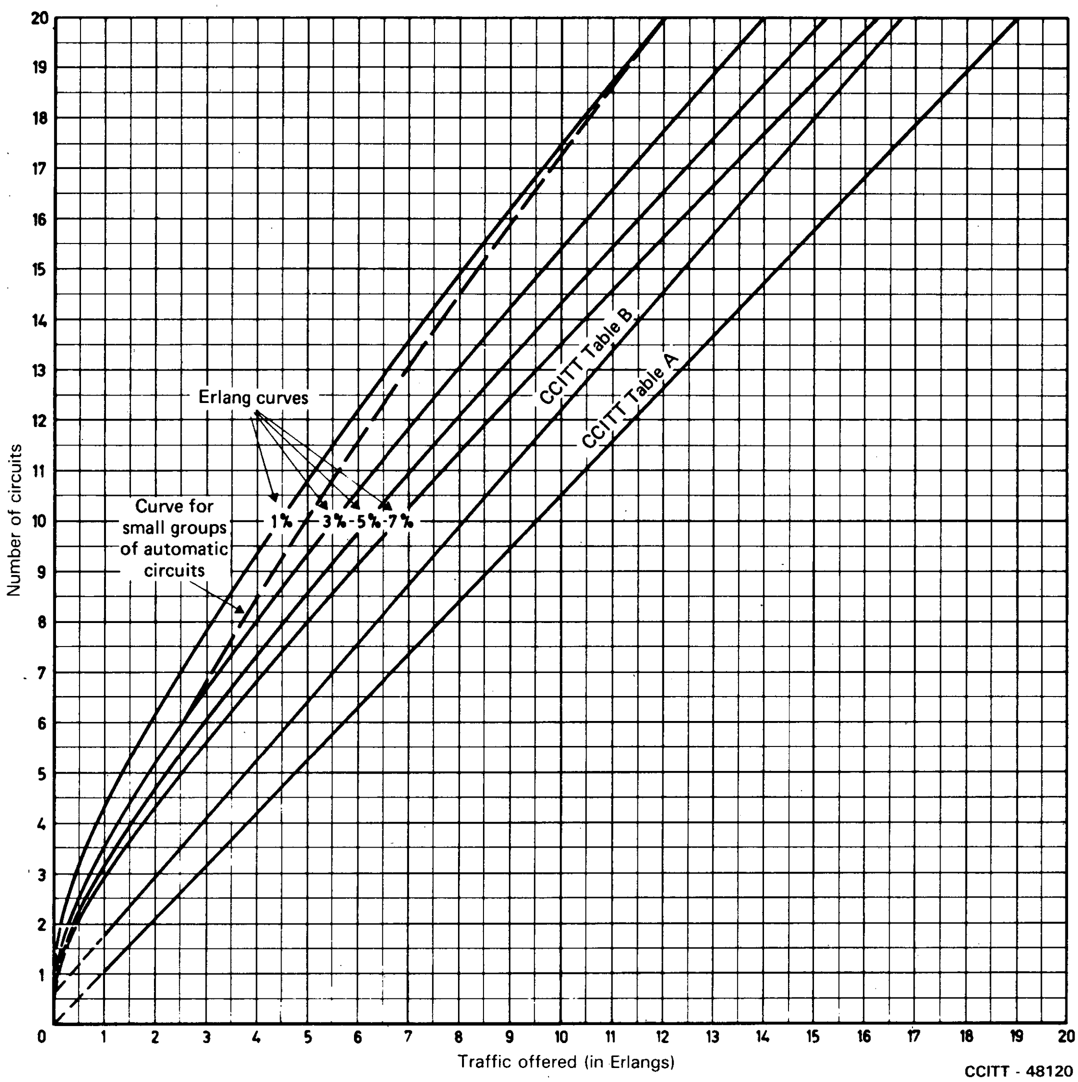
Loss probabilities: 1 %, 3 %, 5 %, 7 %.

Let p = the loss probability
y = the traffic offered (in Erlangs)
n = the number of circuits

Formula: $$E_{1,n}(y) = p = \frac{\frac{y^n}{n!}}{1 + \frac{y}{1} + \frac{y^2}{2!} + \ldots + \frac{y^n}{n!}}$$

