

SWITCHING SYSTEMS MANAGEMENT
NO. 5 CROSSBAR
LOAD BALANCING PROCEDURES

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1. GENERAL

A. Purpose

1.01 This section describes load balancing techniques primarily as they relate to horizontal group balance for customer lines in No. 5 crossbar offices. Included is a description of how these techniques are incorporated into the new load balance index (LBI) described in Division A, Section 5b.

1.02 Whenever this section is reissued, the reason for reissue will be listed in this paragraph.

1.03 This practice is a full revision and consolidation of many documents on the subject of load and balance. In conjunction with Division A, Section 5B, it replaces TL 562 which transmitted the previous Overall Balance Index Plan, issued July 13, 1966; subsequent modification 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, that 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 purposes are more stringent to ensure uniformity among all offices. Thus, Division A, Section 5b is the final arbiter of data requirements and procedures required for index generation.

B. Responsibilities

1.06 The network administrator has the responsibility for good load balance and subsequent index reporting. To achieve the objectives of good balance, this responsibility includes the following:

- (a) Busy hour and side hour determination
- (b) Scheduling studies
- (c) Data collection
- (d) Preparation of loading plans
- (e) Preparation of load balancing forms
- (f) Preparation of customer line usage assignment forms
- (g) Data validation
- (h) Analysis and corrective action
- (i) Preparation and distribution of the load balance index form.

2. PRINCIPLES OF LOAD BALANCE

A. Definition of Terms

2.01 Definition of a *traffic unit* is the same as the definition of a *dial entity*. The term *traffic unit* is used to conform with *Common Language Location Identification* practice, BSP 795-100-100. Examples of traffic units are as follows:

- (a) *Step-By-Step*—A group of lines requiring use of the same intermediate distributing frame.

- (b) **Panel**—A group of lines using a common decoder group or having common translator arrangements.
- (c) **No. 1 Crossbar**—A group of lines using a common terminating marker group.
- (d) **No. 5 Crossbar**—A group of lines using a common marker group.
- (e) **Electronic Switching Systems**—A group of lines associated with one central control system using the same logic and processor.

2.02 A **load unit** is defined as the component of line originating equipment arranged for usage measurements and for which individual scores are to be computed. In a No. 5 crossbar office, a load unit is a horizontal group.

2.03 The general definition of a **loading division** is a group of load units of the same type of dial equipment, with the same capacity designed to be loaded similarly by both usage and classes of service and not requiring telephone number changes to effect line-load balance within the loading division. Where equipment features, such as Unigauge or TOUCH-TONE®, prevent similar loading and assigning due to equipment design, the Operating Telephone Company (OTC) has the option of further breakdowns by loading divisions. Uniformity of justification for creating more loading divisions should be maintained within an OTC. 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 administration for proper loading between divisions.

2.04 Loading divisions of the same class of service, possessing only slightly different capacities, may conveniently be combined in order to assign customer lines. Combinations of this type are called **assignment 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 a loading division has the highest average hundred called seconds (CCS) usage measured for five days during the same

week. The hour may start and end on the clock hour or half-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-half hour. For example, if the BH is 9 to 10 AM, the side hour could be 8 to 9 AM, 10 to 11 AM, or 8:30 to 9 AM, 10 to 10:30 AM, etc.

2.08 **Session busy hours** (SBH) 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.

B. Balance by Loading Division

2.09 Studies show that good load balance is required if the inherent call carrying capacity of a dial office is to be satisfactorily achieved. A good loading plan is one that improves balance at each opportunity and assures optimum balance during periods of peak loads. It recognizes that as engineered capacities are reached or exceeded, intensified administrative attention to balance is needed to assure that service goals will then be met. 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, on account of the 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. Good practical balance is the goal that this section is intended to help the administrator achieve.

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2.11 Balance requires constant analysis of the changes in group loads and of the effects on service. A single group that 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 (maximization of capacity). 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. Finally, a well-balanced office provides reliable data that shows sound load-service relationships. This is conducive to engineering correct equipment quantities and the anticipation of future service levels.

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.

C. 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 horizontal groups in a mixed class of service loading division 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 groups 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 engineering purposes.

2.15 While a good class-of-service mix does not prevent load fluctuations, it does tend to spread them across all horizontal groups, 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 groups having busy hours differing from the loading division 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 will want to be informed before extensive special procedures are undertaken.

D. Service Indicators

2.16 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 level of that office. Primarily this will be indicated by the dial line index, especially those components most sensitive to the level of loading such as dial tone speed and matching loss. During the busy season, an office with a good overall dial line index should not require line transfers for balance but should be able to rely on effective line assignment procedures.

2.17 An office that is experiencing poor service will require efforts to determine the extent to which balance is contributing to the problem. Poor dial tone speed results may be caused by poor balance or may have no relation at all depending on the office configuration and problem.

2.18 Out of the busy season and in other periods of light loading more reliance must be placed on other than the dial line index. The relationship of lost (or delayed) calls to offered load (load-service curves) becomes more important. Procedures for analysis of problem conditions are adequately

described in Division H, Section 5d(3) under Problem Analysis and Corrective Action.

E. Determination of Balance Periods, Busy Hours and Side Hours

2.19 *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.

2.20 The hours on either side of the busy hour in most cases will be close to the busy hour in CCS and have the same general traffic characteristics. Where the usage in a side hour is at least **90 percent of the busy hour load** during the busy season, the side hour 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.

2.21 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 in one of the following methods:

- (a) Use the busiest hour and two periods adjoining the busy hour.

Examples:

Study the periods as follows:

PRIOR	BUSY HOUR	AFTER
3:00—3:30	3:30—4:30	4:30—5:30

At least half-hourly readings are required to determine if the load for the 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.

2.22 The combination of CCS from nonadjacent busy hours, such as a combination of 10-11 AM with 7-8 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**.

2.23 Where there are two distinct nonadjacent hours (the busy hour and another) that are almost equal in CCS load levels, it may be necessary to study both periods separately. Line assignment procedures should call for assignment into those horizontal groups which are found to have below average loading in both periods with consideration 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.

2.24 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 then may even be used for index reporting purposes if necessary. With register grouping, combining two 5-hour periods may become necessary to obtain the 10 hours for index reporting (see 4.07).

2.25 Loading divisions of the same class of service may have similar traffic characteristics and could use the weekly study period of the largest loading division.

2.26 Loading divisions of different classes of service are more likely to have different study period requirements. A common study period would be appropriate for all divisions having the same number of study hours and having study

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periods commencing and terminating within one-half hour of the principal loading division (or grouping of class-of-service loading divisions).

2.27 Load balancing usage data for all loading divisions should be collected as frequently as required to insure good balance with a minimum of ten hours a month. The ten-hour minimum is imposed by the load balance index requirement.

F. Quality Control Limits (QCL)

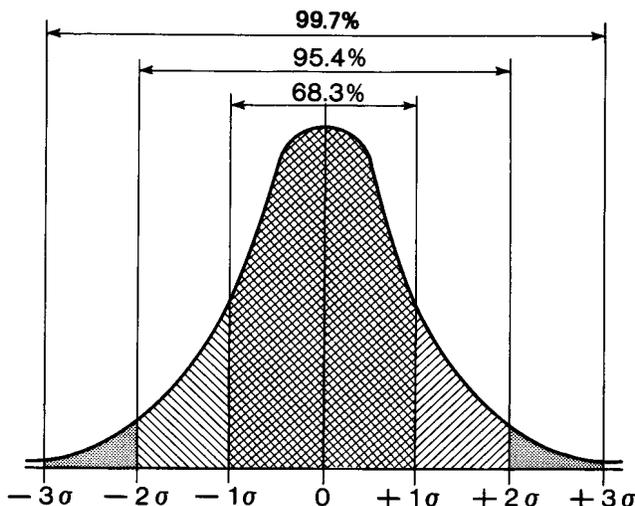
2.28 The quality control technique is a practical way of taking advantage of mathematics in order to create a uniform approach to load balance procedures. This technique indicates reliably whether fluctuations in load data might be the result of chance or are probably the result of differences in traffic unit 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.

