INTERNATIONAL TELECOMMUNICATION UNION

CCITT

E.508

(11/1988)

THE INTERNATIONAL
TELEGRAPH AND TELEPHONE
CONSULTATIVE COMMITTEE

SERIES E: OVERALL NETWORK OPERATION, TELEPHONE SERVICE, SERVICE OPERATION AND HUMAN FACTORS

Traffic engineering – Forecasting of traffic

FORECASTING NEW INTERNATIONAL SERVICES

Reedition of CCITT Recommendation E.508 published in the Blue Book, Fascicle II.3 (1988)

NOTES

1 CCITT Recommendation E.508 was published in Fascicle II.3 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

2 In this Recommendation, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

Recommendation E.508

FORECASTING NEW INTERNATIONAL SERVICES

1 Introduction

The operation and administration of an international telecommunications network should include the consideration of subscriber demands for new services which may have different characteristics than the traditional traffic (i.e. peak busy hours, bandwidth requirements, and average call durations may be different). By addressing these new demands, Administrations can be more responsive to customer requirements for innovative telecommunications services. Based on the type of service and estimated demand for a service, network facilities and capacity may have to be augmented. An augmentation of the international network could require large capital investments and additional administrative functions and responsibilities. Therefore, it is appropriate that Administrations forecast new international services within their planning process.

This Recommendation presents methods for forecasting new services. The definitions of some of the characteristics of these services, together with their requirements, are covered in § 2, followed by base data requirements in § 3. § 4 discusses research to identify the potential market. Presentation of forecasting methods are contained in § 5. § 6 concludes with forecast tests and adjustments.

2 New service definitions

2.1 A distinction exists between those services which are enhancements of existing services carried on the existing network and those services which are novel.

Many of the services in this latter category will be carried on the Integrated Services Digital Network (ISDN). It is not the purpose of this section to provide an exhaustive list of services but rather to establish a framework for their classification. This framework is required because different base data and forecasting strategies may be necessary in each case.

2.2 enhanced services offered over the existing network

These are services which are offered over the existing network, and which offer an enhancement of the original use for which the network was intended. Services such as the international freephone service, credit card calling and closed user groups are examples of enhancements of voice services; while facsimile, telefax and videotex are examples of non-voice services. These services may be carried over the existing network and, therefore, data will concern usage or offered load specific to the enhancement. Arrangements can be established for the measurement of this traffic, such as the use of special network access codes for non-voice applications or by sampling outgoing circuits for the proportion of non-voice to voice traffic.

2.3 novel services

Novel services are defined as totally new service offerings many of which may be carried over the ISDN. In the case of ISDN, Recommendation I.210 divides telecommunications services into two broad categories: bearer services and teleservices. Recommendation I.210 further defines supplementary services which modify or supplement a basic telecommunications service. The definition of bearer services supported by the ISDN is contained in Recommendations I.210 and I.211, while that for teleservices is found in Recommendations I.210 and I.212. Bearer services may include circuit switched services from 64 kbit/s to 2 Mbit/s and packet services. Circuit switched services above 2 Mbit/s are for further study.

Teleservices may include Group 4 facsimile, mixed mode text and facsimile, 64 kbit/s Teletex and Videotex, videophone, videoconferencing, electronic funds transfer and point of sale transaction services. These lists are not exhaustive but indicate the nature and scope of bearer services and teleservices. Examples of new services are diagrammatically presented in Table 1/E.508.

TABLE 1/E.508

Examples of enhanced and novel services

Enhancement of existing services	"Novel" services	
	Bearer services	Teleservices
Teletex Facsimile Videotex Message handling systems International freephone Credit cards Closed user groups	Packets Circuit switched services – 64 kbit/s – 2 Mbit/s	Group 4 facsimile Mixed mode Videophone Videoconferencing Electronic funds transfer Point of sale transactions Teletex (64 kbit/s) Videotex (64 kbit/s)

3 Base data for forecasting

3.1 *Measurement of enhanced services*

Measurements for existing services are available in terms of calls, minutes, Erlangs, etc. These procedures are covered in Recommendation E.506, § 2. In order to measure/identify enhanced service data from other traffic data on the same network it may be necessary to establish sampling or other procedures to aid in the estimation of this traffic, as described in § 4 and § 5.

3.2 *Novel services*

Novel services, as defined in § 2, may be carried on the ISDN. In the case of the ISDN, circuit switched bearer services and their associated teleservices will be measured in 64 kbit/s increments. Packet switched bearer services and associated teleservices will be measured by a unit of throughput, for example, kilocharacters or kilopackets per second. Other characteristics needed will reflect service quality measurements such as: noise, echo, post-dialing delay, clipping, bit-error rate, holding time, set-up time, error-free seconds, etc.