n	$p = 1\%$	$p = 3\%$	$p = 5\%$	$p = 7\%$	n	$p = 1\%$	$p = 3\%$	$p = 5\%$	$p = 7\%$
1	0.01	0.03	0.05	0.08	51	38.80	42.89	45.53	47.72
2	0.15	0.28	0.38	0.47	52	39.70	43.85	46.53	48.76
3	0.46	0.72	0.90	1.06	53	40.60	44.81	47.53	49.79
4	0.87	1.26	1.53	1.75	54	41.50	45.78	48.54	50.83
5	1.36	1.88	2.22	2.50	55	42.41	46.74	49.54	51.86
6	1.91	2.54	2.96	3.30	56	43.31	47.70	50.54	52.90
7	2.50	3.25	3.74	4.14	57	44.22	48.67	51.55	53.94
8	3.13	3.99	4.54	5.00	58	45.13	49.63	52.55	54.98
9	3.78	4.75	5.37	5.88	59	46.04	50.60	53.56	56.02
10	4.46	5.53	6.22	6.78	60	46.95	51.57	54.57	57.06
11	5.16	6.33	7.08	7.69	61	47.86	52.54	55.57	58.10
12	5.88	7.14	7.95	8.61	62	48.77	53.51	56.58	59.14
13	6.61	7.97	8.84	9.54	63	49.69	54.48	57.59	60.18
14	7.35	8.80	9.73	10.48	64	50.60	55.45	58.60	61.22
15	8.11	9.65	10.63	11.43	65	51.52	56.42	59.61	62.27
16	8.88	10.51	11.54	12.39	66	52.44	57.39	60.62	63.31
17	9.65	11.37	12.46	13.35	67	53.35	58.37	61.63	64.35
18	10.44	12.24	13.39	14.32	68	54.27	59.34	62.64	65.40
19	11.23	13.11	14.31	15.29	69	55.19	60.32	63.65	66.44
20	12.03	14.00	15.25	16.27	70	56.11	61.29	64.67	67.49
21	12.84	14.89	16.19	17.25	71	57.03	62.27	65.68	68.53
22	13.65	15.78	17.13	18.24	72	57.96	63.24	66.69	69.58
23	14.47	16.68	18.08	19.23	73	58.88	64.22	67.71	70.62
24	15.29	17.58	19.03	20.22	74	59.80	65.20	68.72	71.67
25	16.13	18.48	19.99	21.21	75	60.73	66.18	69.74	72.72
26	16.96	19.39	20.94	22.21	76	61.65	67.16	70.75	73.77
27	17.80	20.31	21.90	23.21	77	62.58	68.14	71.77	74.81
28	18.64	21.22	22.87	24.22	78	63.51	69.12	72.79	75.86
29	19.49	22.14	23.83	25.22	79	64.43	70.10	73.80	76.91
30	20.34	23.06	24.80	26.23	80	65.36	71.08	74.82	77.96
31	21.19	23.99	25.77	27.24	81	66.29	72.06	75.84	79.01
32	22.05	24.91	26.75	28.25	82	67.22	73.04	76.86	80.06
33	22.91	25.84	27.72	29.26	83	68.15	74.02	77.87	81.11
34	23.77	26.78	28.70	30.28	84	69.08	75.01	78.89	82.16
35	24.64	27.71	29.68	31.29	85	70.02	75.99	79.91	83.21
36	25.51	28.65	30.66	32.31	86	70.95	76.97	80.93	84.26
37	26.38	29.59	31.64	33.33	87	71.88	77.96	81.95	85.31
38	27.25	30.53	32.62	34.35	88	72.81	78.94	82.97	86.36
39	28.13	31.47	33.61	35.37	89	73.75	79.93	83.99	87.41
40	29.01	32.41	34.60	36.40	90	74.68	80.91	85.01	88.46
41	29.89	33.36	35.58	37.42	91	75.62	81.90	86.04	89.52
42	30.77	34.30	36.57	38.45	92	76.56	82.89	87.06	90.57
43	31.66	35.25	37.57	39.47	93	77.49	83.87	88.08	91.62
44	32.54	36.20	38.56	40.50	94	78.43	84.86	89.10	92.67
45	33.43	37.16	39.55	41.53	95	79.37	85.85	90.12	93.73
46	34.32	38.11	40.54	42.56	96	80.31	86.84	91.15	94.78
47	35.22	39.06	41.54	43.59	97	81.24	87.83	92.17	95.83
48	36.11	40.02	42.54	44.62	98	82.18	88.82	93.19	96.89
49	37.00	40.98	43.53	45.65	99	83.12	89.80	94.22	97.94
50	37.90	41.93	44.53	46.69	100	84.06	90.79	95.24	98.99

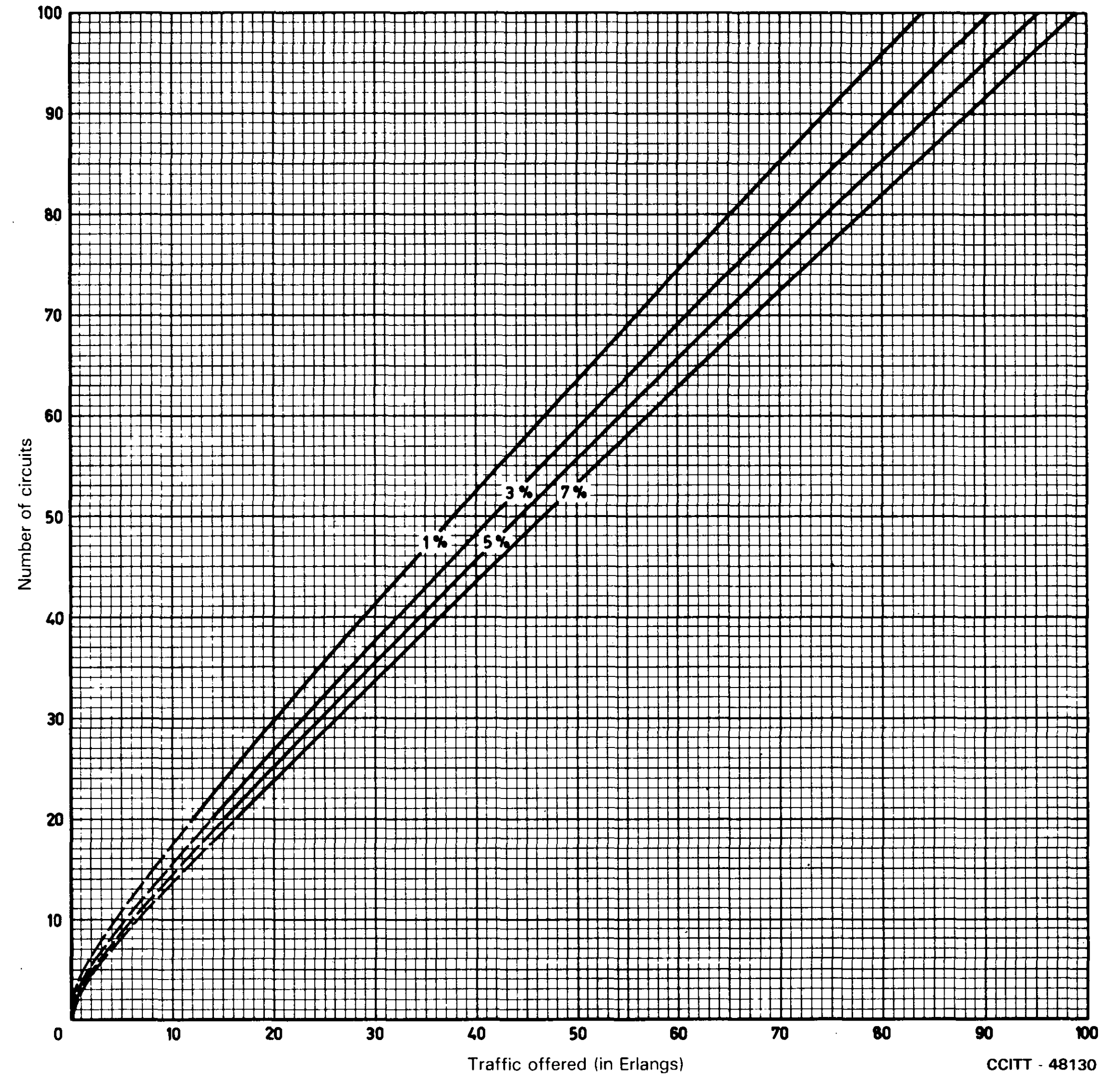
CURVES SHOWING THE RELATION BETWEEN THE TRAFFIC OFFERED AND THE NUMBER OF CIRCUITS REQUIRED



