SWITCHING SYSTEMS MANAGEMENT
NO. 1 ELECTRONIC SWITCHING SYSTEM
LOAD BALANCING PROCEDURES

CONTENTS PAGE

FIGURES

NOTICE
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1. GENERAL

PURPOSE

1.01 This section describes load balancing techniques primarily as they relate to load balance for customer lines in Electronic Switching System (ESS) offices. Included is a description of how these techniques are incorporated into the new load balance index (LBI) described in Dial Facilities Management Practices (DFMPs), Division A, Section 5b, which is being issued concurrently with this section.

1.02 When this section is reissued, this paragraph will contain the reason for reissue.

1.03 This section is a full revision and consolidation of many documents on the subject of load and balance. In conjunction with Dial Facilities Management Practices, Division A, Section 5b, this section replaces TL-562 which transmitted the previous overall balance index plan, issued July 13, 1966; subsequent modification was made by TWX (March 1, 1967 and August 21, 1967).

1.04 This section replaces all parts of the Central Office Management Guide, Division E, Section 4, which describe line balance by class-of-service and by line loading including the development and interpretation of the score system and quality control limits.

1.05 While balancing and indexing may both be based on the same usage data, data qualifications for indexing puposes are more stringent to ensure uniformity among all offices. Thus, Dial Facilities Management Practices, Division A, Section 5b, Load Balancing Index Plan, is the final arbiter of data requirements and procedures required for index generation.

RESPONSIBILITIES

1.06 The network administrator has the responsibility for load balance and index reporting. In order to achieve the objectives of good load balance, this responsibility includes:

(1) Loading plans

(2) Busy hour and side hour determination

(3) Scheduling studies

(4) Data collection

(5) Preparation of load balance forms

(6) Preparation of subscriber line usage assignment forms

(7) Data validation

(8) Analysis and corrective action

(9) Preparation and distribution of the load balance index form.

1.07 The title of each figure in this section includes a number(s) in parentheses which identifies the paragraph(s) in which the figure has been referenced.

2. PRINCIPLES OF LOAD BALANCE

DEFINITION OF TERMS

2.01 The definition of a ***traffic unit*** is the same as the definition of a ***dial entity.*** The term traffic unit is used to conform with the common language location identification practice, Bell System Practices Section 795-100-100. In No. 1 ESS the traffic unit is the control group; ie, the customer lines associated with one central control system using the same logic and processor.

2.02 A ***load unit*** is defined as that component of line originating equipment arranged for usage measurements and for which individual scores are to be computed. A load unit in No. 1 ESS is the concentrator.

2.03 The general definition of a ***loading division*** is a group of load units of the same type of dial equipment, designed to be loaded similarly by both usage and classes of service. Generally, No. 1 ESS control groups will consist of only one loading division. The major exception to this general rule will occur when line switch frames or line link networks are added to a control group. As defined in Dial Facilities Management Practices Division A, Section 5b, new equipment may be temporarily indexed as a separate loading division. Fractional and partial (prior to CTX-6) line link networks (LLNs) are not considered separate loading divisions. The line-junctor ratio remains the same for full or fractional networks and, therefore, the load capability of the load unit remains the same.

2.04 Uniformity of justification for creating more loading divisions should be maintained within an operating telephone company. Care should be taken that the establishment of additional loading divisions does not create undetectable imbalances in other equipment components. Creation of more than one loading division requires stringent administration for proper loading between divisions.

2.05 A ***study*** is the period of time scheduled to measure and score the usage to determine load balance by quality control techniques.

2.06 The ***busy hour (BH)*** is the time-consistent hour during which the ESS line link networks have the highest average CCS usage measured for five days during the same week. The hour may start and end on the clock hour, half-hour, or quarter-hour.

2.07 A ***side hour*** is an amount of time equal to one hour that is time consistent and adjacent to the BH. It may be on one side or both sides of the BH in order to provide the highest possible CCS for the side hour, but must not be divided into time periods of less than one quarter of an hour. For example, if the BH is 9:00 to 10:00 am, the side hour could be 8:00 to 9:00 am, 10:00 to 11:00 am, 8:15 to 9:00 am, and 10:00 to 10:15 am, etc.

2.08 ***Session busy hours (SBHs)*** are comprised of the BH and the side hour if the side hour has average weekly usage equal to at least 90 percent of the BH during the busy season and at least 80 percent of the BH during the nonbusy season studies.

BALANCE BY LOADING DIVISION

2.09 A loading plan is the key to achieving good load balance. A loading plan is necessary prior to assigning lines on an initial installation and must be maintained on an on-going basis through the office life. Its purpose is to improve balance at each opportunity and to assure optimum balance during periods of peak loads. The plan itself anticipates the achievement of engineered capacities while meeting service goals. Good loading plans maintain balance between loading divisions, traffic units in multientity situations, and buildings where they serve the same geographical area.

2.10 ***Perfect balance*** might be thought of as a condition where customer usage is so distributed that each load unit within a division carries exactly its proportionate share of the total load. As customer-offered loads always vary, by chance, from day to day and week to week, such perfect balance is not a practical or even meaningful goal. Furthermore, due to these chance variations, load studies can never be taken as exact measurements of the state of balance. If, however, the measured variations among the load units do not exceed a reasonable estimate of the largest possible chance variation, a good ***practical*** balance exists. The intent of this section is to assist the administrator in achieving this good practical balance.

2.11 Balance requires constant analysis of the changes in group loads and of the effects on service. A single concentrator which appears to have a load substantially above average in one week may be below average the next week without having had any assignment changes or any corrective action applied to it. The trend is important as well as the relative position of a group for any given study period.

2.12 The degree of balance within an office affects three important phases of the administrative job. The first, of course, is service. Balancing improves service by reducing the possibility of switching blockages, thus minimizing customer dissatisfaction which should, in turn, reduce calls to repair service. A second important item is effective utilization of equipment (maximum utilization of capacity). A well-balanced office provides reliable data that show sound load-service relationships. This is conducive to engineering correct equipment quantities and the anticipation of future service levels. Finally, whenever a balanced condition exists among groups of a loading division, the best possible maintenance condition will result because of even wear on equipment components.

2.13 Good balance also is important in underloaded offices as a safeguard against the results of unforeseeable heavy loads and in preparation for busy season or other anticipated loads. It is difficult, time consuming, and expensive to rebalance an office once it has been permitted to get out of balance. An office that is out of balance and is being brought back into balance by the issuance of line transfers over a relatively short time span is likely to fall short of the degree of balance expected. Therefore, advantage should always be taken of directed line assignments to improve the balance within an office.

BALANCE BY CLASS OF SERVICE

2.14 In addition to the distribution of CCS usage, it is important to maintain a good distribution by classes of service among concentrators to give them similar traffic characteristics. Balancing techniques which use load measurements alone may inadvertently lead to a poor class-of-service mix causing the concentrators to vary in an irregular manner from day-to-day and from hour-to-hour. Typical of these circumstances are: Friday evening business loads caused by shopping centers or local sports activities, early school dismissals, weather problems, social conditions, sudden stock market activities, etc. Results are most unsatisfactory when there are periods of heavy load that occur daily or frequently at times other than the entity busy hour(s) used for load balancing or network design purposes.

2.15 While a good class-of-service mix does not prevent load fluctuations, it does tend to spread them across all concentrators, thereby helping to maintain a uniform balance condition. A balance which includes good distribution by usage and by class of service will aid in deriving maximum utilization of central office equipment while producing the best possible service to the customer. It should also reduce tendencies toward separate load and service busy hours and minimize the number of concentrators having busy hours differing from the control group busy hour. When separate load and service busy hours exist that do not appear to be satisfactorily minimized by a class-of-service redistribution, the appropriate Company staff group and the AT&T Company Network Administration Group should be informed before extensive special procedures are undertaken.

2.16 A good distribution by classes of service across the switches is also very important. The problems discussed in 2.14 and 2.15 can also occur in switches if the class-of-service distribution is poor. Corrective action is more difficult, however, as there is no usage measurement for switches and, until dial tone blocking or matching loss occurs, there will be no indicator of imbalance.

SERVICE INDICATORS

2.17 The degree of effort and attention to be given a particular office in regard to balance will depend to a large degree on the service results in that office. The primary indicators are blocked dial tone and matching loss results. During the busy season, an office with good performance in these indicators should seldom require line transfers for balance but should be able to rely primarily on effective line assignment procedures.

2.18 An office that is experiencing poor service, as measured by the dial line index (network switching performance measurement plan), will require efforts to determine the extent to which balance is contributing to the problem. For example, poor dial tone speed results may be caused by poor balance, overload, or a combination of both.

2.19 Out of busy season and in other periods of light loading, the dial line index (network switching performance measurement plan) and the service indicators may not be adequate to signal the need for corrective action. It will be necessary to review the load balance data and determine if any line transfers are necessary to prevent poor service during the busy season when heavier loads will occur.

DETERMINATION OF BALANCE PERIODS, BUSY HOURS, AND SIDE HOURS

2.20 ***Busy hour*** studies are taken periodically for the purpose of determining busy hours for engineering and administrative purposes. After the busy hour has been determined, side hours and balance periods may be easily selected.

2.21 For the purposes of determining the busy hour and balance period, the office count A-link usage register is used to correspond with the usage counts provided in the W-block. The usage busy hour must be the time-consistent hour of the highest total usage generated.

2.22 It is recommended that those ***side hours*** immediately adjoining the busy hour be reviewed first. The hours on either side of the busy hour in most cases will be close to the busy hour in CCS and will have the same general traffic characteristics as the busy hour. ***Where the usage in a side hour is at least 90 percent of the busy hour load during the busy season, it should be used with the busy hour for balancing purposes. Out of the busy season, the side hour should have at least 80 percent of the busy hour load.***

2.23 Since the 10-hour study is mandatory for the load balance index system, the 10-hour period is also recommended for regular balance studies (those weeks not reported for the LBI). Ten-hour study periods can be developed using one of the following methods:

(a) Use the busiest hour and two periods adjoining the busy hour. For example:

Prior	Busy Hour	After
3:00—3:30	3:30—4:30	4:30—5:00

At least half-hourly readings are required in order to determine if the load from the combined side period is at least 90 percent (80 percent nonbusy season) of the busy hour load.

(b) Use the busiest hour and one adjoining side hour that is at least 90 percent (80 percent nonbusy season) of the busy hour load.

(c) Use the busy hour for two adjacent weeks.

2.24 The combination of CCS from nonadjacent busy hours, such as a combination of 10:00 am to 11:00 am with 7:00 pm to 8:00 pm, is not acceptable since, in most cases, the two periods will have different traffic characteristics. An inordinate investment of time and money would have to be made in order to ascertain similarities between these periods. Bell Laboratories has conducted a study which indicates that, in virtually every case, the characteristics are different for nonadjacent busy hours. Therefore, combining nonadjacent hours will not be allowed.

2.25 Where there are two distinct nonadjacent hours, the busy hour and another, that are almost equal in their load levels, it may be necessary to study both periods separately if service is poor in the secondary period. Line assignment procedures should call for assignment into those concentrators which are found to have below average loading in both periods with considerations for proper class-of-service distribution. As stated previously, a combination of two different periods with different characteristics, even though 90 percent of the busy hour, will most likely produce misleading balancing information.

2.26 With 10-hour studies required for load balance index reporting, 5-hour studies will present a more difficult administrative problem and will become more difficult to justify. In addition, 5-hour studies lack the statistical reliability of 10-hour studies and their use is recommended only in instances where balance conditions indicate some action is required prior to the acquisition of more statistically accurate data. Two 5-hour studies from adjacent weeks may be utilized quite effectively, however, by combining them into one 10-hour study. These data may then be used for index reporting purposes when necessary.

2.27 All loading divisions in No. 1 ESS ordinarily should have similar traffic characteristics and should use the weekly study period of the largest division. (See 2.03 for loading division definition.)

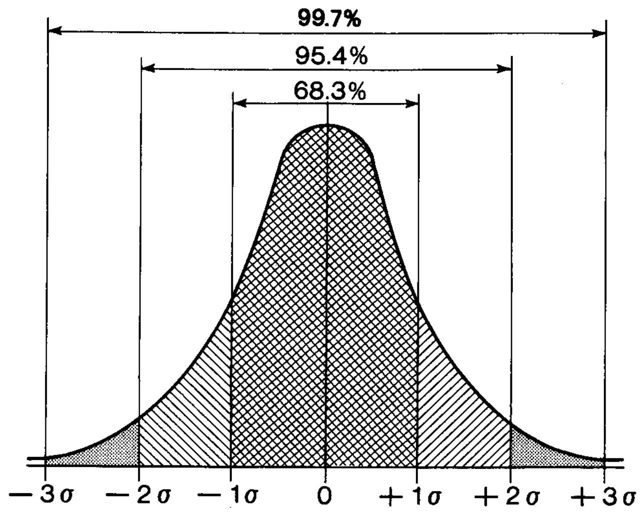
2.28 Load balancing usage data should be collected as frequently as required to ensure good balance with a minimum of 10 hours a month. The 10-hour minimum is imposed by the load balance index requirement. As the office approaches capacity, more frequent studies will be needed to ensure the most efficient balancing of office load.

QUALITY CONTROL LIMITS

2.29 The quality control technique discussed below is a practical way of using mathematics in order to create a uniform approach to load balance procedures. This technique indicates reliably whether fluctuations in load data might be the result of chance or are probably the result of differences in office performance and consequently indicate whether or not some action should be taken. A successful quality control plan requires limits to be used that will satisfactorily and accurately indicate a true imbalance.

2.30 There are two primary causes for variation of an individual load unit's usage from the average of a number of groups in the same division; they are ***chance*** and ***imbalance.*** Chance variations result from the random calling patterns of customers using their telephones. The size of chance variations depends upon certain measurable office characteristics: average holding time (AHT) of calls, percentage of loading of the division, and number of customers. The general rule is: the larger the sample measured, the smaller the chance variation relative to the size of the sample. Each of the characteristics listed above affect the size of samples observed in load studies.

2.31 It can be demonstrated that group variations due to chance in a reasonably balanced loading division will follow the normal distribution pattern, which is a bell-shaped distribution about the mean (average). This normal distribution can be described by stipulating a mean value and the measure of dispersion of group loads around that value. The measure of dispersion, adjusted for the number of hours of data, is commonly called the standard deviation (SD). Office trends will not be a factor since each group is related to the average of all groups every time a record is taken. An area representing one standard deviation from the mean in a normal distribution may be expected to include 68.3 percent of all the group measurements, two standard deviations 95.4 percent of all measurements, and three standard deviations 99.7 percent of all measurements. This is illustrated in the distribution curve which follows:



2.32 The problem of isolating and evaluating chance variation may be resolved by utilizing procedures involving the standard deviation. In this way the size of a deviation from the mean may be used to judge whether that deviation may be due to chance or is most probably due to imbalance. As a basis for this judgment, standard quality control limits (QCLs) representing three standard deviations have been developed. (This approach is arbitrary and is used by many industries to indicate items not meeting manufacturing tolerances.) To see what this means, consider 1000 groups for which the measured loads are averaged. The mathematical analysis indicates that only three (the 0.3 percent outside the 99.7 percent) of those measurements can be expected to differ by chance from the mean by more than three standard deviations; ie, the QCL. In effect, it can be assumed that ***all*** deviations from the mean greater than the QCLs are due to imbalance. Choosing larger QCLs would increase this assurance; however, there will be a greater chance that some deviations that truly reflect imbalance will be ignored. These three standard deviations (3 sigma) limits are shown in the quality control limit charts in Figure 1.

2.33 There are two steps required in determining the appropriate QCL. The first step is to calculate the ***percentage of capacity*** for the study period. This is accomplished by taking the actual average load and comparing it to the engineered load. The QCL value derived from this computation makes allowance for the fact that group loads in a lightly loaded office may fluctuate more than those in a comparable heavily loaded office.