4 Market research

Market research is conducted to test consumer response and behaviour. This research employs the methods of questionnaires, market analysis, focus groups and interviews. Its purpose is to determine consumers' intentions to purchase a service, attitudes towards new and existing services, price sensitivity and cross service elasticities. Market research helps make decisions concerning which new services should be developed. A combination of the qualitative and quantitative phases of market research can be used in the initial stages of forecasting the demand for a new service.

The design of market research considers a sampling frame, customer/market stratification, the selection of a statistically random sample and the correction of results for non-response bias. The sample can be drawn from the entire market or from subsegments of the market. In sampling different market segments, factors which characterize the segments must be alike with respect to consumer behaviour (small intragroup variance) and should differ as much as possible from other segments (large intergroup variance); each segment is homogeneous while different segments are heterogeneous.

The market research may be useful in forecasting existing services or the penetration of new services. The research may be used in forecasting novel services or any service which has no historical series of demand data. It is important that potential consumers be given a complete description of the new service, including the terms and conditions which would accompany its provisioning. It is also important to ask the surveyees whether they would purchase the new service under a variety of illustrative tariff structures and levels. This aspect of market research will aid in redimensioning the demand upon final determination of the tariff structure and determining the customers' initial price sensitivity.

5 Forecasting procedures

5.1 *General*

The absence of historical data is the fundamental difference between forecasting new services and forecasting existing services. The forecast methodology is dependent on the base data. For example, for a service that is planned but has not been introduced, market research survey data can be used. If the service is already in existence in some countries, forecasting procedures for its introduction to a new country will involve historical data on other countries, its application to the new country and comparison of characteristics between countries.

5.2 *Sampling and questionnaire design*

The forecasting procedure for novel services based on market research is made up of five consecutive steps. The first of these consists in defining the scope of the study.

The second step involves the definition and selection of a sample from the population, where the population includes all potential customers which can be identified by qualitative market research developed through interviews at focus groups. The research can use stratified samples which involves grouping the population into homogeneous segments (or strata) and then sampling within each strata. Stratification prevents the disproportionate representation of some parts of the population that can result by chance with simple random sampling. The sample can be structured to include specified numbers of respondents having characteristics that are known, or believed, to affect the subject of the research. Examples of customer characteristics would be socio-economic background and type of business.

The third step is the questionnaire design. A trade-off exists between obtaining as much information as practical and limiting the questionnaire to a reasonable length, as determined by the surveyor. Most questionnaires have three basic sections:

1) qualifying questions to determine if a knowledgeable person has been contacted;
2) basic questions including all questions which constitute the body of the questionnaire;
3) classification questions collecting background on demographic information.

The fourth step involves the implementation of the research – the actual surveying portion. Professional interviewers, or firms specializing in market research should be employed for interviewing.

The fifth and final step is the tabulation and analysis of the survey data. § 5.3-5.7 describe this process in detail.

5.3 *Conversion ratios for the sample*

Conversion ratios are used in estimating the proportion of respondents expressing an interest in the service who will eventually subscribe.

The analysis of the market research data based on a sample survey, where a stratified sample is drawn across market segments, for a service that is newly introduced or is planned, is discussed below:

Let

X_{1i} = the proportion of firms in market segment i that are very interested in the service.

X_{2i} = the proportion of firms in market segment i that are interested in the service.

X_{3i} = the proportion of firms in market segment i that are not interested in the service.

X_{4i} = the proportion of firms in market segment i that cannot decide whether they are interested or not.

The above example has 4 categories of responses. Greater of fewer categories may be used depending on the design of the questionnaire.

Notice that

$$\sum_j X_{ji} = 1,$$

where j = the index of categories of responses.

Market research firms sometimes determine conversion ratios for selected product/service types. Conversion ratios depend on the nature of the service, the type of respondents, and the questionnaire and its implementation. Conversion ratios applied to the sample will estimate the expected proportion of firms *in the survey* that will eventually subscribe, over the planning period. For studies related to the estimation of conversion ratios, refer to [1], [3] and [5].

Then,

c_1X_{1i} = the proportion of firms in market segment i that expressed a strong interest and are expected to subscribe.

c_2X_{2i} = the proportion of firms in market segment i that expressed an interest and are expected to subscribe.

c_3X_{3i} = the proportion of firms in market segment i that expressed no interest but are expected to subscribe.

c_4X_{4i} = the proportion of undecided firms in market segment i that are expected to subscribe.

where c_j = conversion ratio for response j.