Relation between the traffic (in Erlangs) offered and the number of circuits required in the case of:
— the curves A and B of Table 1/E.510;
— the Erlang formula (p = 1 %, 3 %, 5 % and 7 %);
— the curve for small groups of automatic circuits (see Annex A to Recommendation E.520).

FIGURE 1

Number of circuits between 1 and 20



Relation between the traffic (in Erlangs) offered and the number of circuits required in the case of the Erlang formula for (p = 1 %, 3 %, 5 % and 7 %).

FIGURE 2

Number of circuits between 1 and 100

Supplement No. 3

INFORMATION ON TRAFFIC ROUTING IN THE INTERNATIONAL NETWORK

(Results from study in 1973-1976 of Question 11/XIII
concerning actual connections of international telephone calls

(For the text of this Supplement, see Supplement No. 7,
Volume II.2, *Orange Book*, Geneva, 1976)

Supplement No. 4

USE OF COMPUTERS FOR NETWORK PLANNING AND CIRCUIT GROUP DIMENSIONING

(For the text of this Supplement, see Supplement No. 8, Volume II.2, *Orange Book*, Geneva, 1976)

Supplement No. 5

GUIDANCE IN INTERNATIONAL TELEPHONE NETWORK MANAGEMENT PRACTICES

1 Introduction

The purpose of this Supplement is to augment the information given in Recommendation E.410, and to provide general guidance on international network management practices.

2 The need for network management

2.1 International telephone networks are usually dimensioned to provide a satisfactory grade of service during the busy hours of the busy season. However, there may be periods when traffic levels will exceed the circuit and/or switching capacity of international switching centres. This may be due to delays in the provision of additional circuits or switching capacity or to traffic surges. Traffic surges can be caused by unusual local events such as severe weather conditions, transmission systems or switching centre problems or failures; by events such as national holidays and major disasters; or by events of international or national interest. It follows that such traffic levels may affect the international networks generally, or be localized to a small number of switching centres and circuits.

2.2 One of the outcomes of traffic levels which exceed the capacity of the network is that many customers who fail to establish a connection at the first attempt immediately make repeat attempts. Such repeat attempts represent an unusually heavy demand on common control switching systems, which can lead to switching congestion caused by delays in seizing common control equipment. Such delays tend to spread rapidly throughout the network, with delays at one switching centre causing delay at others as common control switching equipment waits for responses from the congested switching centre. Without prompt and effective action, the call-carrying (and revenue producing) capacity of the network, or portions of the network, can be substantially reduced.

2.3 The growth of the international automatic service has reduced the capability for direct control of international telephone traffic, since a smaller portion of the traffic is operator handled. There is therefore a need to provide the means of supervising the network to identify the situations mentioned above, so that prompt corrective action may be taken by trained personnel when necessary.

3 Network management principles

The following are the basic principles which guide the network management actions specified in § 1.3 of Recommendation E.410.

3.1 *Utilize all available international circuits*

There are periods during localized situations (see Recommendation E.410, § 1.1) when, due to changing traffic patterns, the demand for service cannot be met by the circuit within that part of the international network. At the same time, many circuits to other locations may be idle due to differences in calling patterns caused by the time zones, local calling habits, or busy season variations. After negotiation and agreement between the Administrations concerned, some portion of the unusually heavy traffic can be redirected to this idle capacity for completion.

3.2 *Keeping all available international circuits filled with traffic which has a high probability of resulting in effective calls*

The international network is basically circuit limited; therefore the maximum number of effective calls is determined by the number of available circuits. Ineffective calls occupy circuit capacity which would otherwise be available for effective calls. Therefore identifying those calls which are likely to be ineffective because of an event in the network (e.g., a failure), and reducing them as far back in the network as possible, will allow circuit capacity to be available for calls which have a high probability of being effective.

3.3 *When all available international circuits are in use, giving priority to calls requiring a minimum number of international circuits to form a connection*

When international networks are designed using a routing hierarchy with automatic alternate routing of calls, efficient operation occurs when traffic loads are at or below planned values. However, as traffic loads increase above the planned value, the ability of the network to carry effective calls decreases since an increased number of calls require two, or more circuits to form a connection. Such calls increase the possibility of one call blocking several potential calls.

Thus automatic alternate routing should be restricted to give preference to direct routed traffic during periods of abnormally high demand.

3.4 *Restricting switching congestion and preventing its spread*

An increase in ineffective calls with its associated increase in repeat attempts can result in switching congestion at the international switching centre (see § 2.2). If this switching congestion is left uncontrolled, it can spread to other contiguous switching centres and cause a further degradation of the network. Network controls should be applied which inhibit switching congestion by removing call attempts from the congested switching centre (e.g., by cancelling alternate routed traffic via the congested switching centre).

4 Interpretation of parameters

The interpretation of parameters on which network management actions are based can most conveniently be made by considering the originating international switching centre as the reference point.