2.34 This computation is made by dividing the total actual average usage (in CCS) per load unit by the engineered load (in CCS) per load unit and multiplying the result by 100. The answer will be the ***percentage of capacity*** at which the groups are operating for the given study period. This is done for each loading division. This percentage is then used to determine the table from which the QCL will be selected for that loading division. There are eight of these tables to cover the percentage of loading ranges from 30 percent to over 96 percent. A capacity table can be found in Figure 2 of this section. This table indicates the load carrying capacity based upon the concentration type and line junctor ratio configuation. Further details on LLN capacity may be found in Traffic Facilities Practices, Division D, Section 10e. The calculation of the percentage of capacity for the study period is illustrated in the following example:

Office Parameters:
3:1H 4 LLN 6 LSF/LLN 16 Conc/LSF

Step 1:

LLN capacity = 15,960 (per engineering table in Fig. 2)

LSF capacity = 2660

Conc capacity = 166

ie, ***Engineered load*** = 166

Step 2:

A-link usage (SBH) = 391,390 CCS

$$\text{Avg. actual load (AL)} = \frac{\text{A-Link Usage}}{\text{10 Hours}}$$

$$\frac{\text{A-Link Usage}}{\text{10 Hours}} = 39{,}139$$

AL LLN = 9785 CCS

AL LSF = 1631 CCS

AL Conc = 102 CCS

ie, ***Actual load*** = 102

Step 3:

$$\text{Percentage of capacity} = \frac{\text{AL}}{\text{EL}} \times 100$$

$$= \frac{102}{166} \times 100 = 61.4\%$$

Rounded to the nearest whole number (integer) 61.4 percent is ***61 percent.***

2.35 The mechanized load balance program will store the LLN table capacities. A-link usage will be fed into the program via the W-schedule. Once the program has been given individual office parameters, it can automatically compute percentage of capacity for the study period.

2.36 The second step in determining an appropriate QCL is to calculate the AHT of the calls creating usage on line equipment. Documentation of the AHT in a traffic unit is necessary for each balance study in order to be statistically accurate. One of the following methods may be employed.

(a) If one of the load balance SBHs corresponds to the H-block hour submitted to PATROL, the PATROL holding time calculation may be used for ease of collection. That calculation is:

$$\frac{2\,(\text{L-to-L Junctor Usage}) + (\text{L-to-T Junctor Usage})}{\text{Originating PC} + \text{Total of LLN PCs} + \text{IAO PC}} \times 100$$

The average holding time should be obtained for the balance study period. It is available by requesting an intermediate office totals, "office counts," report or by manually calculating the AHT from the data summaries received after each data entry session.

(b) For offices not on a mechanized program, or without a load balance hour coincident with a PATROL report hour, or for offices with a need to compute the AHT manually the following formula should be used:

$$\text{AHT} = \frac{\text{A-Link Usage} \times 1.05}{\text{OPC} + \text{IPC} + \text{IAOPC}} \times 100$$

Where:

OPC = Originating peg count

IPC = Total line link network incoming peg count (this does not include intraoffice, incoming busy, and tandem)

IAOPC = Intraoffice peg count (including line busies)

Note: Total office usage is calculated as follows:

2(L-L junctor usage) + L-T junctor usage

This result may be approximated with the formula "A-link usage times 1.05" which considerably reduces the arithmetic effort required and is shown above.

The AHT should be calculated for the load balance busy hour on each day of the study and an average for all days in the study should be obtained.

(c) If data should be lost for any portion of the week in either a mechanized or manual situation, use the average of the available holding time data. However, when computing the AHT with less than five days of data, be reasonably sure that the data compute to an expected range or "good" AHT. Should the AHT be questionable in this situation, use the computed AHT from the previous week.

2.37 The QCL is selected using the AHT and the percentage of capacity in the following manner:

(a) Using the example in 2.34 select the appropriate QCL table on sheet *1* of Figure 1.

(b) Assume AHT is 174 seconds.

(c) Under column "Average Holding Time-Seconds," find the line designated 171-190.

(d) Go across line to the appropriate "Percentage of Engineered Load" column, 56 to 65 percent.

(e) Locate the appropriate line junctor ratio and read the QCL percentage which is ***28***.

2.38 The quanlity control limit tables in Figure 1 were constructed using 10 hours of data for a base. These tables are the only system tables allowed for computing the load balance index as described in Dial Facilities Management Practices Division A, Section 5b. It is recommended that 10 hours of data be obtained for all balance studies whenever possible. In those cases where this is not possible, an adjustment for the number of hours may be made on any studies ***not*** used for the load balance index. This adjustment corrects the QCL for the lesser reliability of smaller sessions and is calculated as follows:

$$Q = \sqrt{\frac{10}{N}} \times \text{Table QCL Value}$$

Where:

Q = the new QCL

N = the number of hours of the study

The value of the square root may be determined from the following table. This answer can then be multiplied by the table QCL value (Fig. 1) to determine Q.

N	5	6	7	8	9	10
$\sqrt{\frac{10}{N}}$	1.41	1.29	1.20	1.12	1.05	1.00

Example:

Given — Table QCL value = 47%
— N = 8 hours

$$Q = \sqrt{\frac{10}{8}} \times 47.0$$

$$Q = 1.12 \times 47.0$$

$$Q = 52.6\% = 53\%$$

Note: This procedure may ***not*** be applied to studies used for the LBI.

2.39 After computing the QCL as described in the preceding paragraphs, it is possible to establish CCS values for the ± 3 sigma points. It is also necessary to indicate load units which are approaching these limits. This is established by designating intermediate points at ± 1.5 sigma.

Example:

Assume average usage per load unit in a loading division is 200 CCS and the QCL is 44 percent.

$$200 \text{ CCS} \times 0.44 \doteq 88 \text{ CCS}$$

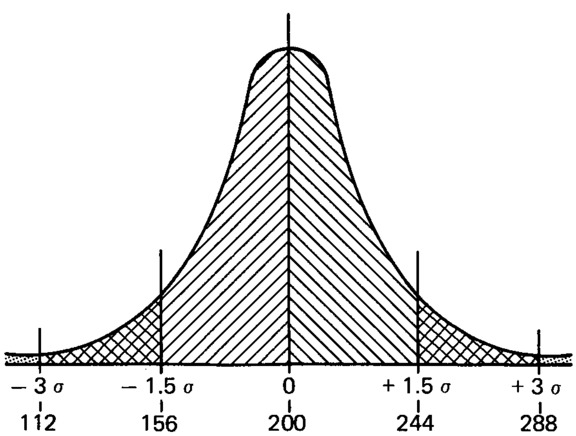
$$+3.0 \text{ SD} = 200 \text{ CCS} + 88 \text{ CCS} = 288 \text{ CCS}$$

$$-3.0 \text{ SD} = 200 \text{ CCS} - 88 \text{ CCS} = 112 \text{ CCS}$$

$$+1.5 \text{ SD} = 200 \text{ CCS} + 44 \text{ CCS} = 244 \text{ CCS}$$

$$-1.5 \text{ SD} = 200 \text{ CCS} - 44 \text{ CCS} = 156 \text{ CCS}$$

This is illustrated in the distribution curve below where σ (sigma) represents 1 standard deviation.



2.40 The use of CCS values at the specified 3 and 1.5 sigma limits works well for one week's data. Unfortunately, when a history is maintained to increase statistical reliability, the mathematics becomes too complicated to utilize on a manual basis. This deficiency is overcome through the use of an alternate method called the score system.

DEVELOPMENT OF SCORES

2.41 The score system has been developed to simplify the mathematics required in the balancing of loading units. The system substitutes a very simple number for a much larger number to enable subtractions and additions to be made quickly and simply. Numerical values are assigned to represent the extent each load unit has departed from the unit average during a measurement period. In application, all load units exceeding the quality control limit on a weekly record are assumed to be out of balance. The other units, however, also deviate to a lesser degree above and below the average.

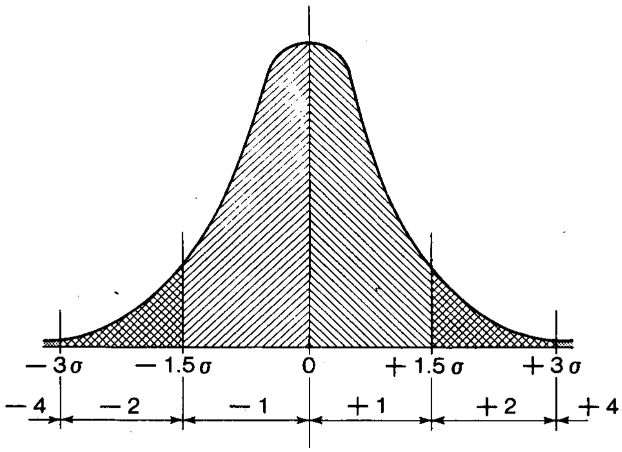
2.42 The procedure for deriving scores is to take the QCL percentage as determined from the preceding paragraphs and apply it as follows.

(a) Each concentrator with exactly average CCS is assigned a score of 0 (zero).

(b) Each concentator deviating above or below average, up to and including 1.5 standard deviations (one-half the QCL), is assigned a score of +1 or −1.

(c) Each concentrator deviating above or below 1.5 standard deviations from the average and up to and including 3.0 standard deviations is assigned a score of +2 or −2.

(d) Each concentrator deviating above or below 3.0 standard deviations from the average is assigned a score of +4 or −4. Note that 4 is used rather than 3 in order to accentuate this undesirable deviation (see distribution curve which follows).



Example:

Assume average usage per load unit in a loading division is 200 CCS and the QCL is 44 percent. A total of 3.0 standard deviations is 44 percent and 1.5 standard deviations are 22 percent. Scores are computed as follows:

Load Unit CCS	Score
289 and higher	+4
245 through 288	+2
201 through 244	+1
200	0
156 through 199	−1
112 through 155	−2
111 and lower	−4

3. SWITCHING SYSTEM BALANCE CONSIDERATIONS

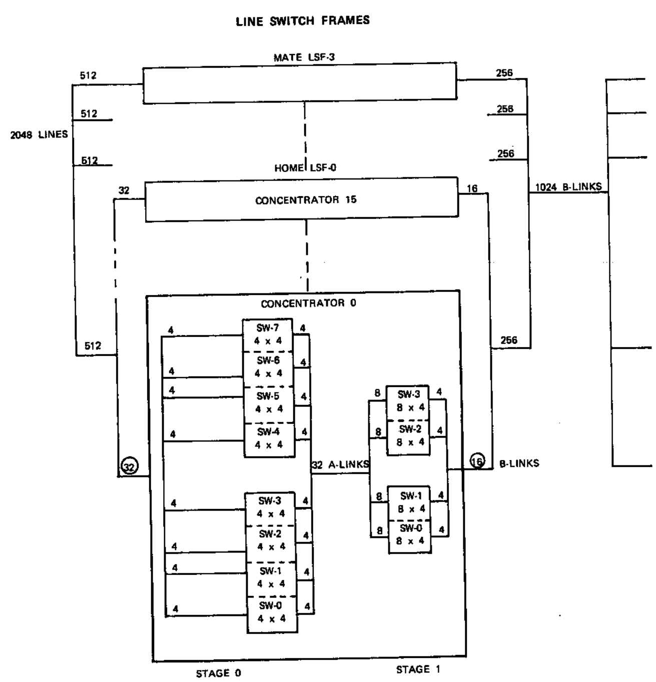
PURPOSE

3.01 This part of this section is intended to give a brief description of the ESS load unit, point out some loading restrictions, and provide administrative guidance in loading an ESS unit.

LOAD UNIT CONFIGURATION

3.02 The load unit in a No. 1 ESS (2-wire) machine is the concentrator. It is economically the smallest measurable piece of equipment. There are two types of concentrators, 2:1 and 4:1. The 2:1 is designed for heavy traffic conditions while the 4:1 is designed for medium to light traffic. Each concentrator type is composed of two stages of switching which are designed to concentrate and distribute the traffic paths.

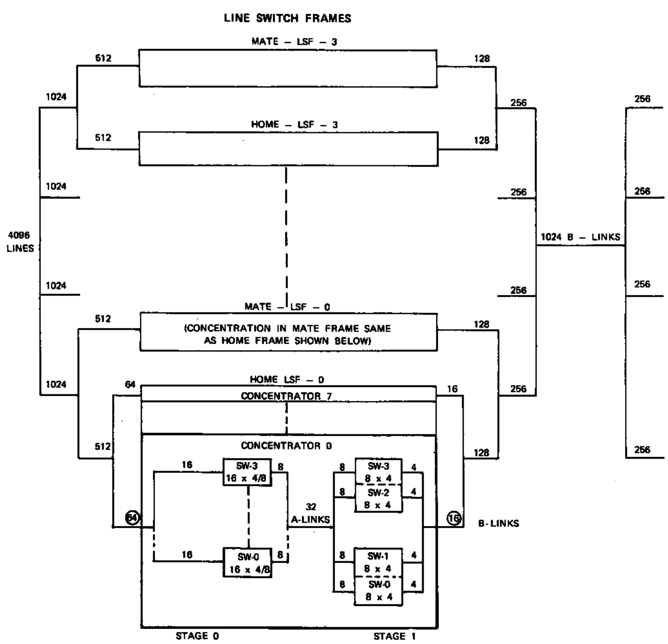
3.03 The 2:1 type concentrator serves 32 customers. As shown in the illustation below, these 32 lines can access 16 B-links. Each concentrator contains eight 4-by-4 stage 0 switches and four 8-by-4 stage 1 switches. Stage 0 switches do not provide any concentration and are used only to distribute traffic over the stage 1 switches. Stage 1 switches provide 2:1 concentration and distribute traffic over 16 B-links. The B-links, in turn, are distributed in a patterned manner over the line junctor switch frames within the network. No concentration occurs in the line junctor switch frames.



2:1 CONCENTRATOR (HEAVY TRAFFIC)

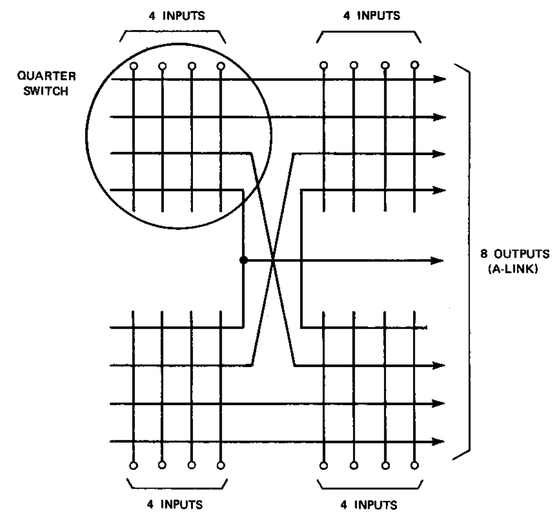
3.04 Although the basic measured balancing unit in a 2:1 network is the concentrator, switch balance is important. Within the concentrator, blockage can occur in stage 1, the B-links. Even though concentration does not occur in stage 0, equal distribution by class of service is necessary by concentrator and switch. Further, high line-to-junctor ratios and large numbers of "same classes of service" in one concentrator or switch increase the probability of blocked dial tone delay even in underloaded concentrators.

3.05 The 4:1 type concentrator serves 64 customer lines. The illustration below shows how these 64 lines can access 16 B-links. Each concentrator contains four 16-by-8 stage 0 switches and four 8-by-4 stage 1 switches. Stage 0 switches perform a 2:1 concentration function and distribute the 32 paths over the stage 1 switches. Stage 1 switches also perform a 2:1 concentration function and distribute traffic over the 16 B-links. The B-links are distributed in a specific pattern across the line junctor switch frames within the network. No concentration occurs in the line junctor switch frames.



4:1 CONCENTRATOR
(LIGHT TO MEDIUM TRAFFIC)

3.06 The basic balancing unit in the 4:1 network is also the concentrator. However, concentration occurs in both stages; hence blockage may occur in both the A- and B-links. The A-links are particularly load sensitive because of the quarter-switch arrangement as shown in the illustation below. Study of the figure demonstrates that a poor distribution by class of service over the quarter-switches could result in blockage even though from an overall CCS load standpoint the concentrator could be underloaded.



STAGE 0 IN 4:1 NETWORK

3.07 Detailed information about the line link network and its component parts may be found in the Traffic Facilities Practices, Division D, Section 10-e. Information on the switching network is found in Dial Facilities Management Practices, Division H, Section 6b.

FEATURE RESTICTIONS

3.08 There are two assignment restrictions in the No. 1 ESS, namely essential service and ground start. Each of these involve line equipment locations.

3.09 Lines classified in the essential service category are assigned to levels reserved for class A line load control. The number of levels assigned varies with office requirements and is fixed in the parameter area of the program store.

Illustrated below are the switches and levels involved, depending upon the concentrator type.

