



INTERNATIONAL TELECOMMUNICATION UNION

CCITT

E.506 (rev.1)

THE INTERNATIONAL
TELEGRAPH AND TELEPHONE
CONSULTATIVE COMMITTEE

TELEPHONE NETWORK AND ISDN
QUALITY OF SERVICE,
NETWORK MANAGEMENT AND TRAFFIC
ENGINEERING

FORECASTING INTERNATIONAL TRAFFIC

Recommendation E.506 (rev.1)



Geneva, 1992



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FOREWORD

The CCITT (the International Telegraph and Telephone Consultative Committee) is a permanent organ of the International Telecommunication Union (ITU). CCITT is responsible for studying technical, operating and tariff questions and issuing Recommendations on them with a view to standardizing telecommunications on a worldwide basis.

The Plenary Assembly of CCITT which meets every four years, establishes the topics for study and approves Recommendations prepared by its Study Groups. The approval of Recommendations by the members of CCITT between Plenary Assemblies is covered by the procedure laid down in CCITT Resolution No. 2 (Melbourne, 1988).

Recommendation E.506 was prepared by Study Group II and was approved under the Resolution No. 2 procedure on the 16th of June 1992.

CCITT NOTE

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

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Recommendation E.506**FORECASTING INTERNATIONAL TRAFFIC¹⁾***(revised 1992)***1 Introduction**

This Recommendation is the first in a series of three Recommendations that cover international telecommunications forecasting.

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 which 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.

The purpose of this Recommendation is to give guidance on some of the prerequisites for forecasting international telecommunications traffic. Base data, not only traffic and call data but also economic, social and demographic data, are of vital importance for forecasting. These data series may be incomplete; strategies are recommended for dealing with missing data. Different forecasting approaches are presented including direct and composite methods, matrix forecasting, and top down and bottom up procedures.

Recommendation E.507 provides guidelines for building forecasting models and contains an overview of various forecasting techniques. Recommendation E.508 covers the forecasting of new international telecommunications services.

2 Base data for forecasting

An output of the international traffic forecasting process is the estimated number of circuits required for each period in the forecast horizon. To obtain these values, traffic engineering techniques are applied to forecast erlangs, a measure of traffic. Figure 1/E.506 outlines two different approaches for determining forecasted erlangs.

The two different strategies for forecasting are the direct strategy and the composite strategy. The first step in either process is to collect raw data. These raw data, perhaps adjusted, will be the base data used to generate the traffic forecasts. Base data may be hourly, daily, monthly, quarterly, or annual. Most Administrations use monthly accounting data for forecasting purposes.

With the direct strategy, the traffic carried in erlangs, or measured usage, for each relation would be regarded as the base data in forecasting traffic growth. These data may be adjusted to account for such occurrences as regeneration (see Recommendation E.500).

In both strategies (direct and composite) it is necessary to convert the carried traffic into offered traffic erlangs. The conversion formula can be found in Recommendation E.501 for the direct strategy and in this Recommendation for the composite strategy.

¹⁾ The old Recommendation E.506 which appeared in the *Red Book* was split into two Recommendations, revised E.506 and new E.507 and considerable new material was added to both.