2.29 The two primary causes for variation of individual load unit usage from the average of a number of horizontal groups in the same loading division are **chance** and **imbalance**. Chance variations result from the random calling patterns of customer telephone usage. The size of chance variations depends upon certain measurable office characteristics: average holding time (AHT) of calls, percent 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 aforementioned characteristics affects the size of samples observed in load studies.

2.30 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** σ . 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, as illustrated in the distribution curve below:

Normal Distribution . . .



2.31 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, quality control limits (QCLs) representing three standard deviations have been selected (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 whose measured loads are averaged together. The mathematical analysis tells us that we may expect only three (the 0.3 percent outside the 99.7 percent) of those measurements to differ by chance from the mean by more than three standard deviations, ie, the QCL. In effect, we can assume 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 change 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 of Fig. 1.

2.32 There are two steps in determining the appropriate QCL. The first step is to

calculate the **percent 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 can fluctuate more than those in a comparable heavily loaded office.

2.33 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. Engineered line link frame (LLF) capacities may be found in Traffic Facilities Practices Division D, Section 8b(2), or obtained from the Network Design engineer. The answer will be the percentage of capacity at which the horizontal groups are operating for the given study period. This is done for each loading division; where only sample usage is read, usage must be calculated (see Part 3E for specific details with multiple loading divisions). The 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 percentage loading ranges from 30 to over 96 percent. The calculation of the percentage of capacity for a study period is illustrated in the following example:

Office Parameters

LLFs Installed = 30 (300 Horizontal Group)
 TLFs Installed = 15
 Pattern = 36 × 9P

Step 1

LLF Capacity = 1140 CCS
 Horizontal Group Capacity = 114 CCS
 ie, Engineered Load (EL) = 114 CCS

Step 2

Marker Total Channel P.C. (TCPC) = 11454
 Marker Sample Channel P.C. (SCPC) = 2907
 Sample Channel Usage (DGU) = SU = 6480

$$\text{Total Office CCS} = \frac{\text{TCPC}}{\text{SCPC}} \times \text{Sample Usage}$$

$$= \text{T/S Ratio} \times \text{SU}$$

$$\text{T/S Ratio} = \frac{11454}{2907} = 3.9$$

$$\text{Total Office CCS} = 3.9 \times 6480 = 25272 \text{ CCS}$$

$$\begin{aligned} \text{Average Actual Load (AL)} &= \frac{\text{Total CCS}}{\text{No. of HG}} \\ &= \frac{25272}{300} \\ &= \underline{84} \text{ CCS} \end{aligned}$$

Step 3

$$\begin{aligned} \text{Percent of Capacity} &= \frac{\text{AL}}{\text{EL}} \times 100 \\ &= \frac{84}{114} \times 100 = 73.6 \end{aligned}$$

73.6% rounded to the nearest whole number (integer) would be 74%.

2.34 QCL tables also require the use of average holding times (AHTs) of the calls creating usage on line equipment. Documentation of the AHT in a traffic unit is necessary for each balance study, by loading division if possible, to get the most accurate results. However, where this procedure is impossible or uneconomical to implement, one of the following methods (listed preferentially) may be employed:

- (a) Use an AHT for a SBH in the most recent available week.

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(b) As a last resort, and only in cases where data are unavailable, use 200 seconds as an AHT.

(c) In methods (a) and (b) where AHT for loading divisions cannot be established separately, use the AHT for the entire traffic unit. Procedures for approximating AHTs by loading division will be discussed in Part 3D.

2.35 Computation of AHT in seconds for a No. 5 crossbar office is as follows:

$$\text{AHT} = \frac{\text{Sample Channel Usage} \times 100}{\text{Sample Channel Peg Count}}$$

Example:

$$\begin{aligned} \text{AHT} &= \frac{6480}{2907} \times 100 \\ &= \underline{223} \text{ sec.} \end{aligned}$$

2.36 Following, is an example of selecting the QCL percent with the results in 2.33 and 2.35:

Step 1

Given 74 percent of capacity in 2.33, select the table in Fig. 1, entitled 66 percent to 75 percent.

Step 2

Given an 1140 CCS per LLF in 2.33, select the proper column, 1040-1159, of the table found in Step 1.

Step 3

Given a 223 second holding time from 2.35, select the proper range, 211-230 AHT.

Step 4

Where the line chosen in Step 3 intersects the column designated in Step 2, the QCL is found equal to 48 percent.

2.37 For 10-hour QCLs not represented by tables, the company staff may contact the AT&T Network Administration group.

2.38 The eight quality control limit tables in Fig. 1 were constructed using ten hours of data for a base. These tables are the only system tables allowed for computing the load balance index as described in Division A, Section 5b. It is recommended therefore that ten hours of data be used for all balance procedures where 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 LBI. 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
and N = the number of hours of the study

The value under the square root sign may be determined from the following table. This answer can then be multiplied by 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 = 48%
— N = 8 hours

$$Q = \sqrt{\frac{10}{8}} \times 48.0\%$$

$$= 1.12 \times 48.0$$

$$Q = 53.7\%$$

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 that are approaching these limits. This is established by designating intermediate points at ± 1.5 sigma, as illustrated in the distribution curve below:

Example:

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

$$200 \text{ CCS} \times .44 = 88 \text{ CCS}$$

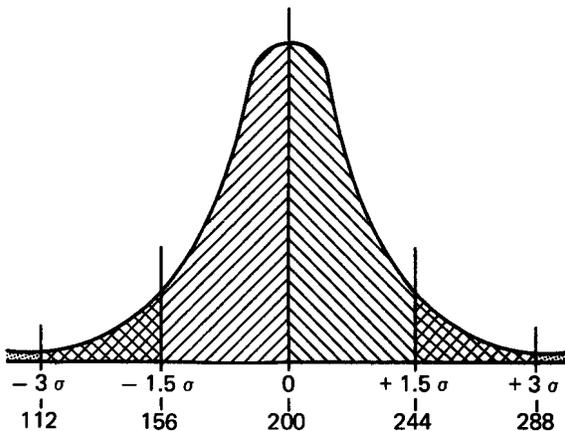
$$+3.0 \text{ S.D.} = 200 \text{ CCS} + 88 \text{ CCS} = 288 \text{ CCS}$$

$$-3.0 \text{ S.D.} = 200 \text{ CCS} - 88 \text{ CCS} = 112 \text{ CCS}$$

$$+1.5 \text{ S.D.} = 200 \text{ CCS} + 44 \text{ CCS} = 244 \text{ CCS}$$

$$-1.5 \text{ S.D.} = 200 \text{ CCS} - 44 \text{ CCS} = 156 \text{ CCS}$$

CCS Value ...



2.40 The use of CCS values at the specified 3 and 1.5 sigma limits works well for one

week 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 with an alternate method being used, called the Score System.

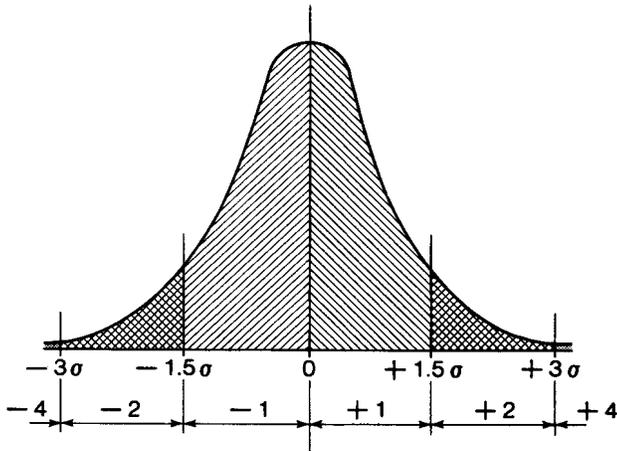
G. Development of Scores

2.41 The Score System has been developed to simplify the mathematics required in the balancing of loading groups. 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 group average during a measurement period. In application, all groups exceeding the quality control limit on a weekly record are assumed to be out of balance. The other groups, 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 (see distribution curve below).