2:1 TYPE CONCENTRATOR		
% LLC EQUIP'D	SW. NO	LEVEL
6.25	1,5	00
12.50	1,2,5,6	00
18.75	1,2,5,6	00
	3,7	03
25.00	0,1,2,4,5,6	00
	3,7	03
4:1 TYPE CONCENTRATOR		
% LLC EQUIP'D	SW. NO	LEVEL
6.25	0,1,2,3	04
12.50	0,1,2,3	04,08
18.75	0,1,2,3	04,08,15
25.00	0,1,2,3	04,08,15,00

3.10 Ground start is required for certain operations such as coin lines (except dial tone first lines) and some types of PBX direct dial trunks. Only ***even-numbered levels*** may be used for ground start lines. It is suggested that certain preselected levels be wired for ground start service and assignments be made accordingly. Additional levels may be wired if demand for service increases.

LOAD BALANCE PROCEDURES

3.11 This section provides guidance to effect good load balance and to minimize problems associated with feature restrictions discussed in 3.08 through 3.10.

3.12 A loading plan, as previously stated, is the key to achieving good load balance. This plan should reflect the needs of the current busy season as well as those of the future, especially when engineered capacities are reached or exceeded. The loading plan is developed by the network administrator using four major sources of information: official documentation, historical data, office characteristics, and coordination with the network design engineer. Each of these sources must be melded together to create a unique, comprehensive, and effective plan. The official documentation includes the following.

(a) ***Commercial Forecast:*** This forecast provides the expected growth/loss for lines and main stations as well as a breakdown by broad classes of service. It should be used for determining the class-of-service mix and trends.

(b) ***Demand and Facility Chart:*** This chart provides office data as it relates to capacities, office limitations in main stations (MSs), growth expectations, and CCS/MS data history and projections. This information should be used for identifying specific equipment limitations, equipment capacities, centrex demand, and job exhaust time frames. Service levels as they relate to load may be compared and projected.

(c) ***Equipment Order:*** The equipment order provides the installed equipment information about the entity. Basic data may be found here such as engineered capacity by component, breakdown of trunk groups, number of installed service circuits, etc.

3.13 Historical data should be analyzed for developing trend information and to assist in making realistic decisions about CCS/MS by class of service, expected in-and-out movement, calling rates, service levels, etc.

3.14 Each entity has its own unique characteristics which should be identified for loading purposes. Calling rates, holding times, in-and-out movement, and class-of-service mix are affected by community items such as seasonal business, conventions, college activities, planned mobile parks or retirement communities, etc. Custom calling features must also be evaluated for their impact. For example, "plain old telephone service" (POTS) customers with custom calling capabilities will probably have different characteristics from centrex customers with the same features.

3.15 Coordination with the network design engineers is very important. The engineer has "designed" the entity based upon some basic traffic assumptions and historical data. The office has to be administered and loaded with this information in mind. It is recommended that prior to each job and every busy season the basic data design values, originating and terminating busy hour calls, and traffic trends should be mutually discussed and agreed upon. If the calling characteristics or class-of-service mix should change during the year, the network administrator should inform the network design engineer. Any major changes in office traffic should be reflected in the loading plan.

3.16 The loading plan should be developed for the busy season year broken down by month for each major class of service. Utilizing the information derived from the four basic sources, the plan should state the expected monthly MS gain or loss and should be compared to the actual monthly growth.

3.17 Once the plan is developed, loading procedures must be developed to assist in the day-to-day assignment job. Switch levels (or in the 4:1, quarter-switch levels) may be identified within each concentrator over which to spread the classes of service. The identification process must be tempered with judgment. Assignment distribution considerations should include identifying the following:

(a) Customers with high call volume services such as outward wide area telephone service (WATS), inward WATS, and data ports

(b) PBX and multiline hunt lines in order to spread them across all frames

(c) Customers with special features which may extend their holding times such as call waiting or conferencing capabilities

(d) Coin classes of service, especially with coin zone, because in ***initial*** call set up two or three links may be used.

3.18 The class-of-service mix may change drastically with the next growth job or the one after. Long-range planning should include a method for efficiently handling such a change. One possible method is to consider certain levels as unassignable or restricted for future growth.

3.19 Once the loading procedures have been established, advantage should always be taken of the line assignments advanced to the customer facilities assignment office. Assignments previously advanced to the assignment office and which no longer meet balance requirements based on new load balance data should be recovered.

MAIN DISTRIBUTING FRAMES

3.20 This part provides basic information with regard to the main distributing frame (MDF) and its impact upon office balance.

3.21 The MDF provides a means of flexible assignment of cable pairs to trunks and line equipments. Line equipments may be assigned on a completely random basis or administered to minimize cross-connection (jumper) lengths.

3.22 Random assignment of lines is unsatisfactory because it tends to increase jumper lengths and congest frame levels, shelves, or troughs. Modular frames are particularly subject to congestion if short jumpers are not utilized.

3.23 The initial layout of an MDF and subsequent additions of cables and line equipments should be planned for optimum use of the opportunities for short jumpers without sacrificing good load balance procedures. The amount of interdepartmental planning required will vary with the type of MDF and the nature or size of the community being served. MDFs with a high service order activity and serving several switching entities must be designed with extreme care.

3.24 The network administrator should establish appropriate interdepartmental and intradepartmental contacts to ensure that loading considerations are included in the decision-making process for locating cables and line equipments. Network administrators must be familiar with their MDF layouts so that they can participate effectively in the planning process.

3.25 It is generally agreed that a well-engineered layout of cable pairs and line equipment, together with reasonable preferential assignment procedures, can accomplish the optimal short jumper design. In order to accomplish this goal, ongoing interdepartmental coordination is required, revolving around a long-range plan. Strict preferential assignment and administrative procedures must be established and maintained interdepartmentally and intradepartmentally. Constant analysis is required to ensure that procedures are achieving the maximum utilization of short jumpers and the goal of good load balance.

3.26 The main source of long jumpers on the MDF comes from cable transfer activity. Either before or after the completion of cable transfers, line equipment transfers (LETs) should be coordinated and prepared to change long jumpers to short jumpers. "T" and "F" service orders within the same wire center where dual service is not involved should be assigned a new equipment that will result in a short jumper.

3.27 ***Conventional Frames:*** The ***conventional MDF*** contains two major components. A ***vertical*** side is used for terminating outside plant cable pairs and a ***horizontal*** side (composed of shelves) is used for terminating line equipment and, where appropriate, directory numbers.

3.28 Conventional MDFs can be constructed in lengths up to several hundred verticals. They are therefore susceptible to long jumper problems. In order to control the lengths of these jumpers, large MDFs are segregated into assignment ***zones.*** These zones are the preferred areas of assignment for selected quantities of cable and central office line equipment. Because of variations in design and layout of equipment on frames, zones must be established locally within each central office.

3.29 Establishing zones will be the joint responsibility of network and frame administrators. The number of zones established on a frame should be the minimum required to control jumper buildup on the horizontal shelves. For further information regarding this subject, refer to Bell System Practices Section 680-830-010.

3.30 In addition to frame zoning, a reduction in jumper buildup and adherence to good loading policies can be effected by:

(a) Spreading cable complements across several verticals, and

(b) In multientity buildings, locating each entity on a different shelf, one above the other.

3.31 Success with a zoned MDF requires that line equipments be made available in all zones as required to meet inward movement. If, however, this conflicts with loading plans for the building, ***service performance objectives will take precedence over MDF considerations.***

3.32 ***Modular Main Frame:*** Modular main distributing frames are designed for use in ESS offices. The frames are configured to be used with preferential assignment procedures which attempt to find the shortest cross-connections. The frame should only be used where approximately 95 percent of the jumpers can be expected to be made between adjacent verticals. Detailed descriptions of the frame can be found in Bell System Practices Section 201-221-101.

3.33 The distributing frame module consists of ten vertical files. Each pair of vertical files is separated by a vertical jumper wire trough. The design is such that each outside plant vertical is adjacent to a line equipment vertical. Each vertical file is considered to be divided into left and right half-verticals. A short jumper is defined as one that runs between terminals in adjacent half-verticals and thus lies wholly within a vertical trough. All other jumpers are defined as long jumpers. There are first- and second-choice long jumpers. The first choice is between terminals that may be separated by as many as ten verticals. The second choice is to run jumpers between terminals that are separated by ten or more verticals. Horizontal wiring troughs for running long jumpers are provided at the top and bottom of each frame. This trough space is ***limited,*** however, which makes it necessary to minimize long jumper assignments.

3.34 Although the design of the ESS MDF is described as flexible, it requires many administrative controls to achieve its goal. The network administrator has two main concerns: to assign equipment preferentially by vertical and to maintain good load balance using the concept of spreading by class of service. These tasks are not small ones. The assignment lists that are advanced to the customer facilities assignment office should be prepared by MDF half-vertical and, when required, also by different classes of service.

3.35 Administering the assignment of equipment requires constant analysis of the load balance results and careful surveillance of the records for long jumpers. Outstanding advance line equipment lists should be recalled by the administrator in order to withdraw line equipment that no longer meets specific load balance requirements.

3.36 ***COSMIC Frame:*** The common systems main interconnecting (COSMIC) frame is a main distributing frame which terminates exchange cables and tie cables. It is associated with No. 1 ESS, No. 1 and No. 5 Crossbar, and Step-by-Step line equipment.

3.37 The COSMIC frame lineup consists of alternating modules of line equipment and exchange feeder cable pairs. Each module has 11 shelves which provide each feeder cable pair access, with a short jumper, to line equipment modules located immediately to the left and right.

3.38 Each module has an upper and lower express trough for routing long jumpers and a large vertical trough between modules for routing short jumpers. A COSMIC frame short jumper is defined as that jumper which does not route via the upper or lower express troughs when making connections of line equipments with an exchange feeder cable pair.

3.39 Incorporated with the COSMIC frame system is a mechanized Program for Arrangement of Cables and Equipment (PACE) which provides an efficient and consistent layout of exchange feeder cable pairs, line equipment, and tie cable pairs.

3.40 The COSMIC frame design depends on preferential assignments which combine load balance and class-of-service requirements with short jumper concepts. The Computer System for Main Frame Operations (COSMOS) is the mechanized system designed to aid in achieving these goals.

TRUNK LINK NETWORK BALANCE

3.41 This part provides general guidance to assist in achieving trunk link network (TLN) balance through directed assignments and to assist in determining when trunk rearrangements may be required. Previous parts of this section deal with imbalance on the line side of an entity and, because of its importance in providing equal service to all customers, concentrator balance is covered in considerable detail. Trunk link network balance and trunk grid balance within a unit may also have a significant impact upon service to customers although trunk grids are not associated with any particular group of subscribers. Poor grid balance results in a loss of TLN capacity and may result in incoming matching loss being experienced by all customers.

3.42 Essentially, the concepts outlined in Part 2 of this section, Principles of Load Balance, are the same for TLNs. Loads on trunk grids should be compared to the average and an attempt made to bring all grids to that average. However, the QCL tables provided in Figure 1 of this section ***do not*** apply to trunk grids. Quality control limits for grids have not been developed but are expected to be ***narrower*** than the limits for concentrators since the traffic loads on grids are substantially higher than the loads on concentrators. Until standard QCL values are established for grids, it is recommended that individual grid usage be analyzed in relation to design capacity and in relation to the average grid usage in the entity. This is discussed in more detail in 3.52 through 3.57.

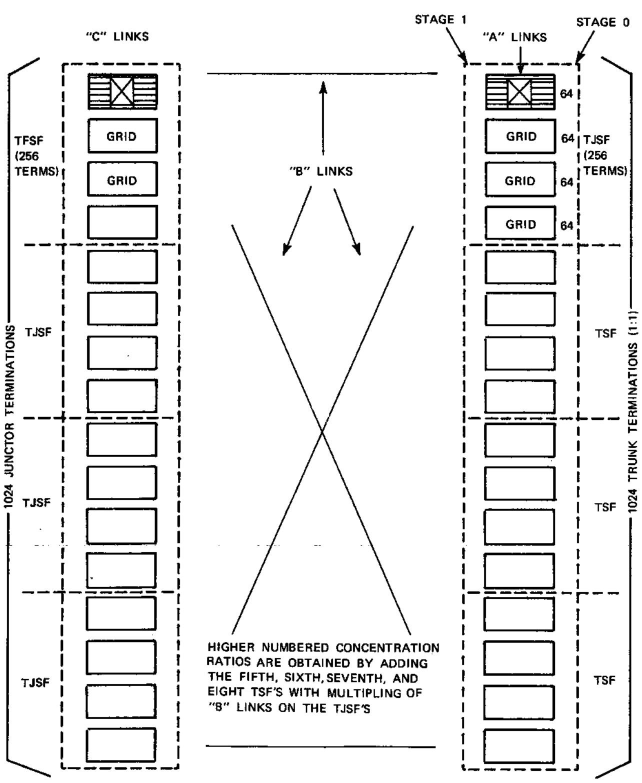
3.43 Establishing and maintaining TLN balance are included in the following job functions:

- Network administrator: responsible for overall service in the entity and performs a surveillance role for trunk provision and balance
- Network design engineer: responsible for providing enough equipment, both switch and trunk, to maintain service objectives
- Trunk administrator: responsible for servicing trunk groups to maintain trunk service levels, forecasting future requirements, and balancing trunk grid load.

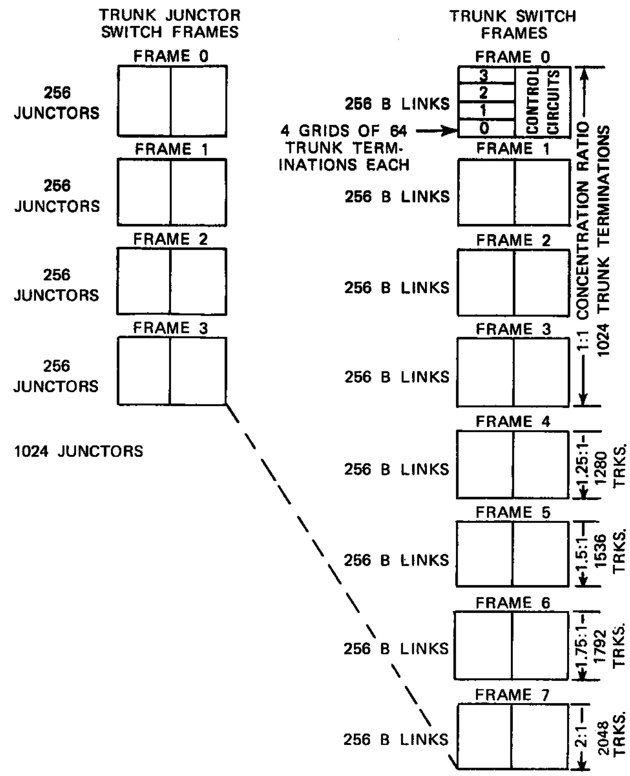
Note: These responsibilities are only shown for their impact upon balance. These job functions may or may not be handled in three separate groups. However, for the purposes of this section the functions are separated as shown.

In following the principles of load balance, trunks and service circuits should be assigned in a manner which will produce a balanced CCS over the load units. A loading plan, jointly developed by the network administrator, trunk administrator, and network design engineer should be established to evenly spread all equipment types. A loading plan for the initial installation and for each subsequent addition of TSFs is recommended.

3.44 The load unit is the trunk grid. The two illustrations which follow show the TLN design and makeup. The second illustration further indicates the trunk-to-junctor concentration ratio. The switching stages are the same in the TLN as they are in the LLN. Each grid is made up of 8 by 8 switches. Since the potential eight trunks on each switch have access to eight A-links, it is not as necessary to maintain a precise CCS balance by switches as it is in the concentrators of the LLNs. However, it is recommended that an equal number of working trunks by type be assigned to each switch to evenly distribute the load. To assist in this distribution process the trunks should be classified as being ***heavy, medium,*** or ***light*** trunks by their estimated busy hour CCS load.



NO. 1 ESS TLN PATTERNS



NO. 1 ESS SPREAD OF TLN LINKS—1:1 CONCENTRATION RATIO

3.45 The determination of heavy, medium, or light trunk loads requires an understanding of how switching machines select trunks and the expected load offered to the group. This determination is largely the responsibility of the trunk administrator.

3.46 No. 1 ESS entities pick originating trunks and service circuits on a ***random*** basis. Random selection is assumed to impart equal loads to all equipment, trunks, or service circuits within a group. Since this even distribution is standard, simply assign equal numbers of these items to each TLN and grid whenever possible. Two-way trunks, however, require directed assignment procedures because selection is ***sequential.***

3.47 Incoming trunks are not always selected on a random basis at the originating entities and must be treated accordingly. The following list provides information about outgoing trunk selection by type of switching system:

System	***Outgoing Trunk Selection***
Step-By-Step	Sequential/random (graded multiple)
Panel	Sequential (graded multiple)
No. 1 Crossbar (XB)	Sequential (circular)
No. 5 XB	Random
No. 4 XB	Sequential
Crossbar Tandem	Sequential (circular)
No. 2 ESS	Random (2-way—sequential)

Note: Sequentially and graded multiple trunks will carry a higher CCS on the first choice, lighter CCS on the last choice, and some intermediate value for middle trunks.