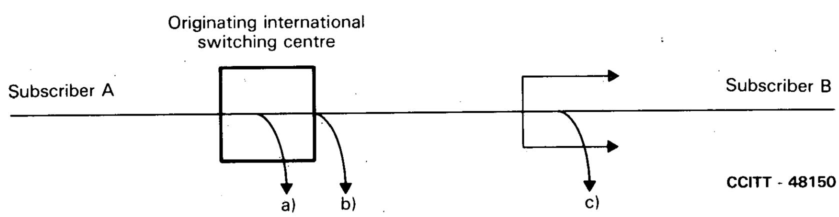


FIGURE 1

From this reference point, the factors which affect call completion can broadly be divided into three main components:

a) Switching loss } Near-end loss
b) Circuit congestion loss
c) Distant network loss } Far-end loss

4.1 *Switching loss*

Switching loss may be due to:

1) common equipment or switchblock congestion, or
2) failures in incoming signalling, or
3) subscriber/operator dependent errors, such as insufficient or invalid digits, premature call abandonment, etc., or

4) routing errors, such as barred transit access, or

5) other technical failures.

Guidance to the identification of switching loss can be obtained from § 3.4.7 of Recommendation E.410.

4.2 *Circuit congestion loss*

This loss will depend on:

1) the number of circuits available for a destination, and

2) the level of demand for that destination.

Indication that circuit congestion loss may occur can be obtained from the status information detailed in § 3.2 of Recommendation E.410.

Circuit congestion loss can be identified by either the following:

- percentage overflow (see § 3.4.1 of Recommendation E.410),
- a difference between the "bids per circuit per hour" and "seizures per circuit per hour" measurements on the final route (see §§ 3.4.2 and 3.4.4 of Recommendation E.410).

It should be noted that for both-way operated routes, excessive demand in the incoming direction may also cause circuit congestion loss. This can be identified by measuring "bids per circuit per hour" on occupancy (see § 3.4.5 of Recommendation E.410) at each end of the routes.

4.3 *Distant network loss*

Distant network loss may be divided into:

1) *Technical loss:* due to distant switching centre and national circuit faults.

2) *Subscriber dependent loss:* due to subscriber B busy, no answer, invalid distant number, number unavailable, etc.

3) *Traffic dependent loss:* these losses are due to lack of distant network capacity to meet traffic demand.

Under normal conditions, and for a large sample measured over a long period, distant network loss can be said to have a fixed or ambient overhead loss (this value depends on destination with some diurnal and day-by-day variations).

Under abnormal situations (heavy demand, failures etc.) distant network losses can be significantly affected. Variations in distant network loss can be identified by any of the following:

- Answer seizure ratio (see § 3.4.3 of Recommendation E.410). This is a direct measurement.
- Seizures per circuit per hour (see § 3.4.4 of Recommendation E.410). This is an indirect measurement.
- Mean holding time per seizure (see § 3.4.6 of Recommendation E.410). This is an indirect measurement.

5 Network management control summary

The following is a list of typical network management controls described in general terms. The availability of any specific control, its nomenclature or the method of operation can vary with the different switching systems and technologies used in the international network. Where specific control capability does not exist, consideration should be given to providing such capability when designing new switching centres, or when upgrading existing ones. In many instances, these network controls can be activated for use on variable percentages of the traffic affected (e.g. 25, 50, 75, 100%), so as to "fine-tune" the control to match the magnitude of the problem.

a) *Cancellation of alternative routing*

There are two variations of this control. One prevents traffic from a selected high usage route from overflowing onto the next alternate route. The other prevents overflow traffic from all sources from accessing a specific route.

b) *Restriction of direct routing*

This control limits the amount of direct routed traffic accessing a route.

c) *Skip route*

This control allows traffic to bypass a specific route and advance instead to the next route in its normal routing pattern.

d) *Code block*

This control bars or restricts routing to a specific destination code.

e) *Circuit directionalization*

This control changes both-way operated circuits to one-way operation.

f) *Circuit turndown (or circuit busying)*

This control removes one-way or both-way operated circuits from service.

g) *Operator controls*

There are a variety of controls which modify the call-handling procedures of operators. They include reducing the number of attempts (or all attempts) on calls to a particular destination, special instructions on emergency call handling during congestion or failure situations, different routing instructions on certain destination codes, additional routes to be used when normal routes are congested, etc.

h) *Recorded announcements*

These are announcements which give special instructions to operators and subscribers, such as deferring their call to a later time during congestion, failures or other abnormal conditions.

i) *Temporary alternative routings*

These are a variety of controls which serve to reroute traffic from congested routes, to other routes not normally available which have idle capacity at the time. This can be accomplished by modifying the routing pattern in a switching centre, or by making new routings available to operators. Temporary alternative routings can be used on a planned basis such as on a recurring peak calling day, or in response to an unexpected demand, or failure situations.

Supplement No. 6

TELETRAFFIC IMPLICATIONS FOR INTERNATIONAL SWITCHING AND OPERATIONAL PROCEDURES RESULTING FROM A FAILURE OF A TRANSMISSION FACILITY

1 Very considerable changes have occurred in the international network over the past decade. These changes have arisen mainly from:

- the growth in the number of long-distance routes;
- the growth in the number of circuits forming individual long-distance routes;
- the world-wide introduction of international automatic operation;
- technological developments associated with all aspects of the international network: switching unit design, transmission facility design, and routing and operational strategies;
- the integration into the international automatic service of the more isolated geographical areas and of centres having low-capacity international switching units.

2 The resultant multiplicity of circumstances and situations arising within the international network is now such that it is no longer possible to specify one single criterion for initiating corrective action to counter the loss of a transmission facility. Indeed, the failure of the whole, or part, of a transmission facility may manifest itself in a different manner to each of several Administration affected by the failure.

3 Among the many aspects of international switching and operational procedures which can influence the degree of curtailment of service arising from a transmission-facility failure, i.e. which can reduce the ability of part of the international network to carry its designed traffic load successfully, the following are specifically stressed (their order has no particular significance):

- the introduction of fully automatic international operation, which means that the control of the network, formerly completely operator-controlled, now depends directly on subscribers' habits;
- the number of routes that could be affected by failure and their proportion of the total routes on the switching unit to which they are directly connected: the range can be from one whole route to a few circuits in each of many routes, depending on the method of allocating circuits to transmission facilities;
- the influence of any route, for which no alternative transmission facility exists, on the performance of the international switching unit to which it is connected;
- the effect on the grade of service of the switching unit itself due to the loss of a complete route or routes, or parts of several routes, directly connected to it;
- the methods of limiting the effect of failure on service by action within the switching unit or at preceding international or national switching unit, e.g. by code blocking or recorded announcements;
- the cause of the failure, and thus the possible restoration time, relative to the 24-hour traffic profile;
- the effect of a failure on overflow and automatic alternative routing strategies;
- the use of diversity of international switching units;
- the use of diversity of international transmission facilities.