- (a) Each load unit with exactly average CCS is assigned a score of 0 (zero).
- (b) Each load unit deviating above or below average up to and including 1.5 standard deviations, half the QCL, is assigned a score of +1 or -1.
- (c) Each load unit 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 load unit deviating above or below 3.0 standard deviations from the average is assigned a score of +4 or -4. Note that four (4) is used rather than three (3) in order to accentuate this undesirable deviation.

Score Method . . .



Example:

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

<u>Load Unit CCS</u>	<u>Score</u>
289 and higher	+4
245 thru 288	+2
201 thru 244	+1
200	0
156 thru 199	-1
112 thru 155	-2
111 and lower	-4

3. SWITCHING SYSTEM BALANCE CONSIDERATIONS

A. Purpose

3.01 This part is intended to give a brief description of the No. 5 crossbar load unit, to point out some loading restrictions, and to provide administrative guidance to effect the best possible balance.

B. Load Unit Configuration

3.02 The line link frame (LLF) serves as a location for each customer line to originate and terminate calls. It consists of line switches and junctor switches. Subscriber lines are associated with verticals on the line switches.

3.03 The basic line link frame has 20 verticals located in each of ten horizontal groups (HGs) (one vertical is always used for *no test*); it is designated a 190 size. The size of the LLFs may be increased from the basic 190 in increments of 50- or 100-line switches to the largest or the 590 LLF.

3.04 The HG is the principal equipment requiring load balancing in a No. 5 crossbar office.

3.05 The ten line links, or channels, as they are sometimes called, of a horizontal group are common to all customers in that group. In the 190 LLF, up to 19 lines share the ten channels to originate and terminate calls; in a 590 LLF, a maximum of 59 lines can share these ten channels.

3.06 Horizontal groups on a line link frame are subject to a controllable load. The effective balance of horizontal groups, within established control limits, should produce proper balance among the frames of any given loading division and provide a uniform grade of service to all customers.

3.07 Detailed information about the line link frame and its component parts may be found in Traffic Facilities Practices Division D, Section 8b. A No. 5 Crossbar System description may be found in Bell System Practices Sections 958-110-100 and 958-120-100 and in Dial Facilities Management Practices Division H, Section 5a.

C. Feature Restrictions

3.08 There are specific limitations that must be considered when balancing a No. 5 crossbar office; namely *frame configurations* and *service features*. Frame configurations include different size line link frames, in addition to paired, partially paired, two wire or four wire line link frames. Service features are provided to identify customer

lines for the purpose of billing, routing restrictions and equipment operation.

3.09 It is necessary to have a working knowledge of the method used to identify lines in order to fully understand details of frame configurations and service features. Individual line locations on a line link frame must be identified in order to provide *dial tone* and *completing markers* with information to handle each call.

Identification of Lines

3.10 Any line may be terminated on any vertical of any line link frame subject to feature and class-of-service limitations (see 3.12). The line location is identified by the following:

- Frame Number (LLF#)
- Vertical Group Number (VG#)
- Horizontal Group Number (HG#)
- Vertical File Number (VF#)

3.11 Verticals are numbered 0 through 4 and repeated four times on each 200-point switch. Correspondingly numbered verticals immediately above each other on each of ten switches constitute a vertical file. Verticals 0 through 4 on each of ten switches constitute a *vertical group*. The vertical group, therefore, is 5 verticals wide and includes 10 switches. A vertical group ordinarily accommodates 50 lines. The groups are numbered beginning at 00 for the first group of each line link frame. The maximum size line link frame has VG 00 through 11; ie, 12 vertical groups at 50 lines per group or a 590 size frame (ten verticals are not usable for customer lines since VG 02, VFO is used as the "no test" vertical on all line link frames).

Class of Service

3.12 Any class of service may be handled on any line link frame. Any vertical file may be designated as a particular class of service as governed by the following limitations:

- (a) Certain files are equipped to operate with coin lines (VG01, VF0 through 4 and VG02, VF1 and 2 are standard provision).

(b) Two-party vertical groups are limited by the provision of tip party AMA translators. Vertical groups 04 and 05 are normally first choice for tip party translators. When required, any other vertical group may be used.

3.13 The entire vertical group 02 is arranged so that calls originating in this group will receive preferential handling. Essential lines generally for police, fire, ambulance, etc, will be assigned in this vertical group.

3.14 A No. 5 crossbar wire spring office can accommodate 100 classes of service. U and Y type No. 5 crossbar offices can accommodate only 60 classes of service. Older offices in both categories were limited to 60 and 30 classes of service respectively, prior to the latest equipment modifications. Network administrators must review each unit to determine which configuration is applicable and whether or not a modification is feasible or desirable.

3.15 Some examples or requirements for different classes of service that may be associated with each line are as follows:

Message Rate (MR)	Junctor - AMA	Dial Tone First (DTF)
Party Flat Rate (2 FR)	Junctor - Tandem	PBX
Manual (MN)	Party Message Rate (2 MR)	CCSA
Outgoing WATS	Coin (CN)	ETC
Junctor - Coin	Manual Coin (MCN)	

3.16 The line link connector circuit passes class-of-service indications to an originating register so that the customer call will receive the proper charge treatment. Class-of-service indications are required to determine the proper routing and charges for each call. The originating register (OR) utilizes the coin class-of-service indications to perform a specific coin test. The OR also makes a two party test on two party class of service lines so that the proper party will be charged for the call.

3.17 Line link frames which are arranged for 100 classes of service may also be arranged to provide a maximum of 20 rate treatment indications.

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Rate treatments are utilized to entitle groups of customers to dial points restricted to others within the same class of service.

3.18 Rate treatments are utilized for Centrex C.O. (see 3.20) class-of-service restrictions as follows:

- Restricted -Dial other stations only
- Semi Restricted -Several variations possible
- Eg -Other stations + local calls
 -Other stations + local class
 + specific toll calls
- Attendant -Unrestricted

However, each C.O. Centrex customer must be identified by a separate class of service.

3.19 Rate treatments are utilized for Centrex C.U. (see 3.21) to determine permission or denial of PBX calls switched through the central office in terms of charging and routing.

As in Centrex C.O., each Centrex C.U. customer must be identified by a separate class of service. A Centrex C.U. customer having two or more PBX locations may be allowed to complete inter-PBX calls within the PBX customer group by matching the originating class of service against the terminating class of the called PBX.

Centrex (CTX)

3.20 There are two general types of Centrex service designated Centrex C.O. and Centrex C.U. Centrex C.O. customers utilize the dial switching equipment on telephone company premises. Each customer has a direct line to the central office where all switching and interconnecting functions are completed. Each Centrex C.O. customer must be identified by a separate class of service. Rate treatments, however, can be multiplied across both Centrex and non-Centrex vertical files where similar treatments are required.

3.21 Centrex C.U. is a service for PBX users which combines the features of automatically identified outward dialing (AIOD) used for billing individual PBX stations and direct inward dialing (DID) to individual PBX stations utilizing line link

pulsing trunks (LLP). Centrex C.U. interconnections are completed by dial switching equipment located on the customer premises. Interconnection to the No. 5 crossbar office is made via direct out dialing (DOD) from the PBX station utilizing ninth level trunks to the No. 5 crossbar LLF. Interconnection from the No. 5 crossbar LLF to the PBX station is made via direct in dialing (DID) line link pulsing (LLP) trunks.

Line Link Pulsing (LLP)

3.22 Line link pulsing (LLP) is a method used to complete DID calls to Centrex CU customers by outpulsing the extension number over a common PBX trunk group. A line link frame can serve a maximum of 30 LLP trunks equipped for automatic identification of outward dialing (AIOD) spread over three vertical files within a specific VG.

Class-of-Service Identification by Hold Magnet

3.23 Each No. 5 crossbar wire spring LLF may have three vertical files arranged for individual class of service by hold magnet. With this feature, commonly used with LLP trunks, a vertical file can be arranged for up to ten classes of service.