The proportion of firms in market segment i, P_i, that are expected to subscribe to the service, equals

$$P_i = \sum_{j=1}^{4} c_j X_{ji} \qquad (5\text{-}1)$$

The conversion ratio is based on the assumption that there is a 100% market awareness. That is, all surveyees are fully informed of the service availability, use, tariffs, technical parameters, etc. P_i, therefore, can be interpreted as the long-run proportion of firms in market segment i that are expected to subscribe to the service at some future time period, T

Two issues arise in the estimation of the proportion of customers that subscribe to the service:

1) while P_i refers to the sample surveyed, the results need to be extrapolated to represent the population.

2) P_i is the long-run (maximum) proportion of firms expected to subscribe. We are interested in predicting no just the eventual number of subscribers but, also, those at intermediate time periods before the service reaches a saturation point.

5.4 *Extrapolation from sample to population*

To extrapolate the data from the sample to represent the population, let

N_i = size of market segment i (measured for example, by the number of firms in market segment i)

Then S_i, the expected number of subscribers in the planning horizon, equals:

$$S_i = P_i N_i \qquad (5\text{-}2)$$

5.5 *Market penetration over time*

To determine the expected number of subscribers at various points in time before the service reaches maturity, let

p_{it} = the proportion of firms in market segment i that are expected to subscribe at time t.

Clearly,

$p_{it} < P_i$

and $p_{it} \to P_i$ as $t \to T$.

The relation between p_{it}, and P_i can be explicitly defined as:

$$p_{it} = a_{it} \cdot P_i \qquad (5\text{-}3)$$

a_{it}, is a penetration function, reflecting changing market awareness and acceptance of the service over time, in market segment i. An appropriate functional form for a_{it} should be bounded in the interval (0,1).

As an example, let a_{it} be a logistic function:

$$a_{it} = \frac{1}{1 + e^{bit}} \qquad (5\text{-}4)$$

$b_i \leq 0$ is the speed with which p_{it} approaches P_i in market segment i, as illustrated in Figure 1/E.508.

For other examples of non-linear penetration functions, refer to the Annex A.

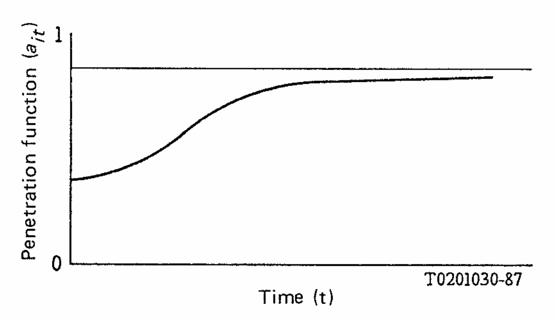

FIGURE 1/E.508

Rate of market penetration

The introduction of a new service will usually differ according to the market segment. The rate of penetration may be expressed as a function of time, and the speed of adjustment (b_i) may vary across segments. Lower absolute values of b_i for the logistic function will imply faster rates of penetration.

While the form of the penetration function relating the rate of penetration to time is the same for all segments, the parameter b_i varies across segments, being greater in segments with a later introduction of the new service.

Let t_{0i} = time period of introduction of service in market segment *i.*

Then, $t - t_{0i}$ = time period elapsed since service was introduced in market segment *i*.

In the diagramatic illustration, of Figure 2/E.508, the service has achieved the same level of market penetration a_0, in t_C periods after its introduction in market *C* as it did in t_A periods after its introduction in market segment *A*. Later introductions may not necessarily lead to faster rates of penetration across segments. However, within the same market segment, across countries with similar characteristics, such an expectation is reasonable.

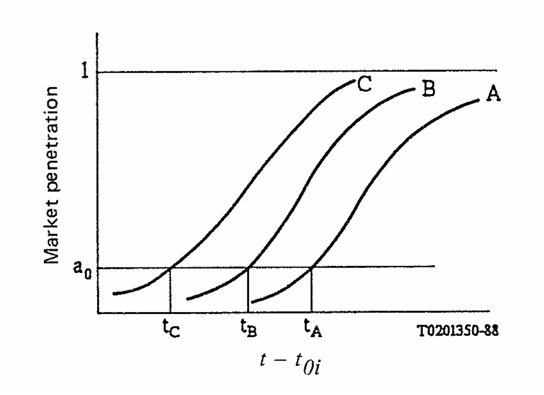

FIGURE 2/E.508

Market awareness as a function of time of introduction of service

5.6 *Growth of market segment over time*

The above discussion has accounted for gradual market penetration of the new service, by allowing p_{it}, to adjust to P_i over time. The same argument can be extended to the size of market segment *i* over time.

