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ITU-T E.521

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QUALITY OF SERVICE, NETWORK MANAGEMENT AND TRAFFIC ENGINEERING

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

ITU-T Recommendation E.521

(Extract from the *Blue Book*)

NOTES

1 ITU-T Recommendation E.521 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.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, ..., 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 I/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 *Null.*

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.

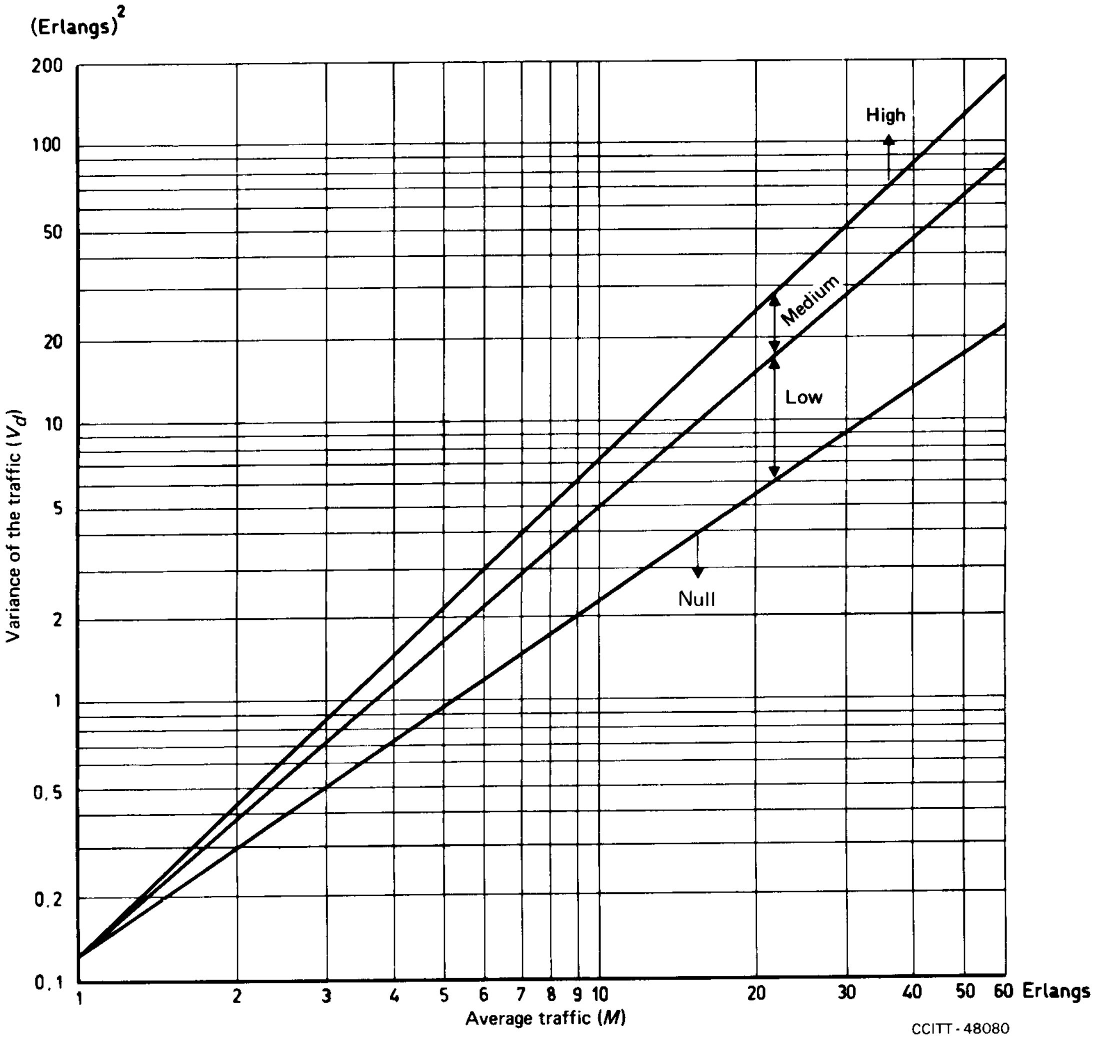

FIGURE 1/E.521

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.

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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].

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.

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 $\overline{\beta}_i$ 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.

$$\overline{\beta_i} = r_i \beta_i$$

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 $\overline{\beta}_i$ over the h parcels of traffic:

$$M = \sum_{i=1}^{h} \overline{\beta_i}$$

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:

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

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	00	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	26.422	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	7.22	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	22.7823.	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	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 to 6/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 $\overline{\beta_i} = r_i \beta_i$
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		
			$\sum_{i=1}^{h} \beta_i = 11.15$			$z = \frac{\sum_{i=1}^{h} \beta_i z_i}{\sum_{i=1}^{h} \beta_i} = \frac{14.7}{11.15} = 1.3$		$M = \sum_{i=1}^{h} \overline{\beta_i} = 11.39$

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.

References

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