Vertical Group Segregation

3.24 In order to establish a dialing connection between a customer line and an idle originating register, the DTM is given information through a line link marker connector as follows:

Line Link Frame

Vertical Group

Horizontal Group

Other information items are passed through a line link connector to the originating register (OR) once it is selected:

Vertical File

Class of Service

3.25 More than one group of ORs may be required in a traffic unit. Examples of OR groups are TOUCH-TONE, dial pulse (DP), and dial tone first (DTF). DTMs can be arranged to serve from

one to six OR groups. Identification of the type of OR required is determined by the calling customer's location on the LLF. A LLF can operate with a specific OR group or may be arranged for mixed operation whereby the OR group is selected on the basis of the VG in which the line is located. When all lines on a LLF access the same OR group, the DTM holding time is normal. When lines are segregated on a VG basis, the DTM work time is increased because of the time required for VG identification.

3.26 When the DTM operates with the **2-originating register group option**, a LLF may have access to only one OR group or may be arranged on a vertical group segregation basis with access to both groups. All LLFs using VG segregation **must** use the same pattern; that is, if VG02 is selected for operation with the DTF originating register group, VG02 in **all** LLFs arranged for VG segregation must access the same OR group.

3.27 When the **6-originating register group option** is used, three different patterns may be used. This permits each of three subgroups of LLFs to have a different set of VGs assigned to a particular OR group. VG00 through 07 can be assigned individually to an OR group, but the balance of the VGs must be assigned in pairs: 08-09 and 10-11.

3.28 Lines assigned to PBX trunks with direct inward dialing (DID) utilizing LLP combined with automatically identified outward dialing (AIOD) have certain restrictions. The three vertical files utilized for AIOD must be in the same ring party vertical group. Tip party vertical groups cannot be used for AIOD.

Horizontal Group Segregation (Unigauge LLF)

3.29 Unigauge line link frames are usually required to serve customers located in excess of 15,000 feet from the central office. Unigauge operation can only be provided with new line link frames. There is no provision for modifying existing frames.

3.30 These long loop customers must be associated with range extenders which are provided on

a line link frame horizontal group basis. They are inserted in each of the ten line links between a particular line switch and the junctor switches. Any number of horizontals on a line link frame may be equipped with range extenders. Although not normally recommended, any vertical group in a fully or partially equipped unigauge frame can, by strap option, be utilized to handle short loop customers in those horizontal groups arranged for long loop customers.

3.31 No special class of service is required to identify unigauge lines. However, when unigauge/nonunigauge distinction is required within a horizontal group, a strap option is provided on the line relays of the horizontal group. Unigauge and short loop lines cannot be mixed within a vertical group of a unigauge horizontal group.

Paired LLF Operation

3.32 Arrangements have been developed for paired line link frame operation in No. 5 crossbar two-wire offices. This feature permits a pair of line link frames to make joint use of their juncctors and increases the load carrying capacity of each line link frame. Paired line link frame operation may be implemented only in offices using the ultimate of "ten" junctor pattern arrangement.

Paired LLF Operation (One LLF not Paired)

3.33 When there are an odd number of LLFs in a paired office, the standard junctor cabling arrangements provided are such that the highest numbered line link frame is in effect an unpaired frame. The CCS capacity of this frame is substantially less than that of all other line link frames and should be treated as a separate loading division.

3.34 Special cabling should be provided between the auxiliary line link frame and the junctor grouping frame for terminating the juncctors for the unequipped mate frame which in effect provides the odd frame with at least the same theoretical capacity as all other paired LLFs.

Partially Paired LLF

3.35 In the case of offices with partially paired line link frames (ie, 42 line link frames in an office of which 30 frames are paired and 12 frames are not), separate loading divisions must be established for the paired and unpaired frames.

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D. Load Balance

3.36 This part provides guidance to effect good load balance and to minimize problems associated with feature restrictions in Part 3C.

3.37 *The best possible balance that can be achieved in an entity is established by spreading each category, such as class of service and rate treatment, equally across all LLFs.* In offices without serious restrictions and enough demand, this approach is feasible. Where feature restrictions are major and demand is small, some equitable manner must be devised to assign lines over as many frames as possible. These procedures will be discussed further in other paragraphs of this section. Once a proper spread is established, usage measurements should be used to *fine tune* these assignments.

Loading Plans

3.38 A loading plan, as previously stated in 2.09, is the key for achieving good load balance. This plan is one that improves balance at each opportunity and assures optimum balance during peak loads. It recognizes that, as engineered capacities are reached or exceeded, intensified administrative attention is needed to assure that service goals will then be met. Good loading plans maintain balance between entities in multientity buildings and buildings serving the same geographical area.

3.39 The loading plan is developed by a network administrator using four major sources of information: official documentation, historical data, expected office characteristics, and coordination with the network design engineer. Each of these sources must be molding together to create a unique, comprehensive, and effective plan.

3.40 Official documentation includes the following:

- (a) Commercial Forecast—provides expected growth by class of service.
- (b) Equipment Order—provides the information regarding installed equipment, engineered capacities (including trended data) by component, trunk and service circuits.

(c) Demand and Facility Chart—provides a pictorial representation of items (a) and (b). Indicates dates for job exhaust.

3.41 Historical data should be looked at 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 and service levels, etc.

3.42 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.

3.43 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.

3.44 The loading plan should be developed for the 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 be compared to the actual monthly growth.

3.45 Once the plan is developed, loading priorities must be developed to assist in the day-to-day assignment job. Horizontal groups may be identified within each LLF over which to spread the classes of service. The identification process must be tempered with judgment. Assignment considerations should include identifying those classes of service with heavy loads, such as Centrex customers and coin service or PBX lines. Special care should be taken to distribute high call volume customers such as outward WATS and data ports.

3.46 If long-range forecasts predict a drastic shift in class-of-service mix, loading plans should consider methods for efficiently managing such a change.

3.47 Once the loading priorities have been established, consideration should be given to line assignments advanced to the assignment bureau. An attempt should be made to recover assignments previously advanced which no longer meet balance requirements based on new load balance data.

Multiple Size LLFs

3.48 Multiple size LLF entities loaded to a low percent of line fill can achieve an equal spread of lines and maintain one loading division by considering all LLFs as having no more line relays than the smallest LLF, eg, in an office with ten 490s and four 590s, all fourteen frames are considered as being the 490 size. This is the preferred method from an administration point of view.

3.49 Multiple size LLF traffic units should be avoided; whenever possible, they should be eliminated on the next addition. However, when additions are not contemplated and there is a high line fill, the approach of 3.48 may prove to be impractical. An extreme procedure to compensate for this problem is to assign heavy usage lines to the smaller frames and light usage lines to the larger frames. In this manner, it is possible to allow each frame to carry the same load (CCS/LLF). Unfortunately, this method may cause a division between classes of service and create **stranded capacity**. The following example will illustrate the impact of this procedure:

- Given:
 Line Link Frames — 30—390 and 30—490
 CS1 — Class of Service—Business
 CS2 — Class of Service—Residence

	<u>CS1</u>	<u>CS2</u>	<u>OBH</u>
	10:30	7:30	3:30
	-11:30	8:30	4:30
Total CCS	51000	51000	60000
Contribution			
— CS1	42000	9000	30000
— CS2	9000	42000	30000
CCS/LLF			
— CS1	1400—	300	1000
— CS2	300	1400—	1000
— Office	850+	850+	1000

In this entity if the LLFs are designed at 1000 CCS/LLF for the office busy hour, service during the class-of-service busy hours will be above objective for at least half the frames. Consequently, the LLFs must be designed at approximately 1400 CCS/LLF in order to maintain service levels. An office with a good class-of-service mix could utilize the lower design value of 1000 CCS/LLF.

3.50 Another approach to loading different size LLFs is to establish a higher percent fill in the smaller frames to effect a more even distribution of classes of service. Form E-6618, is provided for these computations. An example of the filled out form is shown in Fig. 2.

3.51 Basically, the method establishes minimum requirements for high usage lines, such as business, and attempts to load the load units in that direction. This procedure will provide maximum equipment utilization and will maintain one loading division. Load, numbers, and frame limitations must always be taken into account when devising a plan for working entities. In addition, where main stations are working, attempt to minimize moves by judicious selection.