4 Attention is also drawn to four major factors of maintaining continuity of service;

- reliability,
- diversity,
- network management, and
- any redundancy specifically provided to allow restoration of service.

5 Clearly, no practical transmission facility provided will give 100 per cent reliability, so it is inevitable that the other three factors will be involved to varying degrees in maintaining service. The interaction of these four factors will depend largely on the emphasis placed upon each of them by each Administration, thus reinforcing the view that the degree of corrective action that can be taken will depend considerably upon the investment policy (in materials and equipment) and forward-planning objectives of individual Administrations.

6 With respect to diversity, it is recommended that Administrations give consideration to the provision of an adequate number of paths for a particular route, with an adequate level of independence between the paths. Such independence could reduce the effect of a breakdown or other adverse event by confining it, as far as possible, to only one of the paths used by that route.

7 For the further assistance of Administrations in their study of those teletraffic aspects of international switching and operational procedure which influence the degree of curtailment of service and which arise from a transmission facility failure, these four factors are included in Question 17/II [1] related to continuity of service, accepted for study during the 1981-1984 Study Period.

Reference

[1] CCITT – Question 17/II, Contribution COM II-No. 1, Study Period 1981-1984, Geneva, 1981.

LIST OF TERMS AND DEFINITIONS OF TELETRAFFIC

This Supplement is organized as follows [1]:

715 – Teletraffic, trunking and operating

715.1 *Teletraffic*

10 General theory
11 Calls
12 Delays
13 Traffic
14 Trunks
15 Engineering

715.10 *General theory*

10.02 Communication
10.06 Connection (communication path)
10.08 Loss system
10.10 Delay system
10.12 Combined loss and delay system
10.14 Mean waiting time (average delay)
10.16 Reliability
10.18 Availability

715.11 *Calls*

11.06 Bid
11.08 Seizure
11.10 Call attempt
11.12 Call intent
11.16 Repeated call attempt (reattempt)
11.18 Call string
11.20 Busy
11.22 Release
11.24 Busy period
11.28 Blocking congestion
11.30 Internal blocking
11.32 External blocking
11.34 Call congestion (probability of loss; loss)
11.36 Time congestion
11.38 Call attempt, abandoned
11.40 Call attempt, lost
11.42 Call attempt, successful
11.44 Call attempt, completed (call attempt, effective)
11.48 Successful call
11.50 Completion ratio (efficiency ratio; answer seizure ratio)
11.54 Call intensity
11.56 Subscriber calling rate
11.58 Subscriber traffic rate

715.12 *Delays*

12.02 Dialling time
12.04 Dial tone delay
12.06 Incoming response delay
12.08 Exchange call set up delay
12.10 Through-connection delay
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715.13 *Traffic*

13.02 Telecommunications traffic (teletraffic)
13.04 Poisson traffic
13.06 Pure chance traffic
13.08 Peakedness factor
13.10 Smooth traffic
13.20 Lost traffic
13.22 Traffic volume
13.24 Traffic intensity (load)
13.26 Erlang
13.28 Traffic matrix

[1] The terms bear an IEV number, which has the format 715.XX.YY where 715 is the number of the teletraffic chapter of the IEV, XX is a subchapter number, and YY is a sequence number in a subchapter.

13.12 Peaked traffic
13.14 Traffic offered
13.16 Traffic carried
13.18 Overflow traffic
13.30 Traffic relation (traffic stream; traffic item; parcel of traffic; "point-to-point traffic")
13.32 Equivalent random traffic intensity

715.14 *Circuits*

14.02 Unidirectional
14.04 Bidirectional
14.06 One way
14.08 Both way
14.10 Channel
14.12 Pair of complementary channels
14.14 Trunk = circuit
14.18 Circuit subgroup
14.20 Circuit group
14.22 First choice circuit group
14.24 High usage circuit group
14.26 Final circuit group
14.28 Only route circuit group
14.30 Fully provided circuit group
14.32 Last choice circuit group
14.34 Equivalent random circuit group

715.15 *Engineering*

15.02 Route
15.04 Alternative (alternate) route
15.06 Network cluster
15.10 Traffic routing
15.12 Busy hour
15.14 Peak busy hour (bouncing busy hour); post selected busy hour)
15.16 Time consistent busy hour
15.18 Day to busy-hour ratio
15.20 Effective traffic
15.22 Grade of service
15.24 Quality of service
15.26 Originating traffic
15.28 Terminating traffic
15.30 Internal traffic
15.32 Incoming traffic
15.34 Outgoing traffic
15.36 Transit traffic
15.44 Traffic load imbalance
15.46 Traffic distribution imbalance

10.02 **communication**

F: communication

S: comunicación

Exchange of information between two or more users of a telecommunication network, according to agreed conventions.

10.06 **connection (communication path)**

F: connexion (trajet de communication)

S: conexión (trayecto de comunicación)

An association of channels and other functional units providing means for a communication between two or more users of a telecommunication network.

10.08 **loss system**

F: système avec perte

S: sistema de pérdidas

A system in which bids that cannot be served immediately are lost.

10.10 **delay system**

F: système avec attente

S: sistema de espera

A system in which bids that cannot be served immediately are permitted to wait until service can begin.

10.12 **combined loss and delay system**

F: système avec perte et attente

S: sistema mixto de pérdidas y espera

A system in which bids that cannot be served immediately are permitted to wait until service can begin, provided that a waiting place is free or until a time-out occurs. The bids are then lost.

10.14 **mean waiting time (average delay)**

F: délai moyen d'attente

S: tiempo medio de espera

The total waiting time of all bids divided by the total number of bids, including those not delayed.