3.48 Relative load carried by each trunk is also determined by the type of trunk group. For example, regardless of how they are selected, ***high usage*** (first route) groups should carry heavier loads per trunk than either ***final*** or ***full*** groups.

3.49 The most appropriate way to balance trunks from other offices is to spread them over all TLNs as follows:

(a) Trunks within one group should be evenly distributed over all TLNs in order to minimize the effects of overloads and directed traffic during emergencies.

(b) Even numbers of heavy, medium, and light trunks from each group should be assigned to all TLNs. The most accurate way in which to keep track of the expected load is to assign CCS values to each type of trunk.

3.50 The assignment procedure described above maximizes the chance of success in setting up any network connection, especially those for which retrials are possible (eg, distributing a trunk group among the TLNs will often permit use of a new junctor group for each successive trial). Service circuits should be spread in a similar manner as some of them require additional reserve and network paths. These include 3- and 6-port conference circuits and coin control circuits.

3.51 The network administrator is responsible for surveillance of trunk load data and for providing these data to the trunk administrator. Usage measurements on each grid are provided in the office trunk switch frame grid total usage count. It is conveniently collected each time the W-block is requested. Therefore, it is automatically collected at least once a month for the session busy hours. The guidelines which follow are based on weekly load data and average incoming matching loss (IML) results accumulated during the busy season.

3.52 Grid usage data should be used for directing trunk assignments into the least loaded grids. Until standard QCL tables are developed, it is recommended that $\pm$15 percent of the average grid CCS measured in each study be established as the objective range for grid loads. Assignment of new trunks should be made in the following order of preference.

Choice	**Grids**
First	Below 85 percent of average
Second	Between 85 and 100 percent of average
Third	Between 100 and 115 percent of average
Fourth	Over 115 percent of average

3.53 As long as the TLNs are not near their CCS capacity (see table below) and the office is not experiencing IML over objective, some grid imbalance can be tolerated. Trunk transfers are expensive and should be minimized with good assignment procedures. However, trunk transfers will be required if the office is experiencing high IML or if significant TLN capacity loss will result from a continued grid imbalance.

LOAD CARRYING CAPACITIES

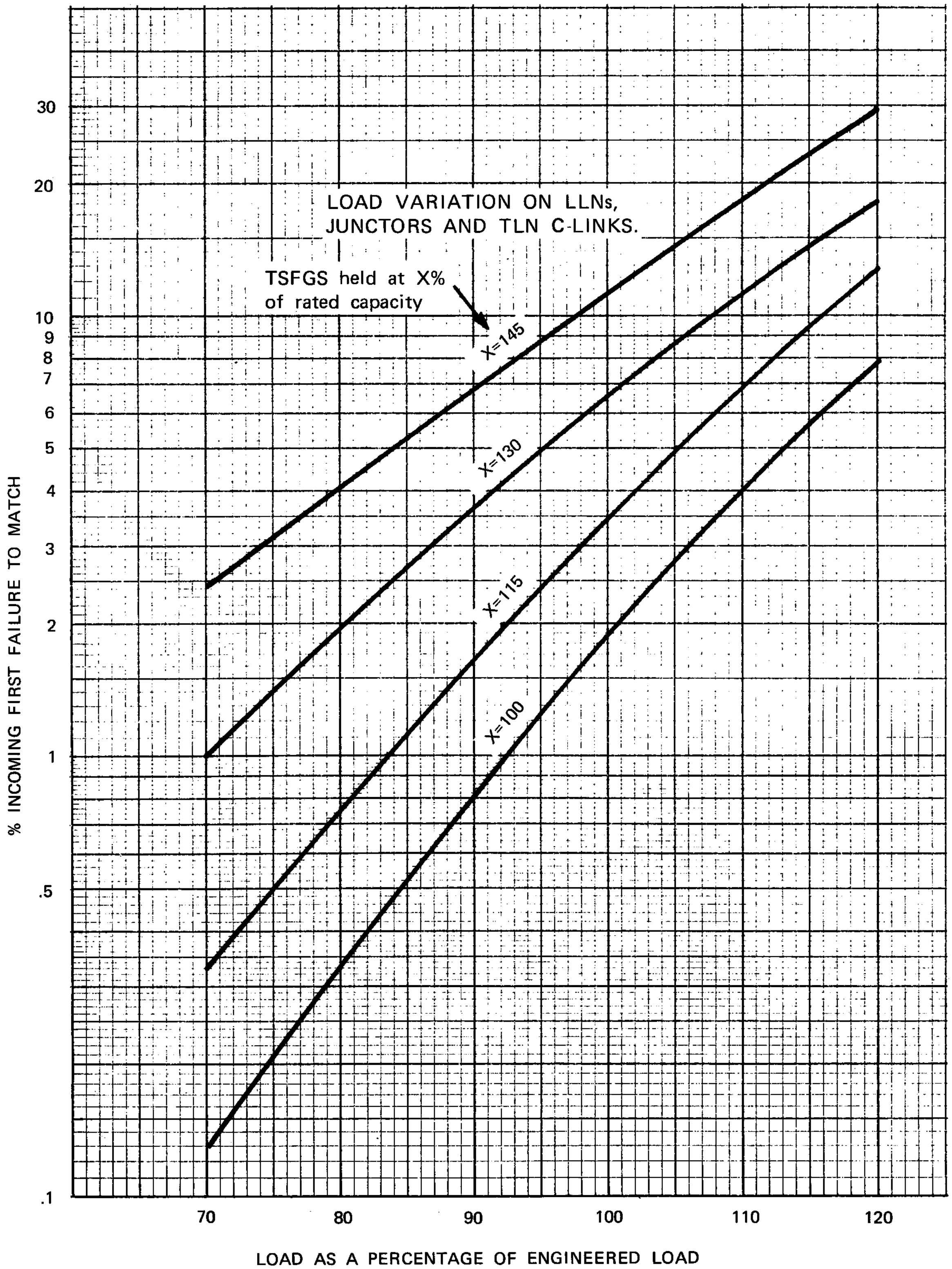
TRUNK SWITCH FRAMES AND GRIDS (TSFGs)

TRUNK-JUNCTOR RATIO	TSF/ TLN	CCS/ TSF	CCS/ GRID*
1.00:1	4	4600	1150
1.25:1	5	3680	920
1.50:1	6	3060	765
1.75:1	7	2620	655
2.00:1	8	2300	575

Note: The CCS capacity for a TLN is 18400 in all cases.

* Average busy hour CCS capacity.

3.54 Selecting the grids for deloading when the office is experiencing high IML depends on the average load in the rest of the network. The following graph shows that a grid loaded to 145 percent of its capacity will see 11 percent blocking when the rest of the office is approximately 100 percent of capacity and will see only 4 percent blocking when the rest of the office is at 80 percent of capacity. Similarly, a grid at 115 percent of its capacity sees 2 percent blocking when the office is around 92 percent capacity and 3.5 percent blocking at 100 percent of capacity. ***Judgment must be used in selecting the grids to be deloaded for the desired improvement in IML.*** The graph which follows assumes that the larger loading units (ie, TLNs, LLNs, and junctor groups) are reasonably well balanced. It should also be noted that the graph predicts the percentage of incoming ***first failure*** to match (IFFM). The IML performance is somewhat better than this since it includes the effects of no trials on calls to busy lines and second trials on calls to multiline hunting (MLH) groups.


LOAD VARIATION ON LLNs,
JUNCTORS AND TLN C-LINKS.
TSFGS held at X%
of rated capacity
X=145
X=130
X=115
X=100
% INCOMING FIRST FAILURE TO MATCH
30
20
10
9
8
7
6
5
4
3
2
1
.5
.1
70
80
90
100
110
120
LOAD AS A PERCENTAGE OF ENGINEERED LOAD

3.55 When the average IML is better than objective, the expense of trunk rearrangements to improve balance can be justified if the rearrangements are necessary to maintain the design capacity of the entity. All the components of an entity do not exhaust at the design main station loading and there may be surplus TLN capacity in the design as a result of equipment breaks. In such cases some grid imbalance is tolerable. The following table shows the estimated TLN capacity loss as the percent of trunk grids out of balance increases.

Expected Decrease in TLN Capacity as a Result of TSFG Load Balance

Percentage Decrease in TLN Capacity	Percentage of TSFGs Exceeding 115% of Average TSFG Load
1	2
2	8
3	12
4	15
5	18
6	20
7	22
8	23

3.56 This capacity loss can result in IML being experienced before the office is fully loaded. For example, if 20 percent of the grids exceed 115 percent of the average grid load, a 6-percent loss in TLN capacity results; ie, 2 percent IML on the average will occur when the office is loaded to only 94 percent of the TLN design. Continuing to load the office to the theoretical TLN design would then result in IML poorer than 2 percent on the average if the imbalance was not reduced.

3.57 Every effort should be made to achieve improved balance by directed trunk assignment before the entity is loaded to capacity. If, however, it becomes apparent that this method will not produce sufficient improvement to provide objective service for the design main stations, then sufficient trunk rearrangements should be planned to recapture the required TLN capacity before the service is impaired.

3.58 The Load Balance System (LBS) mechanized program will provide two printouts for analysis when deciding where to assign or remove trunks. The first printout will show an ordered 12-week history file for trunk link network grids. The second printout is a CCS corrective action guide which will be available for use in a similar manner as the one for concentrators.

3.59 Figure 3 provides a suggested format for manual posting of grid usage data for interim use (Form E-6663). Figure 4 provides a suggested format for manual posting of grid usage analysis data (Form E-6664).

4. DATA COLLECTION

DATA ACQUISTION

4.01 Load balance data are collected on the weekly measurement schedule, also known as the W-schedule. The W-schedule can be varied to collect any number of hours per day for any number of days per week. The load balance data are collected using the office line concentrator total usage count. This count provides line link network load balance data per line concentrator. The measurement is A-link usage for each concentrator including A-links made busy for maintenance purposes and reserved A-link usage. The printout appears in ascending order of network, frame, bay, and concentrator (lowest numbered concentrator, bay, frame, and network to the highest numbered).

4.02 To obtain a load balance tape and printout, the weekly schedule must be programmed using the ESS 1402, ***traffic measurement schedule.*** The specifics on collecting and printing the load balance data can be found in the Translation Guide, TG1A, Division 3, Section 4c, Traffic Measurement Schedule, and the Dial Facilities Management Practice, Division H, Section 6i, Traffic Measurements.

4.03 ***Data Collection Frequency:*** Data must be collected and reported once a month for index purposes. It may be collected more frequently for administrative reasons such as when:

(a) The office is out of balance and the network administrator wants to analyze the results of specific corrective action procedures.

(b) The office is nearing the end of the job interval and/or is load limited; therefore, fine-tuned assignments are required to ensure objective service levels.

(c) The office is a new installation (at or greater than 30 percent of capacity) or a growth addition has just been completed, hence a new load balance data base is required. The more quickly the data are collected, the sooner the balance may be analyzed.

(d) The office has just completed an area cut and the network administrator wants to evaluate the effects of the applied loading techniques.

MISSING OR INCOMPLETE DATA

4.04 Normally, the load balance data are scheduled to print at the end of a study period but it may be appropriate to schedule it daily. The daily printout will consist of a cumulative total of all hours collected, up to and including the day on which the printout is requested. The weekly (study period) total will not be destroyed. Such daily printouts are desirable as a protection against loss of data due to system reinitialization. The requirement for the daily printouts must be individually determined on the basis of past machine performance with regard to data.

4.05 There are circumstances under which the data for the study week may be incomplete as a result of system reinitialization, lost or damaged tapes, etc. The criterion for data reporting in compliance with Dial Facilities Management Practice Division A, Section 5b, is that a minimum of 7.1 hours is required, but the full complement of 10 hours is preferred. Hence, if 6 hours of data are available, there are several ways it can be approached.

(a) Four hours with the same traffic characteristics may be used from the previous collected week within the study month, if available.

(b) The entire 10 hours from a previous study may be used, if available.

(c) As a last resort, as little as 2 hours with the same traffic characteristics from the previous collected study may be used to create an 8-hour study and should be treated as a 10-hour study for scoring purposes.

If valid data cannot be obtained within the study month, then for index purposes, ***the data are considered not available.*** For administrative purposes, the criteria outlined in 2.38 will be followed.

DATA VALIDATION

4.06 The network administrator is responsible for the validation of load balance measurements. Presently there are only a few ways to validate the load balance data. These ways involve visual inspection as well as other methods to determine if the measurements are reasonable.

4.07 One method is to compare actual concentrator usage with the engineered capacity of that concentrator. The line link network load carrying capacity table in Figure 2 specifies the capacity based upon the line to junctor ratio. The busy hour engineered CCS per concentrator must be multiplied to state a 10-hour capacity figure in order to be comparative. Once the percentage of capacity is calculated (as part of the quality control limits requirements), measurements that are at or exceed capacity should be evaluated as to whether they reflect valid data and/or a load balance problem. The percentage of capacity is relative to the expected load. An office at 50 percent of capacity should not expect to have concentrator loads nearing capacity, whereas an office running at greater than 75 percent of capacity could expect such concentrator loads. Service indicators associated with office load would similarly be expected infrequently in balanced offices at 50 percent of capacity and more frequently as capacity is approached.

4.08 Another method is that of applying a comparative check such as:

$$\frac{2(\text{L-L}) + \text{L-T}}{\text{Total LLN A-Link Usage}} = X$$

Let X be the ratio of the usage on the LLN junctors to the usage on the LLN A-links. An office experiencing a light load should have junctor usage approximately 5 to 8 percent higher than the A-link usage since the A-link in a signaling or ringing connection can be reused for the talking connection; that is, load will be frequently measured on ***one*** A-link and on ***two*** junctors (one for the ringing or signaling connection and another for the talking connection). As the load increases, the A-link and junctor usage will become more nearly the same since reuse of the A-link occurs less frequently because of the network blocking. Therefore, as the load increases in an office, the ratio (X) will approach 1.00. A striking change in the ratio would merit investigation of the data (trends, unusual readings, A-links made busy, etc), changes in traffic patterns, or comparative measurements such as originating plus terminating data.

4.09 In the mechanized mode, as should also be done in the manual environment, a validation check will be made to ensure that every register reading has six digits. A check should also be made to ensure there are no zero register readings or readings which exceed 16 times 36 times the number of data hours.

4.10 A phase action can invalidate data. In offices equipped with a CTX-5 or earlier generic program, ***phase 4 (or higher) emergency action affects all traffic measurement up-down usage accumulators, peg count accumulators, and holding registers.*** The reliability of the data collected in subsequent hours is suspect. It is recommended that the W-schedule be recycled and data collection begin anew. Refer to 4.04 and 4.05 for the details on how to handle missing or incomplete data. In offices with a CTX-6 or higher generic program, the office line concentrator total usage count is in the protected area of call store. This means that the registers will not be affected with the exception of a phase 6 action.

5. BALANCE TECHNIQUES

MANUAL PROCEDURES

5.01 There may be instances where it is necessary to manually compute the load balance scores and an LBI. The clerical effort involved with scoring every load unit individually is time-consuming. It is recommended, therefore, that these manual calculations be used only when normal computer operations are unable to develop scores and penalty points for an LBI.

5.02 A ***score control record*** (Form E-6615), shown in Figure 5, is used for developing weekly CCS ranges for a loading division, as discussed in Part 2.

5.03 A ***load unit-load balance chart*** (Form E-6616), shown in Figure 6, is used to record load unit-load balance, load unit weekly scores, penalty points, and hot spot penalty points.

MECHANIZED PROCEDURES

5.04 A mechanized method is being developed to compute the load balance index and to provide administrative aids for assigning lines and achieving acceptable load balance. An interim mechanized load balance program has been incorporated into PATROL which will be in use until the introduction of the LBS as a part of the Total Network Data System (TNDS).

5.05 The Program for Administrative Traffic Reports On Line (PATROL) load balance program as an interim mechanization of the load balance index plan is an independent, stand-alone subsystem. The program computes the LB office index, summarizes the load data by concentrator and line link network, and provides a guide for the assignment or removal of lines. The program maintains up to seven weeks of data and balance study files created from the W-schedule.