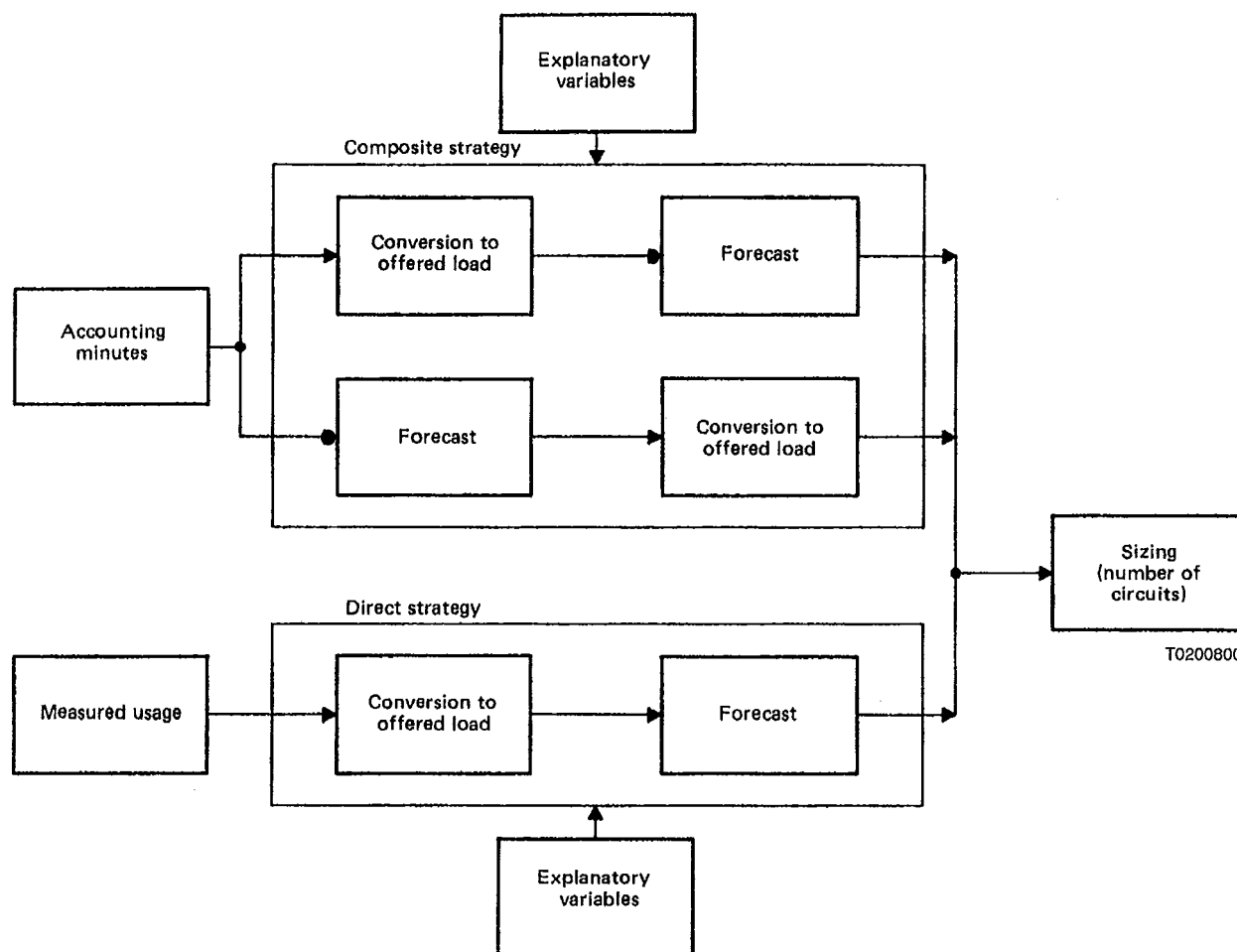


FIGURE 1/E.506

Direct and composite strategy

Composite forecasting uses historical international accounting data of monthly paid minute traffic as the base data. The data may be adjusted by a number of factors, either before or after the forecasting process, that are used for converting paid minutes on the basis of the accounting data into busy-hour erlang forecasts.

As seen in Figure 1/E.506, the forecasting process is common to both the direct and composite strategy. However, the actual methods or models used in the process vary. Forecasts can be generated, for example, using traffic matrix methods (see § 4), econometric models or autoregressive models (see § 3, Recommendation E.507). There are various other data that are input to the forecasting process. Examples of these are explanatory variables, market segmentation information and price elasticities.

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.

In econometric modelling especially, explanatory variables are used to forecast international traffic. Some of the most important of these variables are the following:

- exports,
- imports,

- degree of automation,
- quality of service,
- time differences between countries,
- tariffs,
- consumer price index, and
- gross national product.

Other explanatory variables, such as foreign business travellers and nationals living in other countries, may also be important to consider. It is recommended that data bases for explanatory variables should be as comprehensive as possible to provide more information to the forecasting process.