10.16 **reliability**

F: fiabilité

S: fiabilidad

The ability of a system or a resource to perform its functions under stated conditions over a stated period of time, by maintaining quality of service parameters within stated values.

Reliability is generally expressed as parameters such as the probability that the system or the resource is performing correctly over the stated period of time.

10.18 **availability**

F: disponibilité

S: disponibilidad

Probability that a system, or a resource is not in a state of congestion or failure at any given point in time.

Note – Availability is generally associated to failures only.

11.06 **bid**

F: tentative de prise

S: tentativa de toma

A single attempt to obtain the service of a resource.

11.08 **seizure**

F: prise

S: toma

A successful bid.

11.10 **call attempt**

F: tentative d'appel

S: tentativa de llamada

A call attempt by a caller/device is a single unsuccessful bid, or a successful bid, and subsequent bids, related to the establishment of a telephone call from that caller/device, ending not later that the freeing of the resource seized.

11.12 **call intent**

F: intention d'appel

S: intento de llamada

The desire to establish a call. It is manifested by one or more successive call attempts.

Note – As far as the outgoing international exchange is concerned, this definition is more restrictive than that of the call request defined in Recommendation E.100, point 2. If a call intent cannot be observed, it is however manifested at any point on the communication path by the initial call attempt observed. It may actually be the first call attempt made by the calling party. It may also be a subsequent call attempt.

11.16 **repeated call attempt (reattempt)**

F: tentative d'appel répétée

S: tentativa de llamada repetida

Any of the subsequent call attempts related to a first call attempt.

11.18 **call string**

F: chaîne d'appel

S: cadena de llamadas

All the call attempts related to a single call intent.

11.20 **busy**

F: occupation, occupé

S: ocupado (ocupación)

Condition of a resource which is in use, following its seizure.

11.22 **release**

F: libération (fin, relâchement)

S: liberación

The event which is the end of a busy state.

11.24 **busy period**

F: période d'occupation ininterrompue

S: periodo de ocupación ininterrumpida

The time interval between the seizure of the last available resource in a pool of resources and the next release and resultant idle state of a resource in that pool.

11.28 **blocking (congestion)**

F: encombrement (congestion)

S: bloqueo (congestión)

The state when the immediate establishment of a new connection is impossible owing to the inaccessibility of any of the resources of the system being considered.

Note 1 – When blocking or congestion is used as an abbreviation for probability of blocking or probability of congestion, it should always be made clear whether it refers to time congestion or call congestion probabilities.

Note 2 – Blocking does not necessarily result in the loss of a call attempt, because it may be possible to establish the connection after a certain delay or by using alternative resources.

11.30 **internal blocking**

F: blocage interne

S: bloqueo interno

The condition in which a connection cannot be made between a given inlet and any suitable free outlet owing to the impossibility of establishing a path, within the switching element being considered.

11.32 **external blocking**

F: blocage externe

S: bloqueo externo

When referring to a switching stage, the condition in which no suitable resource, connected to that switching stage, is accessible.

11.34 **call congestion (probability of loss; loss)**

F: encombrement d'appel (probabilité de perte, perte)

S: congestión (o bloqueo) de llamadas (probabilidad de pérdida, pérdida)

The probability that a call attempt encounters congestion. It is estimated by the call congestion ratio.

11.36 **time congestion**

F: congestion temporelle

S: congestión temporal

The probability that a system is congested over any time period. It is estimated by the time congestion rate.

11.38 **call attempt, abandoned**

F: tentative d'appel abandonnée

S: tentativa de llamada abandonada

A call attempt aborted by the calling party.

11.40 **call attempt, lost**

F: tentative d'appel perdue

S: tentativa de llamada perdida

A call attempt that is rejected due to an equipment shortage, malfunction or failure in the network.

11.42 **call attempt, successful**

F: tentative d'appel acheminée

S: tentativa de llamada fructuosa

A call attempt, in which the calling station is either switched through to the exchange line terminating unit of the dialled number, or receives busy tone when the dialled number is busy.

Note – A successful call attempt does not necessarily result in a successful call.

11.44 **call attempt, completed (call attempt, effective)**

F: tentative d'appel ayant abouti (tentative d'appel efficace)

S: tentativa de llamada completada (tentativa de llamada eficaz)

A call attempt answered by a called station; in international service this should always be followed by an answer signal.

Note – The station reached might not be the one wanted by the caller, due to dialling error or network malfunction.

11.48 **successful call**

F: appel ayant abouti

S: llamada fructuosa

A call that has reached the wanted number and allows the conversation to proceed.

11.50 **completion ratio (efficiency ratio; answer seizure ratio)**

F: taux d'efficacité

S: relación respuesta/toma (tasa de eficacia)

The ratio of the number of completed (or effective) call attempts to the total number of call attempts, as measured at a given point of a network.

11.54 **call intensity**

F: intensité d'appel

S: intensidad de llamadas

The number of call attempts observed during a period divided by the duration of the period.

11.56 **subscriber calling rate**

F: taux d'appel d'un abonné

S: intensidad de llamadas de un abonado

The call intensity of a subscriber line.

Note 1 – It should not be used to mean traffic rate.

Note 2 – It should be made clear whether the rate refers to the originating calling rate, or to the terminating calling rate or to the sum of both.

11.58 **subscriber traffic rate**

F: trafic d'un abonné

S: intensidad de tráfico de un abonado

The traffic intensity of a subscriber line.

Note – It should be made clear whether the rate refers to the originating traffic rate, or to the terminating traffic rate, or to the sum of both.

12.02 **dialling-time**

F: durée de numérotation

S: tiempo de marcación

Time interval between the reception of dial tone and the end of dialling of the calling subscriber.

12.04 **dial-tone delay**

F: durée d'attente de tonalité

S: periodo de espera del tono de invitación a marcar

Time interval between subscriber off hook and reception of dial tone.

12.06 **incoming response delay**

F: durée de présélection

S: duración de la preselección

The interval from the instant when an incoming seizure signal has arrived at the incoming side of the exchange to the instant when the exchange is ready to receive the signalling, or to the instant when a proceed-to-send signal is returned to the preceding exchange by the receiving exchange.