5.06 The user is responsible for providing specific information to the program in order for the necessary calculations to be made. This parameter information includes:

(a) Line-to-junctor ratio

(b) Concentrator range (lowest numbered to highest)

(c) Average office holding time

(d) Service observing end-of-month date

(e) Number of data hours

(f) Average office CCS (ACCS) or light office CCS (LCCS)

5.07 Once the parameter information and the W-block have been inputted into the mechanized program, five basic user reports are available.

(a) ***Data Summary Report:*** Provides a summary by concentrator and LLN of the latest week's (CCS) load, percentage of capacity, CCS corrective action, and weekly scores for the past ***seven*** weeks. This report is only generated in an off-line batch mode and should be requested monthly to determine the effectiveness of loading techniques.

(b) ***Study Data Report:*** Provides by loading division the usage and the score of each concentrator for the study period requested. This may be necessary when there is a data validation question. This report is available in an off-line or on-line mode.

(c) ***Assignment/Transfer Guide Report:*** Develops a line assignment guide to be used for line-assigning purposes. The output is discussed in further detail in 5.10 through 5.54 of this section. A removal guide is developed also to identify potential line transfers from overloaded concentrators. Reports may be generated on-line or in an off-line batch mode. For line assignment purposes, this report should be requested at least monthly and supplemented with reports as required. A data study must be entered prior to requesting each report.

(d) ***Load Balance Index Report:*** This report combines the most current load balance data input (W-schedule) with previous index reports saved in memory and calculates the balance and hot spot penalty points for the current service observing month. This report is printed on-line at the user's terminal. In order to meet index requirements, it must be requested once a month after entering a valid data study (W-schedule). The interim system output may be attached to the load balance index report E-6402, with the inclusion of the total main stations as the official report. The LBI report may be requested on an ***unofficial*** basis for administrative purposes.

(e) ***History Summary Report:*** This report is a summary of all the weeks in the history file in order of the oldest week to the most recent week. It is an on-line report which will contain information such as the percentage of valid concentrators, mean concentrator usage, percentage of capacity, average holding time, quality control limit, etc. The report is useful for trending purposes. An optional listing of all the LBIs entered in the history file for the running year is also available.

5.08 Automatic flagging by the system identifies data requiring further investigation. Concentrators exceeding 576 CCS per hour are flagged and excluded from calculations as the data are clearly invalid. Concentrators with zero usage or which meet the "hot spot" criterion are also flagged. These, however, are not excluded from the calculations as the data may be correct. The hot spot criterion is BH CCS capacity times 1.5 times the number of hours in the usage study.

5.09 Detailed information on the interim load balance program can be obtained from the PATROL lessons or through the operating telephone company PATROL coordinator. The LBS information will be available in Dial Facilities Management Practices Division D, Section 1e, Load Balance System.

CORRECTIVE ACTION

5.10 ***Corrective action*** is to be taken when there are adverse service indications or the load measurements point to areas where there are high probabilities of blockage, hence a possible source of customer dissatisfaction.

5.11 The proper corrective action must be established in a specific sequence to be most meaningful.

(a) Review all load balance data. This will indicate load units that are working at exceptionally heavy or light loads.

(b) Review raw data on the load units highlighted in (a). This may prove to be the most valuable step. Errors at this stage will, of course, cause unnecessary or incorrect action.

Note: Links made busy should be investigated when verifying data. This may be done by requesting network maintenance for a FAB-STATUS ALL printout during a corresponding SBH.

(c) Assuming that the data are valid, review the required CCS corrective action.

(d) If time and service conditions permit, achieve balance by ***directed assignments.***

(e) If ***line equipment transfers*** (LETs) are required, several indicators should be analyzed to determine the proper lines to move.

5.12 ***Directed Line Assignments:*** The most economical method for achieving and maintaining a good load balance is through routine line assignment procedures (directed line assignments). A network administrator simply assigns new connects to lightly loaded load units and allows disconnects to accumulate in heavily loaded units. This will be discussed in detail beginning with 5.24.

5.13 ***Outward Movement:*** Disconnected lines are another source for maintaining balance among concentrators. When lines are disconnected in heavily loaded units they serve to equalize the carried CCS among groups. On the other hand, disconnects in lightly loaded concentrators serve to heighten the imbalance. This is discussed in 5.34.

5.14 ***Line Equipment Transfers:*** LETs can accomplish the same result as directed line assignments. As a matter of fact, this corrective action produces quicker results. However, LETs are expensive to implement and therefore should be the last-choice method of corrective action.

5.15 ***CCS Corrective Action List:*** Regardless of the method employed to achieve balance, an appropriate CCS corrective action must be calculated in order not to over- or under-correct. The principal guide provided to the administrator for this purpose is called the CCS corrective action list. It is used for determining where to direct assignments and for calculating the number of assignments to be made. This listing is the output of most load balance procedures (both manual and mechanized) and specifies an estimate of the amount of CCS that each load unit is generating above or below the average for the loading division.

5.16 The following paragraphs will advance methods for developing CCS corrective values in load units for manual and mechanized systems and provide two approaches to the development of a CCS corrective action list.

5.17 In viewing some of the difficulties inherent in previous procedures for developing CCS corrective values, it is clear that any new method for computing remedial action should have the following features.

(a) It should be based on empirical CCS measurements rather than scores. Differences in loads among groups with the same scores could then be detected.

(b) It should be sensitive to usage trends to avoid future overloads.

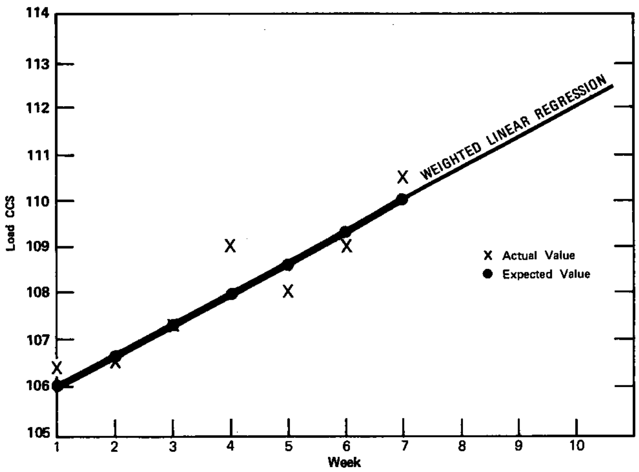
(c) It should apply more weight to recent measurements since they are more representative of the actual load situation.

(d) Finally, it should correct the usage in load units to the average for the loading division to avoid wasteful over-correction.

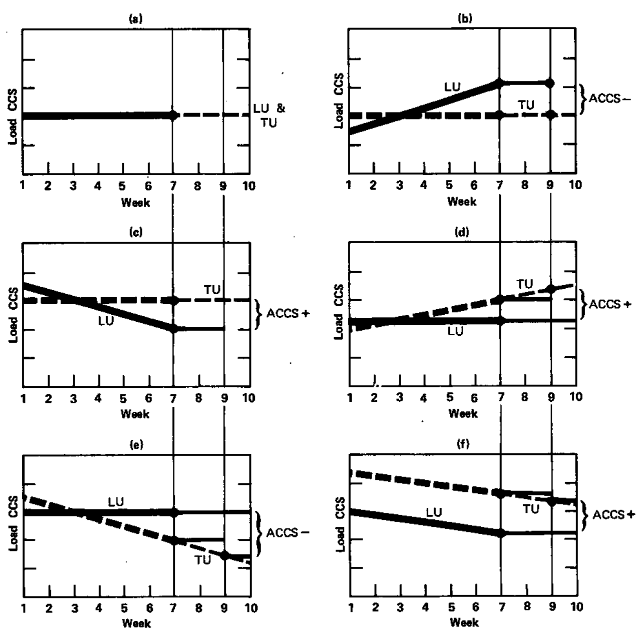
5.18 ***Mechanized Procedure:*** The mechanized data processing procedure developed for the new load balance index plan incorporates all four of the desirable features outlined in 5.17.

5.19 Basically, the mechanized procedure takes historical load unit information and utilizes a weighted linear regression to estimate ***expected*** loads on these units (see graph below). It can be seen that weekly loads do not all fall on the "best fit" line. The points on the line corresponding to each week are the expected values. Each week is numbered from the oldest (week one) to the newest (week seven).

> ***Note:*** The process is shown for a period of seven weeks. However, this number could differ according to the amount of historical data being saved.



5.20 A similar approach is taken for the average load unit load in the traffic unit. Individual load units are then compared to this traffic unit line to determine the CCS amount to be added or removed (see graphs [a] through [f] which follow).



5.21 CCS corrections are applied to the load units depicted on the graphs in this manner.

(a) None. The load unit and traffic unit average track exactly.

(b) Subtract CCS. The load unit load is increasing and the traffic unit load is constant. The CCS difference for the latest week indicates a need for removal of load. Assuming that action will be taken during week nine, this difference during week seven should be removed. This amount is taken at week seven levels because the load unit line is not as stable as the traffic unit line and should not be extrapolated.

(c) Add CCS. The load unit load is decreasing and the traffic unit load is constant. The CCS difference for the latest week indicates a need for additional load. Assuming that action will be taken during week nine, this difference during week seven should be added.

(d) Add CCS. The traffic unit load is increasing and the load unit load is constant. The CCS difference for the latest week indicates a need for additional load. If action is taken during week nine and the difference during week seven is added, there will be a slight under-correction. Therefore, an additional amount must be loaded into this unit.

(e) Subtract CCS. The traffic unit load is decreasing and the load unit load is constant. The CCS difference for the latest week indicates a need for less load. If action is taken during week nine and the difference for week seven is subtracted there will be a slight under-correction. Therefore, an additional amount must be removed from this unit.

(f) Add CCS. Both the load unit and traffic unit loads are decreasing at approximately the same rate. The CCS difference for the latest week indicates a need for additional load. If action is taken during week nine and the difference during week seven is added there will be a slight overcorrection. Therefore, a smaller amount must be loaded into this unit.

5.22 Corrective CCS values developed from the foregoing information cannot be considered exact because of the variable factors involved. Any overestimation in the amount of CCS correction could result in more line moves than necessary to attain balance; compensation for these additional moves may be required at a later date. Consequently, the computer will scale down all values derived in this manner.

5.23 Any method for scaling the CCS correction to be applied to load units would be fairly arbitrary. The procedure, recommended by AT&T and included in the mechanized system, scales the values by a factor based on the variance of the estimated CCS to be added or subtracted. Study results indicate that this procedure produces better load balance than the method used in the previous plan.

5.24 ***Line Assignment Guide:*** The CCS corrective action list, for purposes of this section, will be referred to as the line assignment guide as it provides information to implement a directed line assignment policy.

5.25 Typically, corrective action lists are provided to the network administrator in an ordered fashion with the units that are most below average presented first. See example which follows.

ESTIMATED CCS/MAIN STATIONS = 4

LLN	F	BAY	CONC	CCS TO ADD	LINES TO ADD
00	1	0	5	70	17
10	2	1	0	60	15
07	3	1	3	54	13
03	0	0	2	54	13
06	3	1	6	53	13
08	2	0	7	50	13
03	1	1	2	46	11
08	0	1	1	40	10

5.26 This list is not as useful as it might first appear. The network administrator must still determine the order in which these lines should be assigned, what to do if sufficient spare line equipments are not available in each concentrator, and how to use disconnect information.

5.27 This section will detail two alternative mechanized procedures which provide the network administrator with some guidance in answering these questions. Moreover, these procedures are features of the new load balance system.

5.28 The first procedure presumes that an office is predominantly one broad class of service with one value of CCS/MS such as residence. This approach should only be taken when any of the following are true:

(a) The deviations from the average CCS per main station (CCS/MS) are minimal.

(b) Subscriber line usage (SLU) studies and approximations of CCS/MS for each class of service are unavailable.

(c) There is a need to reduce the length of the line assignment guide (some expertise is required if this procedure is adopted).

5.29 The second procedure should be used when more detail is required, especially when capacity is being approached. It provides a line assignment guide by distinguishing between main stations of three load characteristics: light, medium, and heavy.

5.30 ***Alternative Procedure No. 1:*** The average CCS (ACCS) per main station is estimated by dividing the actual load (CCS) by the number of main stations being handled within the loading division(s). For example:

$$\text{Average CCS/MS} = \frac{\text{32,000 Office CCS}}{\text{8,000 Working MS}} = 4.0$$

> ***Note:*** The working MS count must include trunks such as PBX "dial 9" trunks which have an appearance on the LLN.

5.31 The line assignment guide is then constructed for Procedure No. 1 as illustrated in Figure 7. A list generated in this fashion provides a ***desired order*** of assignments into load units. This is achieved in the computer program by:

(a) Selecting a load unit which needs the largest CCS addition for the next assignment

(b) Subtracting the ACCS/MS from the CCS correction of the unit just selected

(c) Going back to (a).

5.32 The network administrator must determine the number of lines required to satisfy the assignment demand. A guide is then requested and prepared to fulfill that demand. The spare line equipments selected may be recorded in the appropriate columns of the guide as they are being entered on the assignment lists. "NA" is noted when spare equipment is not available. The remaining columns are provided for administrative purposes such as listing the class of service, noting the assignment list number or entering remarks.

5.33 Knowledge of the disconnect activity within a traffic unit is as important as knowledge of inward movement. The disconnect activity may counteract the efforts to bring load units closer to the average or it may satisfy a need for spare equipment. The guide may also be used to account for disconnect activity and its subsequent impact on CCS. This involves keeping track of the number of disconnects within designated concentrators and incorporating the information into the guide. For example:

(a) With the understanding that every disconnect negates an assignment, a flagging system may be devised to identify in the line records those concentrators with a consistent low-usage trend. As disconnects occur within these concentrators, they should be noted on the guide and entered on an assignment list, or

(b) Shortages of spare equipment (NAs) begin to appear when the traffic unit is working at a high-percentage fill. When an NA is noted on the guide, an indication should also be made in the line records in order to take advantage of the disconnect activity. The presence of an NA means that there is still a requirement for additional CCS.

5.34 ***Alternative Procedure No. 2:*** In Procedure No. 1, each customer is assumed to generate approximately the same usage. Usually, this is not the case. Offices that include several broad classes of service, or possess a few distinct classes of service, may not find it effective to load by average office CCS. In this case, the preferred method is Procedure No. 2 which distinguishes between main stations with different load characteristics.

5.35 There are several ways to establish a CCS/MS by class of service. Two ways that are used are:

- Subscriber line usage studies
- Utilization of CCS/MS data from offices with similar characteristics.

5.36 First, establish a CCS per main station for each class of service. Select major classes within the loading division and place them in ranges, such as light (LCCS), medium (MCCS), and heavy (HCCS). Medium and heavy usage customers are assumed to have two and three times the LCCS, respectively.

5.37 The line assignment guide is constructed in the same manner as for Procedure No. 1, only in this case, using the LCCS per line. This is achieved in the computer program by:

(a) Selecting a load unit which needs the largest CCS addition for the next assignment.

(b) Subtracting LCCS from the CCS correction of the unit just selected.

(c) Going back to (a).

5.38 An example of an assignment list established according to Procedure No. 2 is shown in Figure 8. The guide is prepared according to the type of user being assigned. For example, if the network administrator assigns a light user in a load unit, an L is placed adjacent to the load unit's appearance on the list and the remaining columns are filled in as described in 5.32. If a medium user is assigned, a line should be drawn through the assigned column adjacent to the ***first*** appearance of the load unit. An M and the appropriate information are placed adjacent to the ***second*** appearance of that load unit. A heavy user is designated by drawing a line through the first ***two*** appearances of the load unit and all required information is placed opposite the ***third*** appearance on the guide. The disconnect activity should be acknowledged as outlined in 5.33.

5.39 An option is available to generate an assignment guide by zone with both Procedure 1 and Procedure 2. When a zoned assignment guide is requested, the concentrators within each zone will be listed in order of the least loaded. The percentage of capacity column becomes a useful tool in the decision-making process when a choice must be made between loading and preferential assignments. It should be noted that with the first appearance of each concentrator the percentage of capacity will reflect the percentage of capacity at which the concentrator is working, based upon the projected study data. In subsequent listings of the same concentrator, the percentage of capacity will increase to reflect the additional CCS/MS. An additional column designated "MDF Location" is included to permit a further breakdown of the concentrator location such as vertical number in a conventional frame or shelf number in a COSMIC frame.