VG & LLF Segregation

3.52 No. 5 crossbar traffic units modified for multiple OR group operation, such as TOUCH-TONE and DP, are easily maintained from an administrative point of view.

3.53 In traffic units with the 2-originating register group feature, it is necessary to modify an equal number of VGs in each LLF to minimize administrative difficulties. With this OR group feature, the **same numbered** VG in all LLFs with VG segregation must be assigned to the same OR group.

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3.54 The 6-originating register group feature is desirable from an administration point of view. If the traffic unit is to be served by two OR groups (eg, dial pulse and TOUCH-TONE), three mixed patterns could be established for those LLFs where mixed operation is desired. Each pattern could designate different VGs for TOUCH-TONE use. Any of the three mixed patterns could be applied to any LLF. This flexibility permits a more balanced spread of TOUCH-TONE lines over LLFs without impairing efficient use of line terminals and creating separate loading divisions.

3.55 Factors to be considered between the 2-originating register group feature and the 6-originating register group feature are the estimated growth, the amount of originating equipment to be modified, and the administrative limitation imposed by the 2-group feature. With the 2-group feature and VG segregation, all LLFs must use the same pattern.

3.56 From a Network Administration point of view, a traffic unit should be modified for the 6-originating register group feature since this arrangement provides considerable flexibility in the assignment of VGs.

3.57 The network administrator should provide the network design engineer with as much information as possible to make an intelligent decision regarding modification, taking into account the items outlined in 3.55.

Paired LLF Operation

3.58 Paired LLF operation, while increasing the call carrying capacity in an office, requires special assignment practices because of shared talking path arrangements between specific pairs of LLFs. High usage classes of service should be spread over every other LLF on the basis of one per LLF *pair*. Paired frames must be numerically adjacent (eg, LLF 00 and LLF 01, LLF 08 and LLF 09, etc).

Partially Paired LLFs

3.59 Partially paired LLF configurations are extremely difficult to administer because two separate loading divisions must be established. Load and service can be developed for each division, but assignment procedures cause problems. Differences

in capacities change the class-of-service distribution requirements for each group.

3.60 When an odd number of LLFs exist in a paired LLF office, care must be taken to assure that the nonpaired LLF is not overloaded since its capacity (without special cabling arrangements) is less than that of the paired frames.

3.61 Regardless of future configuration plans, it is recommended that an attempt be made to balance classes of service over as many LLFs as possible. Unpaired LLFs should then have fewer lines assigned until they are paired. In the event that nonpaired LLFs are converted to paired LLFs, load balancing can be achieved easily by directed assignment procedures rather than costly line transfers.

Centrex

3.62 Intra-Centrex C.O. traffic is completed between LLF locations via intraoffice trunks. Traffic generated by this community of interest should be spread across all LLFs to prevent peak calling hour blockages. Rate treatment, as well as the class of service, is a further consideration in planning Centrex C.O. customer LLF distribution.

3.63 Intra-Centrex C.U. traffic is completed via switching equipment located on the customer premises and therefore does not utilize central office equipment. Centrex C.U. incoming and outgoing traffic is completed over high usage LLP and ninth level trunks which must be properly spread over all LLF.

Unigaugage

3.64 Unigaugage lines must be assigned to horizontal groups equipped with range extenders. Unless the office is new, it is impossible to have a good spread of unigaugage lines over all line link frames. Offices having small numbers of unigaugage long loop lines tend to have more balance problems caused by heavy intragroup calling because of a high community of interest. As more and more new line link frames are provided to serve unigaugage customers, these problems tend to diminish.

3.65 One feature has been provided to reduce the impact of some of these administrative problems. It permits vertical groups in a unigauged horizontal group to be used for short loop lines. Utilization of this feature may increase the requirement for additional unigauged horizontal groups. However, it provides a greater mix of lines and reduces administrative difficulties.

E. Special QCL Determination

3.66 This part provides guidelines to establish quality control limits in offices having *multiple loading divisions*.

3.67 Multiple loading divisions are not recommended in an office unless differences in one or more of the following items have a significant impact on the QCLs developed:

- (a) Capacities
- (b) LLF sizes (see *Note*)
- (c) Rate treatments
- (d) Features (TOUCH-TONE, dial tone first, etc)
- (e) Partially paired LLFs

Note: If the approaches to loading different size LLFs described in 3.48, 3.50, and 3.51 do not prove to be effective, it may be necessary to create separate loading divisions.

3.68 Since no standard measuring devices exist to determine individual loads carried in offices with two loading divisions (other than partially paired), a formula may be used whereby average holding time and percent of engineered capacity for each loading division can be determined. The formula utilizes a modified Total to Sample (T/S) channel validation chart. The chart is basically used to plot an average T/S ratio for each loading division. The plotted T/S ratio for each division is then used to apportion the total office/sample channel ratio and total office load (CCS/LLF) to each loading division.

3.69 The resultant AHT and percent engineered capacity of each loading division is then applied to the same AHT and QCL tables used for single loading division offices.

3.70 Following is an example of the method used to determine the load carried per loading division in an office having two different sizes of LLFs.

Parameters:

Total LLFs = 41
 LLFs-LDa = 22 (490s)
 LLFs-LDb = 19 (390s)
 Capacity = 1500 CCS/LLF

Step 1

Establish Grouping Line
 Ro = T/S ratio for the office
 SUo = Avg. Sample Usage for the office
 Given:
 Ro = 3.57 SUo = 270

These values are plotted on the chart of Figure 3. A line is then drawn through this plot point parallel to the given line. This becomes the characteristic line for the office.

Step 2

T/S Ratio and CCS/LLF-LDa

Plot the average sample usage for LDa (SUa) along the office line. At this point read across to the vertical for a proper T/S ratio.

Given: SUa = 276
 Find: T/S ratio (Ra) = 3.62
 Calculate: Ra X SUa = CCS/LLFa
 3.62 X 276 = 999

Step 3

Percent of Capacity — LDa

$$\text{Percent of Capacity} = \frac{\text{CCS/LLFa}}{\text{Capacity}} \times 100$$

$$= \frac{999}{1500} \times 100 = 67\%$$

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Step 4

AHT — LDa

Given: $R_o = 3.57$ $R_a = 3.62$
 $LLF_o = 41$ $LLF_a = 22$
 Sample P.C. Total Office (SPCo) = 8083

Calculate: $SPC_a = \frac{R_a}{R_o} \times SPC_o \times \frac{LLF_a}{LLF_o}$

$$SPC_a = \frac{3.62}{3.57} \times 8083 \times \frac{22}{41}$$

$$= 4398$$

$$AHT_a = \frac{SU_{LDa}}{SPC_a} \times 100$$

$$= \frac{6072}{4398} \times 100$$

$$= 138 \text{ sec.}$$

Step 5

T/S Ratio and CCS/LLF — LDb

Plot the average sample usage for LDb (SUb) along the office line.

Given: $SU_b = 262$

Find: T/S Ratio (R_b) = 3.53

Calculate: $R_b \times SU_b = CCS/LLF_b$
 $3.53 \times 262 = 925$

Step 6

Percent of Capacity — LDb

$$\text{Percent of Capacity} = \frac{CCS/LLF_b}{\text{Capacity}} \times 100$$

$$= \frac{925}{1500} \times 100 = 62\%$$

Step 7

AHT — LDb

Given: $R_o = 3.57$ $R_b = 3.53$
 $LLF_o = 41$ $LLF_b = 19$
 SPCo = 8083

$$SPC_b = \frac{R_b}{R_o} \times SPC_o \times \frac{LLF_b}{LLF_o}$$

$$= \frac{3.53}{3.57} \times 8083 \times \frac{19}{41}$$

$$= 3701$$

$$AHT_b = \frac{SU_{LDb}}{SPC_b} \times 100$$

$$= \frac{4985}{3701} \times 100$$

$$= 135 \text{ Sec.}$$

3.71 Develop QCLs for each loading division.

	<u>% Cap.</u>	<u>AHT</u>	<u>QCL</u>
LDa	67	138	32
LDa	62	135	34

Since each division has a different QCL, separate loading divisions should be maintained. When calculations of percent capacity and AHT indicate that both groups have the same QCL and characteristics, combine them for one loading division.