This definition is only applicable in case of channel associated signalling.

12.08 **exchange call set-up delay**

F: durée de sélection d'un commutateur

S: tiempo de establecimiento de la comunicación por una central

The interval from the instant when the address information required for setting up a call is received at the incoming side of the exchange to the instant when the seizing signal or the corresponding address information is sent to the subsequent exchange, or to the instant when the ringing signal is sent to the appropriate user.

12.10 **through-connection delay**

F: durée d'établissement d'un commutateur

S: tiempo de transferencia de la central

The interval from the instant when the information required for setting-up a through-connection in an exchange is available for processing in the exchange, to the instant when the switching network through-connection is established between the incoming and outgoing circuits.

12.12 **post-dialling delay**

F: attente après numérotation

S: periodo de espera después de marcar

Time interval between the end of dialling by the subscriber and the reception by him of the appropriate tone or recorded announcement, or the abandon of the call without tone.

12.14 **answering delay**

F: durée de sonnerie

S: demora de respuesta

Time interval between the setting-up of an end-to-end connection between the calling and called stations, and the detection of an answer signal.

13.02 **telecommunications traffic (teletraffic)**

F: trafic de télécommunication (télétrafic)

S: tráfico de telecomunicación (teletráfico)

A flow of attempts, calls and messages.

13.04 **poisson traffic**

F: trafic poissonnien

S: tráfico poissoniano

A traffic that has a Poisson distribution of arrivals.

13.06 **pure chance traffic**

F: trafic de pur hasard

S: tráfico puramente al azar

A Poisson traffic which has a negative exponential distribution of holding time.

13.08 **peakedness factor**

F: facteur d'irrégularité

S: factor de irregularidad

The ratio of variance to mean of a traffic.

Note – The variance and the mean refer to the number of resources that would be occupied if this traffic was offered to an infinitely large pool of resources.

13.10 **smooth traffic**

F: trafic régularisé

S: tráfico con distribución uniforme

A traffic that has a peakedness factor less than one.

13.12 **peaked traffic**

F: trafic survariant

S: tráfico con distribución en pico

A traffic that has a peakedness factor greater than one.

13.14 **traffic offered**

F: trafic offert

S: tráfico ofrecido

The traffic that would be served by a pool of resources sufficiently large to serve that traffic without limitation.

Its usage is as a calculating quantity similar to a traffic intensity.

13.16 **traffic carried**

F: trafic écoulé

S: tráfico cursado

That part of the traffic offered to a pool of resources which is served by the pool.

13.18 **overflow traffic**

F: trafic de débordement

S: tráfico de desbordamiento

That part of the traffic offered to a pool of resources which is not carried by it, but is offered to additional resources provided to handle such traffic.

13.20 **lost traffic**

F: trafic perdu

S: tráfico perdido

That part of the traffic offered to a pool of resources which is not carried and has no additional resource provided to handle such traffic.

13.22 **traffic volume**

F: volume de trafic

S: volumen de tráfico

The sum of the holding times of the traffic carried by a pool of resources, for a given period of time.

13.24 **traffic intensity (load)**

F: intensité de trafic (charge)

S: intensidad de tráfico (carga)

The traffic intensity on a pool of resources is equal to the volume of traffic divided by the duration of the observation, provided that the period of observation and the holding times are expressed in the same units.

It is therefore equal to the average number of simultaneously busy resources.

Traffic intensity calculated in this way is expressed in Erlangs.

Note 1 – When there is no ambiguity, traffic may be used for traffic intensity.

Note 2 – "Traffic flow" is a deprecated synonym for traffic intensity.

13.26 **Erlang**

F: erlang

S: erlang

The unit of traffic intensity.

13.28 **traffic matrix**

F: matrice de trafic

S: matriz de tráfico

A matrix of which the element at the intersection of row *i* and column *j* gives the traffic which originates at point *i* and is destined for point *j*. The points *i* and *j* may typically be switching centers in a network or the incoming and outgoing circuit groups of a switching center.

Note – Additional traffic generated by the normal operation of the system in setting up and controlling the establishment of the calls needs to be taken into account in any design process using this matrix.

13.30 **traffic relation (traffic stream; traffic item; parcel of traffic; point-to-point traffic)**

F: flux de trafic (trafic point à point, courant de trafic)

S: relación de tráfico (corriente de tráfico, elemento de tráfico, lote de tráfico, tráfico de punto a punto)

The traffic originating at a traffic source and intended for a traffic destination.

13.32 **equivalent random traffic intensity**

F: intensité de trafic équivalent

S: intensidad de tráfico aleatorio equivalente

The theoretical pure chance traffic intensity that, when offered to a number of theoretical circuits (equivalent random circuits), produces an overflow traffic with a mean and variance equal to that of a given offered traffic. The equivalent random concept permits traffic theories that do not explicitely recognize peakedness to be used in peakedness engineering (see equivalent random circuit group).

14.02 **unidirectional**

F: unidirectionnel

S: unidireccional

A qualification which implies that the transmission of information always occurs in one direction.

14.04 **bidirectional**

F: bidirectionnel

S: bidireccional

A qualification which implies that the transmission of information occurs in both directions.

14.06 **one way**

F: à sans unique

S: en un solo sentido

A qualification applying to traffic, which implies that the call set-up always occurs in one direction.

14.08 **both way**

F: à double sens

S: en ambos sentidos

A qualification applying to traffic, which implies that the call set-up occurs in both directions.

Note – The amount of the traffic flowing in the two directions are not necessarily equal either in the short term or in the long term.

14.10 **channel**

F: voie (de communication)

S: canal (de transmisión)

A means of unidirectional communication.

14.12 **pair of complementary channels**

F: paire de voies complémentaires

S: par de canales complementarios

Two channels, one in each direction, which provide a bidirectional communication.

14.14 **trunk circuit**

F: circuit

S: circuito

A pair of complementary channels with associated equipments terminating in two exchanges.