5.40 ***Manual Procedure:*** In manual data processing environments it is uneconomical to expend clerical time to achieve all four of the features mentioned in 5.17. The approach shown in the following paragraphs is recommended as a compromise for manual offices.

5.41 For clerical ease, the proposed plan uses weekly scores in a manner similar to present balancing procedures, rather than actual CCS values (as used in the mechanized plan). The plan weighs recent data more heavily than older data and attempts to correct group loads to average usage without over correcting.

5.42 This procedure is based upon computing an estimate of the average weekly score for each load unit determining a factor and calculating the CCS correction as follows:

$$\text{Corrective CCS} = \frac{\text{QCL x Average CCS x F}}{3}$$

QCL = Quality control limit of the loading division

Avg. CCS = Average load unit load within the loading division for the latest study divided by the number of hours

F = Factor derived from the scores and study intervals

3 = Fixed factor.

5.43 Form E-6617 (Fig. 9) is provided for use in the determination of CCS corrective values on a manual basis for each load unit. It may be useful to reference Figure 9 while following the steps outlined in 5.44.

5.44 QCL and average CCS values are known for each study and they remain constant for an entire loading division. The product of their multiplication will also be a constant which can be multiplied by each factor F for individual load units. F remains the only unknown and is determined as follows.

First Study

Step 1: Develop the corrective CCS values for each of the factor F possibilities shown below (negative scores produce CCS to be added and positive scores produce CCS to be subtracted). Place results at the top of the first section on Form E-6617.

$$\text{Corrective CCS} = \frac{\text{QCL x Average CCS x F}}{3}$$

SCORE	FACTOR (F)
±4	3.0
±2	1.0
±1	.5
0	0

Step 2: ***First study*** scores for each load unit are listed on the first section in the column labeled SC.

Step 3: Knowledge of each score will allow F factors to be selected from the table in Step 1.

Step 4: The appropriate CCS corrective values are taken from the top of the first section and entered for each load unit.

Second Study

Step 5: Factor W is selected from the table which follows using the first (previous) study score. This factor is a weighted estimate of past scores for each collection interval. It is placed in column W for each load unit in the second study.

FACTOR (W)				
FREQUENCY				
Score	Weekly	Biweekly	Triweekly	Monthly*
±4	3.2	2.6	2.0	1.6
±2	1.6	1.3	1.0	.8
±1	.8	.6	.5	.4
0	0	0	0	0

* Includes four week intervals

Step 6: Add the W factors to each load unit score.

$$W + SC = WSC$$

Step 7: New F factors for this study and ***W factors for the next study*** are found in Figure 10 for each WSC value, depending upon the collection interval being used.

Step 8: Only seven F factors are possible for the second and subsequent weeks: 0, 0.5, 1.0, 2.0, 3.0, 4.0, 5.0, and 6.0. Develop CCS corrective values for each of these factors with the formula below and place at top of the appropriate column of Form E-6617.

$$\text{Corrective CCS} = \frac{\text{QCL x Average CCS x F}}{3}$$

Step 9: The appropriate corrective CCS values are then selected from this listing for the corresponding F factor for each load unit.

Subsequent Studies

Step 10: Scores for each load unit are listed in the column labeled SC.

Step 11: The scores listed in Step 10 are added to the W factors found in Step 7.

$$W + SC = WSC$$

Step 12: Same as Step 7.

Step 13: Same as Step 8.

Step 14: Same as Step 9.

5.45 Once corrective CCS values are established for each load unit during a study week, a line assignment guide can be constructed in one of the two alternative methods shown in the mechanized procedure. If they prove to be too difficult or time consuming to develop, a third alternative is proposed. This procedure is simply to establish a list similar to the one shown in 5.25. Extreme care must be taken, however, when it is utilized.

5.46 If a score is unavailable for a group in a measurement period, it is suggested that the last weekly score be used in the calculation. When measurements are unavailable for more than one month, it is suggested that the latest study be considered as week one and that the process be started anew.

5.47 ***Line Transfer Guide:*** Linè transfer guides are constructed in a manner similar to the line assignment guides and are used primarily for decisions regarding line equipment transfer activities. However, the listing starts with the most heavily loaded unit rather than the lightest loaded one. The guide is developed using an ACCS or an LCCS, depending upon the degree of detail required for administrative purposes (see Fig. 11).

5.48 Proceeding in order of removal, the network administrator would list the line equipment number beside each load unit under the ***Selected*** column. This listing includes the switch (SW), level (Lev) and class of service (CS). Disconnects would be accounted for before choosing lines to be transferred in order to avoid any overcorrection as discussed in 5.33.

5.49 ***Other Imbalance Indicators:*** Usage is only one indicator of imbalance. There are other tools available to assist in the analysis of load balance. These tools include:

(a) Register readings

(b) Service results

(c) Customer reports.

When all of the tools are combined, they allow the best available look at office performance and load conditions. The approach and technique of problem analysis and corrective action have been documented in Dial Facilities Management Practices Division H, Section 6l, Problem Analysis. The intent of this section is to specify what should be observed in order to anticipate potential problems or solve existing ones. It is not intended to document how to research and identify given problem areas.

5.50 ***Register Readings:*** There are several registers that reflect the traffic flow through the office and provide input for identifying network blockage. The traffic graphic diagrams of the problem analysis practice illustrate the various peg count and overflow register relationships as a call progresses through an office. The following are some general office measurements which serve as initial indicators of network or junctor blockage.

COUNT	DESCRIPTION
LLN incoming call overflow	Scores on incoming calls that fail to find a talking path from the incoming trunk to the LLN on which the called line is terminated.
TLN incoming call overflow	Scores on incoming calls for which the system failed to find and reserve a path from the TLN serving the incoming trunk to the called line equipment.
Outgoing calls overflow	Scores on all office-originated outgoing calls that fail to obtain an L-T connection.
Intraoffice calls	Scores on originated calls to stations within the control group that fail due to network blockage. See the Translation Guide, TG1A, Division 3, Section 4a, Traffic Register Assignment Record, and Division 12, Section 4a, Traffic Register Measurement Codes.

These measurements are not specific enough to pinpoint a problem but if service measurements indicate that blockage is occurring, then a starting point for further investigation has been defined.

5.51 Measurements are also available for studying specific customer lines or concentrators to identify heavy users or concentrators that require directed corrective action. These measurements include the following.

(a) Selected customer line usage: measures CCS usage on individual customer lines (1 to 128)

(b) Selected concentrator usage: measures the CCS usage on individual lines within a concentrator (one to eight concentrators)

(c) Subscriber line busy: a count of the number of times a specified line is found busy on a terminating call (use general-purpose registers)

(d) Multiline hunt groups: three counts are available to measure attempts, usage, and overflow.

How these measurements are obtained may be found in Translation Guide, TG1A, Division 3, Section 4, ESS 1400 Series Measurements.

5.52 ***Service Results:*** There are also specific data that are used for service indexes and as service indicators. The expected service levels are dependent upon the percentage of engineered capacity and are compared to the actual results. Deviation from the expected may be an indication of an imbalance condition. The counts to be monitored daily during all load periods are:

- Dial tone delay: dial pulse and TOUCH-TONE® for greater than 3 seconds as well as an office delay of greater than 11 seconds
- Incoming matching loss (IML)
- Intraoffice matching loss (IAML)
- Originating matching loss (OML)
- Tandem matching loss (TML)
- Incoming first failure to match (IFFM)
- Blocked dial tone delay (BDT)

- Blocked dial tone queue

Descriptions of these measurements are in Translation Guide, TG1A, Division 12, Section 4, Measurement Codes, and the analyzation method is outlined in Dial Facilities Management Practices, Division H, Section 6l, Problem Analysis.

5.53 ***Customer Reports:*** Customer reports are received several ways. One way is through a direct report to either the repair center or to a switchboard/Traffic Service Position System (TSPS) operator. Another way is through written reports to a State Utility Commission. Reports should be analyzed for patterns which identify trouble areas.

5.54 All customer reports are useful in varying degrees. For determining imbalance indicators, the network administrator will generally find the repair center reports the most useful. The customer trouble report analysis plan (CTRAP) provides detailed and summary reports for analyzing trouble. Such reports are adaptable for patterning imbalance indications. One such report is the no-dial-tone no-trouble-found (NDT-NTF) portion of CTRAP. This report lists by line equipment number and time of occurrence the NDT-NTF reports which can be grouped by concentrator(s). If the occurrence happens during the busy hour, concentrator balance data are available. If the occurrence happens in a nonbusy hour period, it may indicate off-hour blocking.

5.55 Another printout available in CTRAP specifies by line equipment the number of repeated reports by that line and by type of report; ie, no dial tone - no trouble found. This is useful for patterning frequency of occurrences by type of report.

5.56 ***Ordering Forms:*** "E" forms (code A) used in this section may be ordered from a local Western Electric service center. Forms E-6615, E-6616, E-6617, E-6663, and E-6664 may be ordered in multiples of 50 per pad, 2 pads per package (the unit contains 100 forms). Full-size copies of these forms are attached to the back of this section and can be reproduced locally for interim use.

6. THE LOAD BALANCE INDEX

6.01 The new load balance index replaces the current load balance index and overall balance index (OBI) with a single integrated index called the load balance index. This new index applies to load units in all office types capable of terminatng customer lines; eg, Step-by-Step, No. 1 Crossbar, No. 5 Crossbar, No. 1 ESS, and No. 2 ESS. Any office capable of supplying load unit usage data on at least a monthly basis will be indexed regardless of whether usage data processing and line assignments are performed manually or automatically.

6.02 Quality control limits for scoring take into account the office type, usage capacity, actual usage, and holding time. The new LBI is based on balance of an office with respect to average load, the percentage of capacity represented by actual usage, and the presence of load unit loads in excess of preset thresholds above capacity.

6.03 The new LBI is designed to be a true performance index with an objective of 96 through 98 performance for all offices and a weakspot level at 90 and below. The makeup of the new index will permit meaningful comparisons between all offices and groups of offices. The new LBI is intended to be treated as an official reported result and to be published in the AT&T performance results report. Customer service performance of an office will continue to be measured by the existing dial line index.

6.04 The new plan controls the usability of usage data for indexing purposes. The present plan allows for varying amounts of data to be used for indexing purposes and provides for factoring when the required studies are not available. In addition, indexes are carried over when no new studies are subsequently available. A study may consist of 5, 10, or 15 hours with a QCL adjustment based on the number of hours. The new plan indexes an office on the basis of a requirement for one usable 10-hour study per month and is reported as ***not available*** for any month in which a valid study is not obtained. The objective of this plan is to enforce uniformity of indexing by requiring comparable data from all offices.

6.05 The new plan continues to employ the ***score method*** to determine imbalances. As shown in Part 2, Principles of Load Balance, individual study score calculations are identical to the previous plan with the exception that new quality control limits, which are a function of load and holding time, are employed. However, there are significant differences in how the scores are combined into an index.

6.06 The present plan employs individual scores of ±1, ±2, and ±4 to realize a cumulative score (the algebraic sum of the individual scores on a group for the preceding five valid studies, if available; otherwise, standard factors are applied to lesser numbers of valid studies). The percentage of cumulative scores equal to or exceeding a value of ±9 is entered into a table to determine the present LBI. The OBI is then ascertained from a table by entering LBI and service criteria (either IML or dial tone speed depending on office type). The new plan provides ***penalty points*** for all groups with scores of +4 only. Three penalty points apply for each +4 score in the current month's study, two penalty points apply for a +4 score in the preceding month, and one penalty point for each group scoring +4 in the previous preceding month. The cumulative penalty points for the current and two previous valid studies as a fraction of the total load units are entered along with the weighted percentage of engineered capacity into the new LBI table. If hot spots are present, a negative correction is made to the LBI from the ***hot spot*** table based on the fraction of groups exceeding the preset threshold above capacity. Thus the new plan is more responsive to imbalance when it occurs and is also more responsive when the imbalance is corrected.

6.07 Outstanding features of the new plan include the following:

(a) Improved quality control limits based on actual load and holding time

(b) Elimination of nonadjacent busy hours for study use

(c) Correction of +4 groups only means to improve index; overcorrection does not improve index

(d) Equipment additions indexed as a separate loading division for up to six months after addition completion

(e) Elimination of index suspension because of line transfers

(f) Equipment operating below 30 percent of engineered capacity is not indexed

(g) Highlight of groups exceeding heavy load thresholds (hot spots).

(MARCH 1975)

LOAD BALANCE QUALITY CONTROL LIMITS
BASED ON 10 HOUR DATA

NO. 1 ESS (2:1 & 4:1 CONCS.)

AVERAGE HOLDING TIME (SECS)	ACTUAL AVERAGE LOAD PERCENTAGE OF ENGINEERING LOAD																			
	30% TO 35%					36% TO 45%					46% TO 55%					56% TO 65%				
	LINE JUNCTOR RATIO					LINE JUNCTOR RATIO					LINE JUNCTOR RATIO					LINE JUNCTOR RATIO				
	2:1 & 4:1 (L)	2.5:1 & 5:1	3:1 & 6:1	3.5:1 & 7:1	(H) 4:1 & 8:1	2:1 & 4:1 (L)	2.5:1 & 5:1	3:1 & 6:1	3.5:1 & 7:1	(H) 4:1 & 8:1	2:1 & 4:1 (L)	2.5:1 & 5:1	3:1 & 6:1	3.5:1 & 7:1	(H) 4:1 & 8:1	2:1 & 4:1 (L)	2.5:1 & 5:1	3:1 & 6:1	3.5:1 & 7:1	(H) 4:1 & 8:1
0 – 70	19	21	23	25	26	17	19	20	21	23	15	17	18	19	20	14	15	16	17	18
71 – 90	22	25	27	28	30	19	21	23	25	26	17	19	21	22	23	16	17	19	20	21
91 – 110	25	28	30	32	33	22	24	26	28	29	19	21	23	25	26	18	20	21	23	24
111 – 130	27	30	33	35	37	24	26	28	30	32	21	23	25	27	28	19	21	23	25	26
131 – 150	29	33	35	38	40	26	28	31	33	34	23	25	27	29	31	21	23	25	27	28
151 – 170	31	35	38	40	42	27	30	33	35	37	24	27	29	31	33	22	25	27	29	30
171 – 190	33	37	40	43	45	29	32	35	37	39	26	29	31	33	35	24	26	28	30	32
191 – 210	35	39	42	45	47	31	34	36	39	41	27	30	33	35	37	25	28	30	32	34
211 – 230	37	41	44	47	50	32	35	38	41	43	29	32	34	37	38	26	29	31	33	35
231 – 250	39	43	46	49	52	33	37	40	43	45	30	33	36	38	40	27	30	33	35	37
251 – 270	40	44	48	51	54	35	38	42	44	47	31	34	37	40	42	28	31	34	36	38
271 – 290	42	46	50	53	56	36	40	43	46	48	32	36	39	41	43	30	33	35	38	40
291 – 310	43	48	51	55	58	37	41	45	48	50	33	37	40	43	45	31	34	37	39	41
311 – 330	45	49	53	57	60	39	43	46	49	52	35	38	41	44	46	32	35	38	40	42
331 – 350	46	51	55	58	62	40	44	48	51	53	36	39	43	45	48	33	36	39	42	44
351 – 370	47	52	56	60	63	41	45	49	52	55	37	40	44	47	49	34	37	40	43	45
371 – 390	48	54	58	62	65	42	46	50	53	56	38	42	45	48	51	34	38	41	44	46
391 – 410	50	55	59	63	67	43	48	52	55	58	39	43	46	49	52	35	39	42	45	47
411 – 430	51	56	61	65	68	44	49	53	56	59	40	44	47	50	53	36	40	43	46	49
431 – 450	52	58	62	67	70	45	50	54	58	61	41	45	48	52	54	37	41	44	47	50
451 – 470	53	59	64	68	72	46	51	55	59	62	41	46	50	53	56	38	42	45	48	51
471 – 490	54	60	65	69	73	47	52	56	60	63	42	47	51	54	57	39	43	46	49	52

Fig. 1—Load Balance Quality Control Limits Based on 10-Hour Data (Sheet 1 of 2) (2.32, 2.37, 2.38, 3.42)

(MARCH 1975)

LOAD BALANCE QUALITY CONTROL LIMITS
BASED ON 10 HOUR DATA

NO. 1 ESS (2:1 & 4:1 CONCS.)