Forecasts may be based on market segmentation. Base data may be segmented, for example, along regional lines, by business, non-business, or by type of service. Price elasticities should also be examined, if possible, to quantify the impact of tariffs on the forecasting data.

3 Composite strategy – Conversion method

Where both composite and direct strategies are being used and, in any other case, where past data is available, an overall paid-minute/erlang ratio should be derived based on the present value for the particular relation, observed trends and future objectives.

If data is not available, the conversion should be carried out in accordance with the formula.

$$A = Mdh/60e \quad (3-1)$$

where

- A* is the estimated mean traffic in the busy hour,
- 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 Procedures for traffic matrix forecasting

4.1 Introduction

To use traffic matrix or point-to-point forecasts the following procedures may be used:

- direct point-to-point forecasts,
- Kruithof's method,
- extension of Kruithof's method,
- weighted least squares method.

It is also possible to develop a Kalman filter model for point-to-point traffic taking into account the aggregated forecasts. Tu and Pack describe such a model in [16].

The forecasting procedures can be used to produce forecasts of internal traffic within groups of countries, for example, the Nordic countries. Another application is to produce forecasts for national traffic on various levels.

4.2 *Direct point-to-point forecasts*

It is possible to produce better forecasts for accumulated traffic than forecast of traffic on a lower level.

Hence, forecasts of outgoing traffic (row sum) or incoming traffic (column sum) between one country and a group of countries, will give a relatively higher precision than the separate forecasts between countries.

In this situation it is possible to adjust the individual forecasts by taking into account the aggregated forecasts.

On the other hand, if the forecasts of the different elements in the traffic matrix turn out to be as good as the accumulated forecasts, then it is not necessary to adjust the forecasts.

Evaluation of the relative precision of forecasts may be carried out by comparing the ratios $\hat{\sigma}(X)/X$ where X is the forecast and $\hat{\sigma}(X)$ the estimated forecast error.

4.3 *Kruithof's method*

Kruithof's method [11] is well known. The method uses the last known traffic matrix and forecasts of the row and column sum to make forecasts of the traffic matrix. This is carried out by an efficient iteration procedure.

Kruithof's method does not take into account the change over time in the point-to-point traffic. Because Kruithof's method only uses the last known traffic matrix, information on the previous traffic matrices does not contribute to the forecasts. This would be disadvantageous, especially when the growth of the distinct point-to-point traffic varies. Also when the traffic matrices reflect seasonal data, Kruithof's method may give poor forecasts.

4.4 *Extension of Kruithof's method*

The traditional Kruithof's method is a projection of the traffic based on the last known traffic matrix and forecasts of the row and column sums.

It is possible to extend Kruithof's method by taking into account not only forecasts of the row and column but also forecasts of point-to-point traffic. Kruithof's method is then used to adjust the point-to-point traffic forecasts to obtain consistency with the forecasts of row and column sums.

The extended Kruithof's method is superior to the traditional Kruithof's method and is therefore recommended.

4.5 *Weighted least squares method*

Weighted least squares method is again an extension of the last method. Let $\{C_{ij}\}$, $\{C_i\}$ and $\{C_j\}$ be forecasts of point-to-point traffic, row sums and column sums respectively.

The extended Kruithof's method assumes that the row and column sums are "true" and adjust $\{C_{ij}\}$ to obtain consistency.

The weighted least squares method [2] is based on the assumption that both the point-to-point forecasts and the row and column sum forecasts are uncertain. A reasonable way to solve the problem is to give the various forecasts different weights.

Let the weighted least squares forecasts be $\{D_{ij}\}$. The square sum Q is defined by:

$$Q = \sum_{ij} a_{ij} (C_{ij} - D_{ij})^2 + \sum_i b_i (C_i - D_i)^2 + \sum_j c_j (C_j - D_j)^2 \quad (4-1)$$

where $\{a_{ij}\}$, $\{b_i\}$, $\{c_j\}$ are chosen constants or weights.

The weighted least squares forecast is found by:

$$\begin{aligned} &\text{Min } Q(D_{ij}) \\ &D_{ij} \end{aligned}$$