Let n_{it} = size of market segment i at time t.

Then, the expected number of subscribers at time t in market segment i, equals:

$$s_{it} = a_{it} \cdot p_{it} \cdot n_{it} \tag{5-5}$$

and

$S_t = \sum_i s_{it}$ = expected number of subscribers across all market segments at time t.

5.7 *Quantities forecasted*

The above procedure forecasts the expected number of customers for a new service within a country. Other quantities of interest may include lines, minutes, messages, revenue, packets, kilobits, etc. The most straight-forward forecasting method for some of these quantities is to assume constant relationships such as:

expected access lines = (average access lines) × expected number of subscribers

expected minutes = (average use per line) × expected access lines

expected messages = expected minutes/(average length of conversation)

expected revenue = (average rate per minute) × expected minutes

The constants, appearing in parentheses, above, can be determined through 1) the process of market research, or 2) past trends in similar services.

5.8 *Forecasting with historical data: application analysis*

After a new service has been introduced, historical data can be analyzed to forecast demand for expanded availability to other countries. Development of a new service will follow trends based on applications, such as data transmission, travel reservations, intracompany communications, and supplier contact. Applications of a service vary widely and no single variable may be an adequate indicator of total demand.

The following procedure links demand to country characteristics for forecasting expanded availability of a new service to other countries.

Let $D = (D_1, D_2, \ldots\ldots, D_n)'$

represent a vector of country-specific annual demand for the service across n countries, where the service currently exists. Let C = matrix of m characteristics relating to each of the n countries that are reasonable explanatory variables of demand. The components of m would vary depending on the nature of the service and its application.

Some essential components of m would be the price of the service (or an index representing its price) and some proxy for market awareness. As discussed in earlier sections, market awareness is one of the key determinants of the rate of market penetration of the service. Reasonable proxies would be advertising expenditures and time (measured as $t^* = t - t_0$) where t^* would measure time elapsed since the service was first introduced at time t_0. Market awareness can be characterized as some non-linear function of t^*, as presented in § 5.5. Other components of m may include socio-economic characteristics of the customers, market size and location of customers.

The model that is estimated is:

$$D = C\beta + u \tag{5-6}$$

where

C is a $(n \times m)$ matrix of country characteristics

D is a $(n \times 1)$ vector of demand

β is a $(m \times 1)$ vector of coefficients corresponding to each of the m characteristics

$u = (n \times 1)$ vector of error terms

The estimated regression is:

$$\hat{D} = C\hat{\beta} \tag{5-7}$$

Traditional methods of estimating regressions will be applied. Equation (5-7) can be used for predicting demand for any country where the service is being newly introduced, as long as elements of the matrix C are available.

5.9 *Forecasting with limited information*

In the extreme case where no market research data is available (or is uneconomical given resource constraints), or country characteristics that affect demand are not easily available or quantifiable, other methods of forecasting need to be devised.

For example, to forecast the demand for a new international private line service using digital technology, the following elements should be taken into account in the development of reasonable estimates of the expected number of lines:

a) discussions with foreign telephone companies,

b) discussions with very large potential customers regarding their future needs,

c) service inquiries from customers,

d) customer letters of intent, and

e) any other similar qualitative information.

6 Forecast tests and adjustments

6.1 *General*

Forecast tests and adjustments are dependent on the methodology applied. For example, in the case of a market research based forecast, it is important to track the forecast of market size, awareness and rate of penetration over time and to adjust forecasts accordingly. However, for an application-based methodology, traditional tests and adjustments applicable to regression methods will be employed, as discussed below.

6.2 *Market research based analysis*

This section discusses adjustments to forecasts based on the methodology described in §§ 5.2 to 5.8. The methodology was based on quantification of responses from a sample survey.

The forecast was done in two parts:

a) extrapolating the sample to the population,, using market size, N_i;

b) allowing for gradual market penetration (awareness), a_{it} of the new service over time.

The values attributed to n_{it} (which represents thesize of market segment i at time t) and a_{it} can be tracked over time and forecast adjustments made in the following manner:

a) As an example for n_{it}, the segments could be categorized as travel or financial services. The size of the segment would be the number of tourists, and the number of large banks. Historical data, where available, on these units of measurement can be used to forecast their sizes at any point of time in the future. Where history is not available, reasonable growth factors can be developed through subject matter experts and past experiences. The forecast of n_{it}, should be tracked against actual measured values and adjusted for large deviations.

b) For a_{it}, testing with only a few observations since the introduction of the service is more difficult.