ACTUAL AVERAGE LOAD PERCENTAGE OF ENGINEERING LOAD — LINE JUNCTOR RATIO

AVERAGE HOLDING TIME (SECS)	66% TO 75% 2:1 & 4:1(L)	66% TO 75% 2.5:1 & 5:1	66% TO 75% 3:1 & 6:1	66% TO 75% 3.5:1 & 7:1	66% TO 75% (H) 4:1 & 8:1	76% TO 85% 2:1 & 4:1 (L)	76% TO 85% 2.5:1 & 5:1	76% TO 85% 3:1 & 6:1	76% TO 85% 3.5:1 & 7:1	76% TO 85% (H) 4:1 & 8:1	86% TO 95% 2:1 & 4:1 (L)	86% TO 95% 2.5:1 & 5:1	86% TO 95% 3:1 & 6:1	86% TO 95% 3.5:1 & 7:1	86% TO 95% (H) 4:1 & 8:1	96% AND UP 2:1 & 4:1 (L)	96% AND UP 2.5:1 & 5:1	96% AND UP 3:1 & 6:1	96% AND UP 3.5:1 & 7:1	96% AND UP (H) 4:1 & 8:1
0 – 70	13	14	15	16	17	12	13	14	15	16	11	12	13	14	15	11	12	13	14	14
71 – 90	15	16	18	19	20	14	15	16	17	18	13	14	15	17	17	12	14	15	16	16
91 – 110	16	18	20	21	22	15	17	18	20	21	14	16	17	18	19	14	15	16	17	18
111 – 130	18	20	21	23	24	17	19	20	21	23	16	17	19	20	21	15	17	18	19	20
131 – 150	19	21	23	25	26	18	20	22	23	24	17	19	20	22	23	16	18	19	21	22
151 – 170	21	23	25	26	28	19	21	23	25	26	18	20	22	23	25	17	19	21	22	23
171 – 190	22	24	26	28	29	21	23	25	26	28	19	21	23	25	26	18	20	22	23	25
191 – 210	23	26	28	30	31	22	24	26	28	29	20	23	24	26	27	19	21	23	25	26
211 – 230	24	27	29	31	33	23	25	27	29	30	21	24	26	27	29	20	22	24	26	27
231 – 250	25	28	30	32	34	24	26	28	30	32	22	25	27	29	30	21	23	25	27	28
251 – 270	26	29	32	34	35	25	27	29	31	33	23	26	28	30	31	22	24	26	28	30
271 – 290	27	30	33	35	37	26	28	31	33	34	24	27	29	31	32	23	25	27	29	31
291 – 310	28	31	34	36	38	27	29	32	34	36	25	28	30	32	34	24	26	28	30	32
311 – 330	29	32	35	37	39	27	30	33	35	37	26	29	31	33	35	25	27	29	31	33
331 – 350	30	33	36	38	40	28	31	34	36	38	27	29	32	34	36	25	28	30	32	34
351 – 370	31	34	37	40	42	29	32	35	37	39	27	30	33	35	37	26	29	31	33	35
371 – 390	32	35	38	41	43	30	33	36	38	40	28	31	34	36	38	27	29	32	34	36
391 – 410	33	36	39	42	44	31	34	37	39	41	29	32	34	37	39	27	30	33	35	37
411 – 430	34	37	40	43	45	31	35	37	40	42	30	33	35	38	40	28	31	34	36	38
431 – 450	34	38	41	44	46	32	35	38	41	43	30	33	36	39	41	29	32	34	37	39
451 – 470	35	39	42	45	47	33	36	39	42	44	31	34	37	39	42	29	32	35	37	39
471 – 490	36	40	43	46	48	34	37	40	43	45	32	35	38	40	42	30	33	36	38	40

Fig. 1—Load Balance Quality Control Limits Based on 10-Hour Data (Sheet 2 of 2) (2.32, 2.37, 2.38, 3.42)

LINE LINK NETWORK LOAD CARRYING CAPACITIES

	LINE JUNCTOR RATIO	LINE TERMINALS PER LLN	CCS PER LLN	LSFS PER LLN	CCS PER LSF	CONC. PER LSF	CCS PER CONC. *
2:1 CONCENTRATION (HEAVY)	2:1	2,048	15,220	4	3,800	16	238
	2.5:1	2,560	15,600	5	3,120	16	195
	3:1	3,072	15,960	6	2,660	16	166
	3.5:1	3,584	16,380	7	2,340	16	146
	4:1	4,096	16,800	8	2,100	16	131
4:1 CONCENTRATION (LIGHT)	4:1	4,096	14,720	4	3,680	16	230
	5:1	5,120	15,100	5	3,020	16	189
	6:1	6,144	15,480	6	2,580	16	161
	7:1	7,168	15,820	7	2,260	16	141
	8:1	8,192	16,320	8	2,040	16	127

*MAXIMUM CCS PER HOUR

Fig. 2—Line Link Network Load-Carrying Capacities (2.34)

INSTRUCTIONS FOR PREPARING FORM E-6663

TRUNK LOAD UNIT SUMMARY

Building:	Identify the building location.
Traffic Unit:	Identify the traffic unit; eg, 241-CGO.
LU Installed:	Enter the number of trunk load units installed in the traffic unit.
LU CCS Capacity:	Enter the engineered capacity in CCS for a load unit in the traffic unit.
Study Date:	Enter the beginning and ending date of each study; eg, 5-18-75 through 5-24-75.
LU Meas:	Enter the number of trunk load units with valid data for the study.
Total CCS:	Enter the total trunk usage read on the study. This should include usage only from trunk load units with valid data.
Avg. CCS:	Divide the average CCS (Avg. CCS) by the number of LUs measured. The result will be the average session load per load unit.
% of Capacity:	Divide average CCS by the number of study hours and by the LU CCS capacity. Then multiply by 100.
% IML:	Enter the percentage of incoming matching loss for the study week.
Avg x .85:	Multiply the average CCS by 85 percent.
Avg x 115:	Multiply the average CCS by 115 percent.
# of LUs:	Enter the number of trunk load units over 115 percent. This is obtained by adding up the number of "choice 4" units on the Trunk Load Unit Analysis Form (E-6664).
% of LUs:	Divide the number of LUs (over 115 percent of average) by the LUs Meas. and multiply by 100.

TRUNK LOAD UNIT SUMMARY — Form E-6663 (7-75)

Building: Bell	Traffic Unit: 241-CGO	Page of
LU Installed: 80	LU CCS Capacity: 765 (BH) 7650 (10-hr session)	

STUDY DATE	5/18-5/24/75					
LU MEAS	80					
TOTAL CCS	550,800					
AVG CCS	6885					
% OF CAPACITY	90					
% IML	1.5					
AVG X .85	5852					
AVG X 1.15	7918					
LOADS OVER 115% OF AVERAGE						
# OF LU	15					
% OF LU	19%					

STUDY DATE						
LU MEAS						
TOTAL CCS						
AVG CCS						
% OF CAPACITY						
% IML						
AVG X .85						
AVG X 1.15						
LOADS OVER 115% OF AVERAGE						
# OF LU						
% OF LU						

Fig. 3—Trunk Load Unit Summary Form E-6663 and Instructions for Preparation (3.59)

INSTRUCTIONS FOR PREPARING FORM E-6664

TRUNK LOAD UNIT ANALYSIS

Building: Identify the building location.

Traffic Unit: Identify the traffic unit; eg, 241-CGO.

Page of : Number each page consecutively beginning with 1 and show total pages to list all trunk load units.

LUs Installed: Enter the number of trunk load units installed in the traffic unit.

Study: Enter the study date using the beginning and ending date; eg, 5-18-75 through 5-24-75.

LU Ident. #: Identify the trunk load unit abbreviation such as the TLN, frame (FR), and grid (G) in the two blank columns. Under the appropriate column heading will be the sequential listing of the LU identification numbers.

CCS: Enter the study week's CCS value for the specified load unit.

Choice: Choices 1, 2, 3, 4 correspond to the orders of preference for assigning trunks.

CHOICE	TRUNK LOAD UNIT
1	Below 85 percent of average
2	Between 85 and 100 percent of average
3	Between 100 and 115 percent of average
4	Over 115 percent of average

% Cap: The percentage of capacity is only calculated for those trunk load units exceeding 100 percent of capacity. The LU CCS capacity on Form E-6663 multiplied by the number of study hours should be used when scanning the CCS column for LUs over capacity.

The percentage of capacity for these LUs is calculated as follows:

(1) $\frac{\text{CCS (LU)}}{\text{No. of Study Hrs.}} = \text{Average Load for the LU}$

(2) $\frac{\text{Average Load}}{\text{LU CCS Capacity}} \times 100 = \text{\% Capacity}$

TRUNK LOAD UNIT ANALYSIS FORM E-6664 (7-75)

Building: Bell | Traffic Unit: 241-CGO | Page of

LU Installed: 80

LU Ident.		STUDY: 5/18-5/24/75						STUDY:						REMARKS
TLN	F/G	CCS	CHOICE 1	2	3	4	% CAP	CCS	CHOICE 1	2	3	4	% CAP	
00	00	5859		✓										
	01	6400		✓										
	02	5262	✓											
	03	7663			✓									
	10	8244			✓		108							
	11	7804			✓		102							
	12	9151				✓	120							
	13	5629	✓											
	20	5732	✓											
	21	5334	✓											
	22	8317			✓		109							
	23	8044			✓		105							

Fig. 4—Trunk Load Unit Analysis Form E-6664 and Instructions for Preparation (3.59)

INSTRUCTIONS FOR PREPARING FORM E-6615

SCORE CONTROL RECORD

Building: Identify the building location.

Traffic Unit: Identify the traffic unit; eg, 241-CGO.

Page of : Number each page consecutively beginning with 1 and show total pages.

Loading Division: Identify the loading division.

LU's Installed: Enter quantity of load units installed in the loading division.

LU Eng CCS: Enter the engineered capacity in CCS for a load unit in the loading division (all load units must be engineered or designed to operate at the same capacity).

Study Date: Enter the beginning and ending date of each study; eg, 2-9-75 through 2-15-75.

Study No: These numbers may be circled to indicate the studies to be indexed when more than one study a month is made.

Total CCS: Enter the total usage read on the study for the loading division. This should include usage only from load units with valid data.

% Eng. Cap.: Enter the percent the actual load is of the engineered capacity. The method for computing this percentage is outlined in 2.29 through 2.40 of this section.

(1) $\dfrac{\text{Total CCS}}{\text{LUs Meas}} = \text{Average Weekly Load/LU}$

(2) $\dfrac{\text{Average Weekly Load/LU}}{\text{No. of Study Hours}} = \text{Average Load (AL)/LU}$

(3) $\dfrac{\text{Average Load/LU}}{\text{LU Eng CCS}} \times 100 = \text{\% Eng Cap.}$

Avg HT: Enter the average holding time used on the study to select quality control limits. The method is outlined in 2.29 through 2.40 of this section.

% Column

+2: The average CCS will be considered as 100%. Add the quality control limit figure (percentage) found in the tables to 100 and enter here.

+1: Add half the quality control limit figure to 100 and enter here.

0: The average is considered as 100%.

−1: Subtract half the quality control limit figure from 100 and enter here.

−2: Subtract the quality control limit figure from 100 and enter here.

CCS Column

+2: Multiply the figure in "%" column times the average CCS, divide by 100 and round all fractions to the nearest whole number and enter here: eg, 231.6 would be entered as 232, the upper limit for +2 scores.

+1: Multiply the figure in "%" column times the average CCS, divide by 100 and round fractions to the nearest whole number and enter here.

0: Divide the total CCS read on the study by the quantity of load units having valid data on the study. Round off to the nearest whole number and enter here.

−1: Multiply the figure in "%" column times the average CCS, divide by 100 and round fractions to a whole number and enter here; eg, 231.2 would be entered as 231.

−2: Multiply the figure in "%" column times the average CCS, divide by 100 and round fractions to a whole number and enter here.

LOAD BALANCE SCORE CONTROL RECORD — Form E6615 (5-75)

Building: Bell — Traffic Unit: 241-CGO — Page 1 of 1

LOADING DIVISION 01 — LU's INSTALLED 384 — LU ENG. CCS 166

STUDY DATE	2/9-2/15/75													
STUDY NO.	(1)		2		3		4		5		6		7	
TOTAL CCS	375,552													
LU's MEAS.	384													
% ENG. CAP.	59													
AVG. H.T.	174													
	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS
+2	128	1252												
+1	114	1115												
0	AVG.	978	AVG.		AVG.		AVG.		AVG.		AVG.		AVG.	
−1	86	841												
−2	72	704												

LOADING DIVISION ______ LU's INSTALLED ______ LU ENG. CCS ______

STUDY DATE														
STUDY NO.	1		2		3		4		5		6		7	
TOTAL CCS														
LU's MEAS.														
% ENG. CAP.														
AVG. H.T.														
	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS
+2														
+1														
0	AVG.		AVG.		AVG.		AVG.		AVG.		AVG.		AVG.	
−1														
−2														

LOADING DIVISION ______ LU's INSTALLED ______ LU ENG. CCS ______

STUDY DATE														
STUDY NO.	1		2		3		4		5		6		7	
TOTAL CCS														
LU's MEAS.														
% ENG. CAP.														
AVG. H.T.														
	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS
+2														
+1														
0	AVG.		AVG.		AVG.		AVG.		AVG.		AVG.		AVG.	
−1														
−2														

Fig. 5—Load Balance Score Control Record Form E-6615 and Instructions for Preparation (5.02)

INSTRUCTIONS FOR PREPARING FORM E-6616

LOAD UNIT LOAD BALANCE CHART

Building: Identify building location.

Loading Division: Identify the loading division.

Traffic Unit: Identify the traffic unit.

LU's Installed: Enter quantity of load units installed in the loading division.

Page of : Number each page consecutively beginning with 1 and show total pages to list all load units in the loading division.

Study Date: Enter the beginning and ending dates of the study; eg, 2-9-75 through 2-15-75.

Study No.: These numbers may be circled to indicate the studies to be indexed when more than one study a month is made.

LTN-LLN-FR: Enter the line trunk network, line link network, or frame number when required to distinguish among load units.

LG-HG-Conc-Conc Grp: Cross out the three not applicable. Enter the line group, horizontal group, concentrator, or concentrator group identification.

CCS: Enter the total usage for the study period for each load unit (LG, HG, Conc, or Conc Grp) on the study (LG, HG, Conc, or Conc Grp).

S-P-H: These spaces stand for score (S), penalty (P), and hot spot penalty points (H). Detailed information regarding the development of *P* and *H* is found in DFMP Division A, Section 5b, Load Balance Index Plan.

- The *S* space is for entering the study score for the load unit. The +4 scores for indexed studies may be highlighted for ease of counting penalty points.
- The *P* space is for entering the total penalty points for the report month. It is suggested these be entered only when the load unit results are to be reported in the index.
- The *H* space is for entering the total hot spot penalty points for the report month.

LOAD UNIT–LOAD BALANCE CHART

Form E-6616 (5-75)

Building: Bell	Traffic Unit: 241-CGO	Page 4 of 12
Loading Division: 01	LU Installed: 384	

~~LTN~~ LLN ~~FR~~	~~LG~~ ~~HG~~ Conc ~~Conc Grp~~	STUDY DATE / STUDY NO.	2/9-2/15 (1.)	3/2-3/8 2.	3/9-3/15 (3.)	4/13-4/19 (4.)	5.	6.	7.
01	104	CCS	873	958	1042	986			
		S P H	-1 –	-1 –	+1 –	+1 –			
	105	CCS	899	742	780	786			
		S P H	-1 –	-2 –	-2 –	-2 –			
	106	CCS	971	1109	1202	1192			
		S P H	-1 –	+1 –	+2 –	+2 –			
	107	CCS	926	1027	978	1359			
		S P H	-1 –	+1 –	-1 –	+4 3			
	110	CCS	1099	982	867	921			
		S P H	+1 –	+1 –	-1 –	-1 –			
	111	CCS	1292	1263	1288	1315			
		S P H	+4 6	+4 6	+4 6	+4 6			
		CCS							
		S P H							
		CCS							
		S P H							
		CCS							
		S P H							
		CCS							
		S P H							
		CCS							
		S P H							
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		CCS							
		S P H							
		CCS							
		S P H							
		CCS							
		S P H							
		CCS							
		S P H							

S-Study Score

P-Penalty Points

H-Hot Spot Penalty Points

Fig. 6—Load Unit Load Balance Chart Form E-6616 and Instructions for Preparation (5.03)

PROCEDURE 1

ASSIGNMENT PARAMETERS

Conc Capacity (Per Hr): 166 Average CCS/MS: 4.0
Mean Usage (Per Hr): 102 (61.4% Cap.)
$ — Conc In LLN Above OFC Average
& — Conc Data Invalid In Latest Study

ASSIGNMENT	CCS TO	%		ASSIGNED			DISCONNECT		
ORDER	ADD	CAP	CONC NO.	SW	LEV	CS	SW	LEV	CS
1	70	19	05406	6	02				
2			05406	4	00				
3			05406	0	01				
4	60	25	03100	4	03				
5	58	27	05406	NA			4	03	
6	56	28	03100	3	03				
7	54	29	05406	NA			2	01	
8	54	29	01312	7	03				
9	54	29	04311	NA					
10	53	30	02115	7	02				
11	52	30	03100	2	01		6	03	
12	50	31	05406	NA					
13	50	31	01312	5	02				
14	50	31	04311	NA					
15	49	32	02115	6	03				
16	48	33	03100	1	00				

Note: The "CCS to Add" column and the "% Cap" column will be listed with the first appearance of a concentrator. The succeeding, consecutive listings of the same concentrator will not have information listed in these two columns.