14.18 **circuit subgroup**

F: sous-faisceaux

S: subhaz de circuitos

A number of circuits with similar characteristics (e.g. type of signalling, type of path transmission, etc.).

It is not engineered as a unit, but as a part of a circuit group. Circuit subgroups are provided for reasons of service, protection, equipment limitation, maintenance, etc.

14.20 **circuit group**

F: faisceau (de circuits)

S: haz de circuitos

A group of circuits which are traffic-engineered as a unit.

14.22 **first choice circuit group**

F: faisceau de premier choix

S: haz de circuitos de primera elección

At a switching system, the circuit group to which a traffic item is initially offered.

14.24 **high usage circuit group**

F: faisceau débordant

S: haz de circuitos de gran utilización

A circuit-group that is traffic engineered to overflow to one, or more, other circuit groups.

14.26 **final circuit group**

F: faisceau final

S: haz final de circuitos

A circuit-group which receives overflow traffic and for which there is no possible overflow.

It may also carry first choice parcels of traffic, for which it said to be fully provided.

14.28 **only route circuit group**

F: faisceau d'acheminement unique

S: haz de circuitos de una ruta única

A circuit group which is the one and only route for all the parcels of traffic it carries.

It is said to be fully provided for each of these parcels of traffic.

14.30 **fully provided circuit group**

F: faisceau totalement fourni

S: haz de circuitos totalmente provisto

With respect to a particular parcel of traffic, a circuit group which is the first choice circuit group for this traffic and which is not traffic engineered as a high usage group.

14.32 **last choice circuit group**

F: faisceau de dernier choix

S: haz de circuitos de última elección

A circuit group which is not traffic engineered as a high usage group.

It may be a final or only route circuit group.

14.34 **equivalent random circuit group**

F: faisceau équivalent

S: haz de circuitos aleatorios equivalente

A number of theoretical circuits used in conjunction with an equivalent random traffic intensity to permit traffic theories that do not explicitly recognize peakedness to be used in peakedness engineering (see equivalent random traffic).

15.02 **route**

F: voie d'acheminement

S: ruta

The particular circuit group / circuit subgroup, or interconnected circuit group / circuit subgroup between two reference points, predetermined to establish a path for a call.

15.04 **alternative (alternate) route**

F: voie d'acheminement détournée

S: ruta alternativa

A second, or subsequent choice route between two reference points usually consisting of two or more circuit groups in tandem.

15.06 **network cluster**

F: faisceau de faisceaux

S: agrupación de haces

A final circuit group and all the high usage circuit groups which have at least one terminus in common with it and for which the final circuit group is in the last choice route.

15.10 **traffic routing**

F: acheminement

S: encaminamiento de tráfico

The selection of a route or routes, for a given traffic stream; this term is applicable to the selection of routes by switching systems or operators, or to the planning of routes.

15.12 **busy hour**

F: heure chargée

S: hora cargada

The busy hour refers to the traffic volume or number of call attempts, and is the sixty consecutive minutes of a given time period for which the traffic volume or number of call attempts, respectively of an exchange or a circuit groups has been highest.

15.14 **peak busy hour (bouncing busy hour; post selected busy hour)**

F: heure de pointe

S: hora punta

The busy hour each day; it is usually not the same over a number of a days.

15.16 **time consistent busy hour (mean busy hour)**

F: heure chargée moyenne

S: hora cargada media

The 60 consecutive minutes commencing at the same time each day, for which the average traffic volume of the observed exchange or circuit group, is greatest over the days of observation.

15.18 **day to busy-hour ratio**

F: rapport du trafic journalier au trafic à l'heure chargée

S: relación del tráfico diario al tráfico en la hora cargada

The ratio of the 24-hour day traffic volume to the busy hour traffic volume.

Note – Busy-hour to day ratio is also used.

15.20 **effective traffic**

F: trafic efficace

S: tráfico eficaz

The traffic intensity corresponding to the call durations.

15.22 **grade of service**

F: qualité d'écoulement du trafic

S: grado de servicio

A number of traffic engineering parameters used to provide a measure of adequacy of plant under specified conditions; these grade of service parameters may be expressed as probability of loss, probability of delay, etc.

The numerical values assigned to grade of service parameters are called grade of service standards.

The achieved values of grade service parameters under actual conditions are called grade of service performances.

Note – When there is no likelyhood of ambiguity, the term grade of service may be used as an abbreviation for the term grade of service performance.

15.24 **quality of service**

F: qualité de service

S: calidad de servicio

A measure of service provided to the subscriber. The characteristics of this measure must be declared when specifying a quality of service, and may include such characteristics as transmission quality, faults, congestion, delays, etc.

15.26 **originating traffic**

F: trafic de départ

S: tráfico de origen

Traffic generated by sources located within the network considered, whatever its destination.

15.28 **terminating traffic**

F: trafic d'arrivée

S: tráfico de destino

Traffic destined for sinks located within the network considered, whatever its origin.

15.30 **internal traffic**

F: trafic interne

S: tráfico interno

Traffic originating and terminating within the network considered.

15.32 **incoming traffic**

F: trafic entrant

S: tráfico entrante

Traffic entering the network considered, generated by sources outside it, whatever its destination.

15.34 **outgoing traffic**

F: trafic sortant

S: tráfico saliente

Traffic leaving the network considered, destined for sinks located outside it, whatever its origin.

15.36 **transit traffic**

F: trafic de transit

S: tráfico de tránsito

Traffic passing through the network considered, generated by sources outside it and destined for sinks outside it.

15.44 **traffic load imbalance**

F: déséquilibre de trafic

S: desequilibrio de la carga de tráfico en las entradas

Occurs in an exchange when the traffic load is unevenly distributed among similar units.

15.46 **traffic distribution imbalance**

F: déséquilibre interne de trafic

S: desequilibrio de la distribución interna de tráfico

Occurs in an exchange when the traffic flow of one incoming unit is unevenly distributed among all the outgoing units.

Reference

[1] CCITT Recommendation *Definitions of terms used in international telephone operation*, Vol. II, Fascicle II.2, Rec. E.100, § 2.

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