Given that,

$$a_{it} = \frac{p_{it}}{P_i} \tag{6-1}$$

and P_i is assumed fixed (in the long run), testing a_{it} is equivalent to testing p_{it}. p_{it} can be tracked by observing the proportion of respondents that actually subscribe to the service at time t. This assumes the need to track the same individuals who were originally in the survey, as is customary in a panel survey. Panel data is collected through sample surveys of cross-sections of the same individuals, over time. This method is commonly used for household socio-economic surveys. Having observed p_{it} for a new period, values of a_{it} can be plotted against time to study the nature of the penetration function, a_{it}, and the most appropriate functional form that fits the data should be chosen. At very early stages of service introduction, traditional functional forms for market penetration, such as a logistic function (as illustrated in the example in § 5.5), will be a reasonable form to assume. Other variations of the functional form depicting market penetration would be the Gompertz or Gauss growth curves. The restriction is that the penetration function should be bounded in the interval (0,1). See Annex A for an algebraic depiction of functional forms.

There are various statistical forms that may be chosen as representations for the penetration function. The appropriate functional form should be based on some theoretical based information such as the expected nature of penetration of the specific service over time.

Continuous tracking of n_{it}, p_{it} and a_{it} over time will enable adjustments to these values whenever necessary and enable greater confidence in the forecasts.

6.3 *Application based analysis*

The application based analysis is a regression based approach and traditional forecast tests for a regression model will apply. For instance, hypothesis tests on each of the explanatory variables included in the model will be necessary. Corrections may be needed for hetero-elasticity, serial correlation and multicollinearity, when suspect. The methodology for performing such tests are described in most econometrics text books. In particular, references [2] and [4] can be used as guidelines. Recommendation E.507 also discusses these corrections.

Adjustments need to be made for variables that should be included in the regression model but are not easily quantifiable. For example, market awareness that results from advertising and promotional campaigns plays an important role in the growth of a new service, but data on such expenditures or the associated awareness may not be readily available. Some international services are targeted towards international travelers, and fluctuations in exchange rates will be a determining factor. Such variables, while not impossible to measure, may be expensive to acquire. However, expectations of future trends in such variables can enable the forecaster to arrive at some reasonable estimates of their impact on demand. Unexpected occurrences such as political turmoil and natural disasters in particular countries will also necessitate post forecast adjustments based upon managerial judgement.

Another important adjustment that may be necessary is the expected competition from other carriers offering similar or substitutable services. Competitor prices, if available, may be used as explanatory variables within the model and allow the measurement of a cross-price impact. In most situations, it is difficult to obtain competitor prices. In such cases, other methods of calculating competitor market shares need to be developed.

Regardless of forecasting methodology, the final forecasts will have to be reviewed by management responsible for planning the service as well as by network engineers in order to assess the feasibility both from a planning implementation and from a technical point of view.

ANNEX A

(to Recommendation E.508)

Penetration functions (growth curves)

Some examples of non-linear penetration functions are illustrated below:

A.1 *Logistic curve*

$$a_{it} = \alpha / \{1 + e^{-bt}\} \qquad \text{(A-1)}$$

For a = 1, the curve is bounded in the interval (0,1). Changing b will alter the steepness of the curve. The higher the value of b, the faster the rate of penetration. This curve is S-shaped and is symmetrical about its point of inflection, the latter being where;

$$\frac{d^2 a_{it}}{dt^2} = 0 \qquad \text{(A-2)}$$

A.2 *Gompertz curve*

$$a_{it} = \alpha \exp\{-be^{-kt}\} \qquad \text{(A-3)}$$

As $t \to \infty$, $a_{it} \to \alpha$, the limiting growth.

Holding $k = 1$ and $\alpha = 1$, higher values of b will imply slower rates of penetration. This curve is also S-shaped like the logistic curve, but is not symmetrical about its inflection point.

When $t = 0$, then $a_{it} = \alpha e^{-b}$, which is the initial rate of penetration.

A.3 *Gauss curve*

$$a_{it} = \alpha\,(1 - e^{-bt2}) \qquad \text{(A-4)}$$

As $t \to \infty$, then $a_{it} \to \alpha$

As $t \to 0$, then $a_{it} \to 0$.

Choosing $\alpha = 1$, the curve is bounded in the interval (0,1).

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Printed in Switzerland
Geneva, 2007