Fig. 7—Assignment Parameters—Procedure 1 (5.31)

PROCEDURE 2

ASSIGNMENT PARAMETERS

Conc Capacity (Per Hr): 166	Light CCS/MS: 3.0
Mean Usage (Per Hr): 102 (61.4% Cap.)	Medium CCS/MS: 6.0
$ — Conc In LLN Above OFC Average	Heavy CCS/MS: 9.0
& — Conc Data Invalid In Latest Study	

ASSIGNMENT	CCS TO	%			ASSIGNED				DISCONNECTED			
ORDER	ADD	CAP	CONC NO.		SW	LEV	CS		SW	LEV	CW	
1	70	19	01406	L	5	02						
2			01406		———							
3			01406	M	4	03						
4			01406	L	1	00						
5	60	25	03216	L	0	01						
6	58	27	01406		———							
7	57	27	03216		———							
8	55	28	01406		———							
9	54	29	03216	M	3	03						
10	54	29	02301		———							
11	54	29	00400		NA				0	01		
12	53	30	07310	L	6	02						
13	52	30	01406	H	6	03						
14	51	31	03216		NA							
15	51	31	02301	M	2	01						
16	51	31	00400		NA				3	02		

Note: The "CCS to Add" column and the "% Cap" column will be listed with the first appearance of a concentrator. The succeeding, consecutive listings of the same concentrator will not have information listed in these two columns.

Fig. 8—Assignment Parameters—Procedure 2 (5.38)

FORM E-6617
(5-75)

CCS CORRECTION

Page of

BUILDING: Bell		TRAFFIC UNIT: 241-CGO	LOAD UNITS: 384
F	STUDY 2/9 - 2/15	STUDY 2/23 - 3/1	STUDY 3/9 - 3/15
	Q/3 X AVG. CCS X F	Q/3 X AVG. CCS X F	Q/3 X AVG. CCS X F
.5	.13 x 120 x .5 = 8	.12 x 130 x .5 = 8	.11 x 140 x .5 = 8
1.0	.13 x 120 x 1.0 = 16	.12 x 130 x 1.0 = 16	.11 x 140 x 1.0 = 15
2.0		.12 x 130 x 2.0 = 31	.11 x 140 x 2.0 = 31
3.0	.13 x 120 x 3.0 = 47	.12 x 130 x 3.0 = 47	.11 x 140 x 3.0 = 46
4.0		.12 x 130 x 4.0 = 62	.11 x 140 x 4.0 = 62
5.0		.12 x 130 x 5.0 = 78	.11 x 140 x 5.0 = 77
6.0			.11 x 140 x 6.0 = 92

LOAD UNIT		W	SC	WSC	F	CCS CORR.	W	SC	WSC	F	CCS CORR.	W	SC	WSC	F	CCS CORR.
A			+4		3.0	-47	2.6	+4	6.6	6.0	-94	2.6	+4	6.6	6.0	-92
B			-2		1.0	+16	-1.3	-1	-2.3	1.0	+16	-.9	0	-.9	0	0
C			+1		0.5	-8	0.6	+2	2.6	1.0	-16	1.0	+2	3.0	1.0	-15
D			+2		1.0	-16	1.3	+1	2.3	1.0	-16	.9	+1	1.9	0.5	-8
E			-4		3.0	+47	-2.6	-2	-4.6	2.0	+31	-1.8	-1	-2.8	1.0	+15
F			-1		0.5	+8	-.6	-2	-2.6	1.0	+16	-1.0	-2	-3.0	1.0	+15
G			-2		1.0	+16	-1.3	-4	-5.3	3.0	+47	-2.1	-2	-4.1	2.0	+31

Fig. 9—CCS Correction Chart Form E-6617 (5.43)

FACTORS (W) & (F)											
WEEKLY						BIWEEKLY					
WSC	W	F	WSC	W	F	WSC	W	F	WSC	W	F
0	0	0	3.6	1.6	1.0	0	0	0	3.4	1.3	2.0
.1	0	0	3.7	1.6	2.0	.1	0	0	3.5	1.4	2.0
.2	.1	0	3.8	1.7	2.0	.2	.1	0	3.6	1.4	2.0
.3	.1	0	3.9	1.7	2.0	.3	.1	0	3.7	1.4	2.0
.4	.2	0	4.0	1.8	2.0	.4	.2	0	3.8	1.5	2.0
.5	.2	0	4.1	1.8	2.0	.5	.2	0	3.9	1.5	2.0
.6	.3	0	4.2	1.9	2.0	.6	.2	0	4.0	1.6	2.0
.7	.3	0	4.3	1.9	2.0	.7	.3	0	4.1	1.6	2.0
.8	.4	0	4.4	2.0	2.0	.8	.3	0	4.2	1.6	2.0
.9	.4	0	4.5	2.0	2.0	.9	.4	0	4.3	1.7	2.0
1.0	.4	0	4.6	2.0	2.0	1.0	.4	0	4.4	1.7	2.0
1.1	.5	0	4.7	2.1	2.0	1.1	.4	.5	4.5	1.8	2.0
1.2	.5	.5	4.8	2.1	2.0	1.2	.5	.5	4.6	1.8	2.0
1.3	.6	.5	4.9	2.2	2.0	1.3	.5	.5	4.7	1.8	2.0
1.4	.6	.5	5.0	2.2	2.0	1.4	.5	.5	4.8	1.9	2.0
1.5	.7	.5	5.1	2.3	2.0	1.5	.6	.5	4.9	1.9	3.0
1.6	.7	.5	5.2	2.3	2.0	1.6	.6	.5	5.0	2.0	3.0
1.7	.8	.5	5.3	2.4	2.0	1.7	.7	.5	5.1	2.0	3.0
1.8	.8	.5	5.4	2.4	3.0	1.8	.7	.5	5.2	2.0	3.0
1.9	.8	.5	5.5	2.4	3.0	1.9	.7	.5	5.3	2.1	3.0
2.0	.9	.5	5.6	2.5	3.0	2.0	.8	.5	5.4	2.1	3.0
2.1	.9	.5	5.7	2.5	3.0	2.1	.8	1.0	5.5	2.1	3.0
2.2	1.0	.5	5.8	2.6	3.0	2.2	.9	1.0	5.6	2.2	3.0
2.3	1.0	1.0	5.9	2.6	3.0	2.3	.9	1.0	5.7	2.2	4.0
2.4	1.1	1.0	6.0	2.7	3.0	2.4	.9	1.0	5.8	2.3	4.0
2.5	1.1	1.0	6.1	2.7	3.0	2.5	1.0	1.0	5.9	2.3	4.0
2.6	1.2	1.0	6.2	2.8	3.0	2.6	1.0	1.0	6.0	2.3	4.0
2.7	1.2	1.0	6.3	2.8	4.0	2.7	1.1	1.0	6.1	2.4	4.0
2.8	1.2	1.0	6.4	2.8	4.0	2.8	1.1	1.0	6.2	2.4	4.0
2.9	1.3	1.0	6.5	2.9	4.0	2.9	1.1	1.0	6.3	2.5	4.0
3.0	1.3	1.0	6.6	2.9	4.0	3.0	1.2	1.0	6.4	2.5	5.0
3.1	1.4	1.0	6.7	3.0	4.0	3.1	1.2	1.0	6.5	2.5	6.0
3.2	1.4	1.0	6.8	3.0	4.0	3.2	1.2	1.0	6.6	2.6	6.0
3.3	1.5	1.0	6.9	3.1	4.0	3.3	1.3	1.0			
3.4	1.5	1.0	7.0	3.1	5.0						
3.5	1.6	1.0	7.1	3.2	5.0						
			7.2	3.2	6.0						

Fig. 10—W and F Factors (Sheet 1 of 2) (5.44)

FACTORS (W) & (F)											
TRIWEEKLY						MONTHLY					
WSC	W	F	WSC	W	F	WSC	W	F	WSC	W	F
0	0	0	3.0	1.0	1.0	0	0	0	2.9	.8	2.0
.1	0	0	3.1	1.0	2.0	.1	0	0	3.0	.9	2.0
.2	.1	0	3.2	1.1	2.0	.2	.1	0	3.1	.9	2.0
.3	.1	0	3.3	1.1	2.0	.3	.1	0	3.2	.9	2.0
.4	.1	0	3.4	1.2	2.0	.4	.1	0	3.3	1.0	2.0
.5	.2	0	3.5	1.2	2.0	.5	.1	0	3.4	1.0	2.0
.6	.2	0	3.6	1.2	2.0	.6	.2	0	3.5	1.0	2.0
.7	.2	0	3.7	1.3	2.0	.7	.2	0	3.6	1.0	2.0
.8	.3	0	3.8	1.3	2.0	.8	.2	0	3.7	1.1	2.0
.9	.3	0	3.9	1.3	2.0	.9	.3	0	3.8	1.1	2.0
1.0	.3	.5	4.0	1.4	2.0	1.0	.3	.5	3.9	1.1	2.0
1.1	.4	.5	4.1	1.4	2.0	1.1	.3	.5	4.0	1.2	2.0
1.2	.4	.5	4.2	1.4	2.0	1.2	.3	.5	4.1	1.2	2.0
1.3	.4	.5	4.3	1.5	2.0	1.3	.4	.5	4.2	1.2	3.0
1.4	.5	.5	4.4	1.5	2.0	1.4	.4	.5	4.3	1.2	3.0
1.5	.5	.5	4.5	1.5	3.0	1.5	.4	.5	4.4	1.3	3.0
1.6	.5	.5	4.6	1.6	3.0	1.6	.5	.5	4.5	1.3	3.0
1.7	.6	.5	4.7	1.6	3.0	1.7	.5	.5	4.6	1.3	3.0
1.8	.6	.5	4.8	1.6	3.0	1.8	.5	1.0	4.7	1.4	3.0
1.9	.6	1.0	4.9	1.7	3.0	1.9	.6	1.0	4.8	1.4	3.0
2.0	.7	1.0	5.0	1.7	3.0	2.0	.6	1.0	4.9	1.4	4.0
2.1	.7	1.0	5.1	1.7	3.0	2.1	.6	1.0	5.0	1.5	4.0
2.2	.7	1.0	5.2	1.8	3.0	2.2	.6	1.0	5.1	1.5	4.0
2.3	.8	1.0	5.3	1.8	4.0	2.3	.7	1.0	5.2	1.5	4.0
2.4	.8	1.0	5.4	1.8	4.0	2.4	.7	1.0	5.3	1.5	4.0
2.5	.8	1.0	5.5	1.9	4.0	2.5	.7	1.0	5.4	1.6	4.0
2.6	.9	1.0	5.6	1.9	4.0	2.6	.8	1.0	5.5	1.6	5.0
2.7	.9	1.0	5.7	1.9	4.0	2.7	.8	1.0	5.6	1.6	6.0
2.8	.9	1.0	5.8	2.0	4.0	2.8	.8	1.0			
2.9	1.0	1.0	5.9	2.0	5.0						
			6.0	2.6	6.0						

Fig. 10—W and F Factors (Sheet 2 of 2) (5.44)

TRANSFER PARAMETERS

Conc Capacity (Per Hr): 166
Mean Usage (Per Hr): 102 (61.4% Cap.)
$ — Conc In LLN Above OFC Average
& — Conc Data Invalid In Latest Study

Light CCS/MS: 3.0
Medium CCS/MS: 6.0
Heavy CCS/MS: 9.0

ASSIGNMENT	CCS TO			SELECTED				DISCONNECTED			
ORDER	REMOVE	% CAP	CONC NO.	SW	LEV	CS		SW	LEV	CS	
1	70	104	$05406	2	00						
2			$05406	7	02						
3			$05406	0	02						
4	60	98	$01307	2	01						
5	58	96	$05406	—	—			3	00		
6	56	95	$01307	3	01						
7	54	94	$05406	—	—			1	04		
8	54	94	$01211	5	01						
9	54	94	$01301	—	—			0	04		
10	53	93	$00211	4	03						
11	52	93	$01307	1	02						
12	50	92	$05406	—	—			6	02		
13	50	92	$03102	6	03						
14	50	92	$01211	—	—			7	02		
15	50	92	$01301	4	00						
16	49	91	$00211	6	02						

Fig. 11—Transfer Parameters (5.47)

LOAD BALANCE SCORE CONTROL RECORD

Form E6615 (5-75)

Building:	Traffic Unit:	Page of

LOADING DIVISION ________ LU's INSTALLED ________ LU ENG. CCS________

STUDY DATE														
STUDY NO.	1		2		3		4		5		6		7	
TOTAL CCS														
LU's MEAS.														
% ENG. CAP.														
AVG. H.T.														
	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS
+2														
+1														
0	AVG.		AVG.		AVG.		AVG.		AVG.		AVG.		AVG.	
−1														
−2														

LOADING DIVISION ________ LU's INSTALLED ________ LU ENG. CCS________

STUDY DATE														
STUDY NO.	1		2		3		4		5		6		7	
TOTAL CCS														
LU's MEAS.														
% ENG. CAP.														
AVG. H.T.														
	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS
+2														
+1														
0	AVG.		AVG.		AVG.		AVG.		AVG.		AVG.		AVG.	
−1														
−2														

LOADING DIVISION ________ LU's INSTALLED ________ LU ENG. CCS________

STUDY DATE														
STUDY NO.	1		2		3		4		5		6		7	
TOTAL CCS														
LU's MEAS.														
% ENG. CAP.														
AVG. H.T.														
	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS
+2														
+1														
0	AVG.		AVG.		AVG.		AVG.		AVG.		AVG.		AVG.	
−1														
−2														

TRUNK LOAD UNIT SUMMARY

Form E-6663
(7-75)

Building:	Traffic Unit:	Page of
LU Installed:	LU CCS Capacity:	

STUDY DATE						
LU MEAS						
TOTAL CCS						
AVG CCS						
% OF CAPACITY						
% IML						
AVG X .85						
AVG X 1.15						
LOADS OVER 115% OF AVERAGE						
# OF LU						
% OF LU						

STUDY DATE						
LU MEAS						
TOTAL CCS						
AVG CCS						
% OF CAPACITY						
% IML						
AVG X .85						
AVG X 1.15						
LOADS OVER 115% OF AVERAGE						
# OF LU						
% OF LU						

LOAD UNIT—LOAD BALANCE CHART

Form E-6616
(5-75)

Building:	Traffic Unit:	Page of
Loading Division:	LU Installed:	

LTN LLN FR	LG HG Conc Conc Grp	STUDY DATE							
		STUDY NO.	1.	2.	3.	4.	5.	6.	7.
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							
		CCS							
		S | P | H							

S-Study Score

P-Penalty Points

H-Hot Spot Penalty Points

FORM E-6617
(5-75)

CCS CORRECTION

Page of

BUILDING:		TRAFFIC UNIT:	LOAD UNITS:
	F	STUDY	STUDY	STUDY
		Q/3 X AVG. CCS X F	Q/3 X AVG. CCS X F	Q/3 X AVG. CCS X F
	.5			
	1.0			
	2.0			
	3.0			
	4.0			
	5.0			
	6.0			

LOAD UNIT		W	SC	WSC	F	CCS CORR.	W	SC	WSC	F	CCS CORR.	W	SC	WSC	F	CCS CORR.

TRUNK LOAD UNIT ANALYSIS

FORM E-6664
(7-75)

Building:	Traffic Unit:	Page of
LU Installed:		

LU Ident.		STUDY:						STUDY:						
		CCS	CHOICE				% CAP	CCS	CHOICE				% CAP	REMARKS
			1	2	3	4			1	2	3	4		