Partially Paired LLF

3.72 The means to establish separate loading divisions in partially paired line link frame offices is readily available on a standard basis since separate measurement capabilities are provided for each division. The nonpaired LLFs have less call carrying capacity than the paired LLF and must be administered accordingly. Total office

CCS in a partially paired office is computed using the following registers provided on a standard basis.

$$\begin{aligned} \text{T/S ratio (Paired)} &= \frac{\text{Mkr. Total Channel — (Paired)}}{\text{Mkr. Sample Channel — (Paired)}} \\ \text{T/S ratio (Non-Paired)} &= \frac{\text{Mkr. Total Channel — (Non-Paired)}}{\text{Mkr. Sample Channel — (Non-Paired)}} \end{aligned}$$

The total office CCS for each loading division will then be computed as shown in 2.33.

F. Load Balance Without Usage Measuring Devices

3.73 This part provides guidelines to follow in traffic units without usage measuring devices installed, full access to existing measurement equipment or inoperative devices.

3.74 The best possible balance that can be achieved in an entity is established by spreading each category, such as class of service and rate treatment, across all LLF's. (As stated in 3.37.)

3.75 Feature restrictions must be accounted for, and a proper spread must be accomplished within these limitations.

3.76 Fine tuning, which is normally provided by the interpretation of usage data, cannot be developed in the same manner. Instead, this fine tuning is dependent upon interpretation of data recorded from various traffic registers and special studies. Since these data do not have the characteristics of precise load indications, the good judgment of the network administrator is a most important factor in maintaining adequate balance.

Traffic Registers and Special Studies

3.77 Measuring devices are available (eg, portable TUR and modified line insulation test frame [LIT]) for special study purposes. However, each is limited by the amount of items that can be studied at any given time due to machine limitations. In most offices with this measurement capability,

it is impossible to measure all of the line link frames and/or horizontal groups at one time.

3.78 If a modified line insulation test frame (LIT) is available, various traffic counts can be taken which include the following:

(a) Line link office count (LLOC) provides usage for all line links in the office. The line link office count feature makes a busy test every 3 minutes on all links (channels) in every line link frame. It starts counting in horizontal group "0" in each frame and progresses through horizontal group "9." The busy links found are scored on the ten busy line registers.

(b) Line link frame count (LLFC) provides usage per frame for ten or less frames at a time. Results obtained are used for determination of over- and under-loaded frames in relation to the average of the ten frames being measured.

(c) Line link horizontal count (LLHC) provides the usage per horizontal group for one frame at a time. Results obtained are used to determine the light and heavy groups within a frame.

3.79 Although there is a limitation of studying up to ten frames at one time, it is possible to rotate LL00 through LL09 in one week, to LL10 through 19 the following week until all line link frames in the office have been studied. After it has been determined that a frame is out of balance in relationship to the other frames in the office, a LLHC can be taken up to pinpoint the heavy and light groups in the frame.

3.80 In addition to the above, or if the above are not available, the following traffic registers could aid in effecting proper load balance:

(a) Line link frame load (one per LLF)—These registers are scored by the completing marker whenever they (1) make an attempt on an outgoing or intraoffice class call to set up a connection between a customer line equipment and a trunk and (2) find that a specified number of the line links serving the horizontal line group in which the calling line is located are busy.

Note: The busy line link measurement can be varied to produce different results.

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(b) Horizontal line group (ten registers which may be associated with any line link frame by operation of a key)—These registers will indicate which horizontal groups have five or more busy links when a completing marker is attempting to establish a connection on an originating class call.

3.81 A computer printout (CTRAP) is available from the maintenance service center which compiles all customer reports including Code 5 (central office trouble), Code 7 (no trouble found outside), and Code 8 (no trouble found inside). Analyzing this printout with the various customer reports as back-up may indicate an imbalance if it is determined that the reports are generated from a particular horizontal group or from a particular class of service.

3.82 After it is determined that a horizontal group is out of balance, an analysis of the lines could be made which may pinpoint the particular subscribers in the horizontal group generating the high usage.

G. Main Distributing Frames

3.83 This part provides basic information regarding the main distributing frame (MDF) and its impact upon office balance.

3.84 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.

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

3.86 The initial layout of an MDF and subsequent additions of cables and line equipments should be planned to optimize 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 and administered with extreme care.

3.87 The network administrator should establish appropriate inter- 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.

3.88 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 inter- and intradepartmentally. Constant analysis is required to insure that procedures are achieving the maximum utilization of short jumpers and the goal of good load balance.

3.89 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.

Conventional Frames

3.90 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, for terminating line equipment and, where appropriate, directory numbers.

3.91 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.

3.92 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 on this subject, refer to Bell System Practices Section 680-830-010.

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

- (a) Spreading cable complements across several verticals.
- (b) Locating each entity on a different shelf, one above the other, in multientity buildings.

3.94 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.

COSMIC Frame

3.95 The common systems main interconnecting (COSMIC) is a main distributing frame which terminates exchange cables and tie cables. It is associated with No. 1 ESS, No. 1 and 5 crossbar, and step-by-step line equipment.

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

3.97 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.

3.98 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.

3.99 The COSMIC frame design depends on preferential assignments which combine load balance and class-of-service requirements with short jumper concepts. This method, must be fine tuned to do the total load balance job as it is based on an average CCS/MS for each class of service.

H. Trunk Link Frame Balance

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

3.101 Essentially, the concepts outlined in Part 2, Principles of Load Balance, are the same for TLFs. ***Loads on trunk switches should be compared to the average and an attempt made to bring all switches to that average.*** However, the QCL tables (Fig. 1) do not apply. Quality control limits for trunk switches have not been developed, but are expected to be more narrow than the limits for HGs, since the traffic loads on switches are substantially higher than the load on HGs. Until standard QCL values are established, it is recommended that individual switch usage be analyzed in relation to design capacity and to the average switch usage in the entity.

3.102 Establishing and maintaining TLF balance are included in the following job functions:

Network Administrator—Responsible for overall service in the entity, performing a surveillance role for trunk provision and balance.

Network Design Engineer—Responsible for providing enough equipment (both TLFs and trunk equipment) to maintain service objectives.

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Trunk Administrator—Responsible for servicing trunk groups to maintain trunk service levels, forecasting future requirements and balancing TLFs.

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 practice the functions are separated as shown.

3.103 In following the principles of load balance, trunks 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 for the initial installation and for each subsequent addition of TLFs.

3.104 The pattern of TLF balance in a No. 5 crossbar office is, to a great degree, the result of initial trunk equipment arrangements and assignments. Subsequent trunk additions may not be able to correct errors in the initial phase. The trunk administrator does not have the routine day-to-day control over TLF balance, as is the case with LLFs where there is daily service order activity.

TLF Equipment Configuration

3.105 The TLF in a No. 5 crossbar system contains crossbar switches which connect trunks and originating registers to junctors. The TLF consists of two types of switches, namely trunk switches and junctor switches. Junctors provide the talking paths between line link and trunk link frames. Trunks and originating registers are associated with horizontals of the trunk switches. Paths between junctor and trunk switches are called trunk links and are cabled to the verticals of junctor and trunk switches.

3.106 The trunk switch bay of a TLF contains ten 200-point, 6-wire switches. The verticals provide terminations of 200 trunk links and horizontals provide terminations for 160 trunks and originating registers.

3.107 As approximately the same number of junctors are provided from each trunk link frame to each line link frame, it is important to maintain an even balance of busy hour traffic among trunk link frames and among line link frames.

3.108 The number of trunk link frames per originating entity is determined by a consideration of the total number of proposed trunks, originating registers and the total office busy hour CCS (O + T). A minimum of two TLFs is provided per installation. Heavy traffic loads on the TLFs will increase the percent IML beyond the point of satisfactory service.

Balance Procedures

3.109 It is recommended that an equal number of working trunks (by trunk 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. A heavy trunk is defined as one having 67 percent or more BH usage, a **medium** trunk 33 percent to 67 percent BH use, and a **light** trunk less than 33 percent BH use. (Reference Traffic Facilities Practices Division K.)

3.110 The determination of **heavy**, **medium** or **light** trunk loads also requires an understanding of how switching machines select trunks. This determination is largely the responsibility of a trunk administrator.

3.111 No. 5 crossbar entities pick originating trunks and originating registers on a **random** basis. Random selection is assumed to impart equal loads to all equipment, trunks or originating registers, within a group. Since this even distribution is standard, simply assign equal numbers of these items to each TLF and switch whenever possible.

3.112 Incoming trunks to No. 5 crossbar entities are not always selected on a random basis at the originating units and must be treated accordingly. The following list provides information about outgoing trunk selection by type of switching system:

<u>System</u>	<u>Outgoing Trunk Selection</u>
Step-by-Step (SXS)	Sequential/Random (graded multiple)
Panel	Sequential (graded multiple)
No. 1 Crossbar	Sequential
No. 5 Crossbar	Random
No. 4 Crossbar	Sequential
Crossbar Tandem	Sequential
No. 1 ESS	Random (2-way trunks sequential)
No. 2 ESS	Random (2-way trunks sequential)

3.113 Sequentially and graded multiple trunks will carry a heavier CCS load per trunk on the first choices, a lighter CCS load per trunk on the last choices, and some intermediate value for trunks selected in the middle of the sequence.

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

3.115 The most appropriate way to balance trunks from other offices is to spread them over all TLFs, as follows:

- (a) Trunks within one group should be evenly distributed over all TLFs 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 TLFs. The most accurate way in which to keep track of the expected load is to assign CCS values to each type of trunk.

3.116 TLF must be viewed in relation to their groupings. For example, tertiary (triple) operation may have as many as three TLFs sharing the same junctors from all LLFs. It is also possible,

although not desirable, to have only one TLF utilizing a junctor group within this configuration. When such a condition exists, there will be an inherent problem that must be cared for.

3.117 Certain guidelines must be followed by network designers when changing office junctor patterns. If they are not followed and stipulated in the Western Electric order, severe service problems could result. These guidelines are as follows:

- (a) When a pattern change results in fewer junctors to each TLF group, existing **loaded** TLFs should be moved to the new junctor groups (face frame).
- (b) If there is a pattern change as outlined in (a), and it is not feasible to reassociate existing TLFs, then working trunks should be moved to the new face TLFs as a minimum. In order to achieve the best possible condition with this situation, all TLFs both old and new, should have the trunks and originating registers spread equitably across each.
- (c) Where originating registers or trunks are too few to spread across all TLFs, it is recommended that they be divided equitably across each TLF group. This procedure will minimize service problems during severe overloads.

3.118 The approaches taken in 3.114 and 3.117 should maximize the chance of success in setting up any network connection, especially those for which retrials are possible; ie, splitting a trunk group among the TLFs will often permit use of a new junctor group for each successive trial.

3.119 Initially, network administrators can compare total LLF usage with the sum of usages for TLFs. Any major discrepancy should be analyzed in detail by reviewing each trunk switch individually.

3.120 Another approach is taken by comparing actual trunk switch usage with the appropriate engineering capacity.

Example:

Given:
 $CCS/Switch = 252 \text{ CCS/HR}$
 $252 \times 10 \text{ Hrs.} = 2520 \text{ CCS}$

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An office at 50 percent of main station capacity should not be expected to have trunk switch loads at or near 100 percent of capacity. Offices nearing capacity, on the other hand, could be expected to have some load units of this magnitude.

3.121 The most meaningful approach to loading, regardless of the percent of capacity, is to load toward the best office average. This average should be weighted over several weeks to be stable. Loading should then be controlled to achieve that average within each trunk switch. Trunks should only be transferred from TLFs with extremely heavy loads.

3.122 Switch usage data should be used for directing trunk assignments into the least loaded grids. Until standard QCL tables are developed, it is recommended that ± 15 percent of the average switch CCS measured in each study be established as the objective range for all switch loads. Assignment of new trunks should be made in the following order of preference. Forms E-6663 and E-6664 are provided for selection of switches on a manual basis. Examples of the filled-out forms are shown in Figures 4 and 5.

Choice	Switches
1st	Below 85 percent of average
2nd	Between 85 and 100 percent of average
3rd	Between 100 and 115 percent of average
4th	Over 115 percent of average

3.123 TLFs that are loaded to a low percent of capacity (CCS) and not experiencing incoming matching loss (IML) over objective, can tolerate some switch imbalance. Proper assignment procedures should suffice, with expensive trunk transfers minimized or eliminated completely. TLFs that are out of balance will experience some loss in CCS capacity and are subject to IML at a lower percent of load. Trunk transfers may then be required to increase capacity and reduce the propensity for service deterioration. When an office is experiencing high IML at a low load level, transfers should be mandatory unless there is some other plan for relief within a short period of time.

3.124 As stated previously, studies are not complete with regard to TLF balance; therefore, no official QCL or index can be provided. In addition, capacity reduction tables are unavailable and any guidelines at this time would have to be purely arbitrary. Until these items are provided, it is recommended that each company establish benchmarks for offices above 90 percent of capacity. A percent of groups over 115 percent of the average should be selected for the guidance of trunk administrators. This practice will be revised when further information becomes available.

Mechanization

3.125 The BIS-LBS mechanized program will provide two printouts for analysis when deciding where to assign or remove trunks. The first printout will show an ordered twelve-week history file for TLF switches. The second printout is a CCS corrective action guide which will be available for use in a similar manner as the one for horizontal groups.

4. DATA COLLECTION

A. Data Acquisition

4.01 Load balance data for No. 5 crossbar traffic units are collected on registers or some mechanized system, such as EADAS, and processed in a manual or mechanized mode. TURs can provide the data on a daily basis, or through the use of a limited scan feature, on a total week basis. Total week readings reduce the total clerical effort required.

4.02 The measurement is a sample (Channels 0 and 5) of the total line links in each HG. In order to determine the total HG CCS this value must be multiplied by the Total/Sample ratio.

Data Collection Frequency

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

- (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 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.

B. Missing or Incomplete Data

4.04 Normally, load balance data are scheduled for collection on a total week basis, but there are times when it may be appropriate to schedule it daily. Such daily information is desirable as a protection against loss of data due to TUR or mechanization problems. In a register film environment this method increases the clerical effort and should be avoided unless absolutely necessary.

4.05 There are circumstances when the data for the study week may be incomplete as a result of lost or damaged tapes and so on. The criterion for data reporting in compliance with 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 the previous week may be used, if available.
- (c) As a last resort, only 2 hours with the same traffic characteristics from the previous collected week may be used.

C. Validation of Readings

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 methods to determine if the measurements are reasonable.

(a) One method is to compare actual horizontal group usage with engineered capacity of that horizontal group. The busy hour engineered CCS per horizontal group must be multiplied out to state the 10-hour measurement in order to be comparative. Once the percent 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 percent of capacity is relative to the expected load. An office at 50 percent capacity should not expect to find horizontal group loads nearing capacity, whereas an office running at greater than 75 percent would expect such horizontal group loads. Service indicators associated with load balance would be expected infrequently (if the office is balanced) in an office at 50 percent of capacity and more frequently as capacity is approached.

(b) Another method used is applying a comparative check of the register readings. A marked change in the percentage would merit investigating the data (trends, unusual readings, etc) changes in traffic patterns, or comparisons to other data (originating + terminating, etc).

(c) In the mechanized mode, as should also be done in the manual environment, a validation check will be made to ensure that each register is scoring. A check will also be made to ensure there are no zero register readings or readings that exceed 2 X 36 X number of data hours.

D. Register Grouping

4.07 Although not desirable, it is possible to effect economies in the provision of traffic registers by installing the register grouping feature. This feature permits using the same traffic registers to record usage, for example, on line link frame horizontal groups during one study period and on trunk link frame switches and the subscriber lines of one or two horizontal groups during another study period. Thus, the number of traffic registers that must be provided for load balance can be reduced. Usage data for engineering purposes is required on a daily basis; therefore, traffic registers on which such usage is scored are never assigned on a register group basis.

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4.08 A maximum size No. 5 X-Bar marker group of 60 line link frames and 30 trunk link frames actually requires 900 traffic registers exclusively for balancing purposes. At the expense of normally required time consistent LLF and TLF "LB" data collection, register grouping allows a reduction in the required LB registers to 600 as follows:

<u>Period</u>	<u>Items to be Measured</u>	<u>Registers Required</u>
1st Week	Horizontals for 60 LL	600
2nd Week	Horizontals for 30 TL	300
	Customer lines for 2 Horizontal Groups	118

4.09 All equipment in a loading division that is measured for LBI reporting should be arranged to collect data simultaneously. Register grouping does not allow this to be accomplished, and it is not recommended.

4.10 Problems with multiple loading divisions requiring two weeks of data may be further compounded because of the lack of a valid side hour. It is entirely possible that a loading division with register groupings may require four weeks of data to be complete. This, of course, is an undesirable situation and should be corrected as soon as possible.

5. BALANCE TECHNIQUES

A. Manual Procedures

5.01 There may be instances when it may be necessary to manually compute the load balance scores and an *LBI* (see Part 6). 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) (Fig. 6) is used to develop weekly CCS

weekly CCS ranges for a loading division, as discussed previously in Part 2G. An example of the filled out form is shown in Fig. 6.

5.03 Form E-6616, *Load Unit—Load Balance Chart*, shown in Fig. 7, is used to record the load unit weekly scores, penalty points and hot spot penalty points. An example of the filled out form is shown in Fig. 7.

Ordering Forms

5.04 "E" Forms (Code A) utilized by this practice may be ordered from your local Western Electric service center as follows:

Order Wording/Multiple

Form E-6615 (5-75), 50 per pad, 2 pads per package; unit 100 forms.

B. Mechanized Procedures

5.05 A mechanized method has been prepared to provide procedures for the proper balance and assignment of lines in addition to computing an LBI. This method is called the load balance system (LBS) and is a Business Information (BIS) product which includes full user documentation.

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

- (a) Service observing end-of-month date
- (b) Number of data hours
- (c) Average holding time
- (d) Capacity
- (e) Average office CCS/MS (ACCS) or lowest office CCS/MS (LCCS) (see 5.29, 5.35, and 5.36)

5.07 Once parameter and usage information have been inputted to the mechanized program, four basic user reports are available in an off-line mode.

(a) *Load Balance Summary*

Provides a summary by HG and by LLF of

the latest week's (CCS) load, percent of capacity, CCS corrective action and weekly scores for the past twelve weeks.

- (b) **Study Data Report**
Provides by loading division, the usage and the score of each HG for the study period requested. This may be necessary when there is a data validation question.
- (c) **Assignment Guide Report**
Develops a *line assignment guide* to be used for line assigning purposes. The output is discussed in further detail in Part 5C of this section. A similar *removal guide* is developed to identify potential line transfers from overloaded HGs. For line assignment purposes, this report should be requested at least monthly and supplemented with reports as required.
- (d) **Load Balance Index Report**
This report combines the most current load balance data input with previous index reports saved in memory and calculates the balance and hotspot penalty points for the current service observing month. The BIS-LBS will automatically assemble all required information in appropriate format. The LBI report may be requested on an unofficial basis for administrative purposes.

5.08 Flagging capabilities are available for data validation purposes. The system automatically flags HG data that register as follows:

- (a) "0" usage
- (b) Usage that exceeds 2 X 36 X number of hours input
- (c) As a hotspot following the criterion of 210 X number of hours

C. Corrective Action

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

5.10 The proper corrective action must be established in a specific sequence to be most meaningful:

- (a) Review the 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: A TUR detector test will only check leads from the TUR to registers. A continuity test must be made to check the entire circuit operation.*)
- (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* are required, several indicators should be analyzed to determine the proper lines to move.

Directed Line Assignments

5.11 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 5.23.

Outward Movement

5.12 Disconnected lines would be another source for maintaining balance among HGs. When lines are disconnected in heavily loaded units it serves to equalize the carried CCS among groups. On the other hand, disconnects in lightly loaded HGs serve to heighten the imbalance. This is discussed in 5.32.

Line Equipment Transfers (LET)

5.13 Line equipment transfers can accomplish the same result as directed line assignments. As a matter of fact, this corrective action produces

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quicker results. However, LETs are expensive to implement and therefore should be the last choice method of corrective action.

CCS Corrective Action List

5.14 Regardless of the method employed to achieve balance, an appropriate CCS corrective action must be calculated to determine whether or not that correction is sufficient. The principle 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.

5.15 This part will advance methods to develop CCS corrective values in load units for manual and mechanized systems and to provide two approaches to the development of a CCS corrective action list.

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

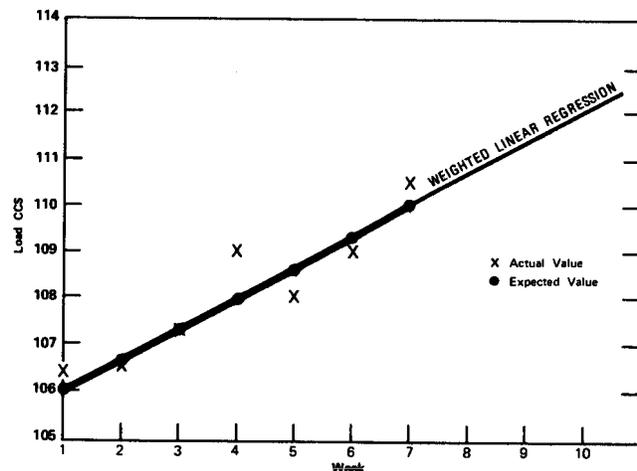
- (a) It should be based on CCS measurements rather than scores. Differences in loads, even among groups with the same scores, could then be detected.
- (b) It should be sensitive to usage trends to avoid future overloads.
- (c) It should apply more weight to recent measurements since they are more representative 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.

Mechanized Procedure

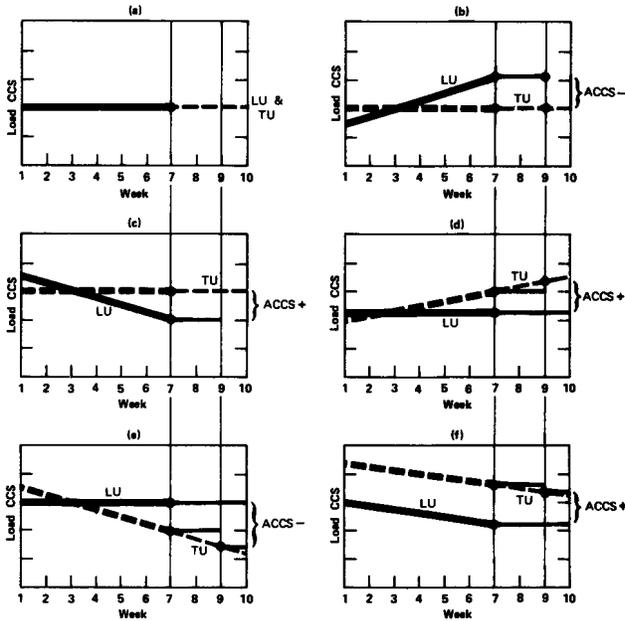
5.17 The mechanized data processing procedure developed for the new load balance index plan incorporates all four of the desirable features outlined in 5.16.

5.18 Basically, the mechanized procedure takes historical load unit information and utilizes a weighted linear regression to estimate **expected** loads on these units, as shown on the following graph. 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 1) to the newest (week 7).



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.

5.19 A similar approach is taken for the average load unit (LU) load in the traffic unit (TU). Individual load units are then compared to their traffic unit line to determine the CCS amount to be added or removed (See Graphs (a) through (f) below).



Corrective Action Examples

5.20 CCS corrections are applied to the load units depicted on graphs (a) through (f) 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 9, this difference during week 7 should be removed. This amount is taken at week 7 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 9, this difference during week 7 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 9 and the difference during week 7 is added, there will be a slight undercorrection. 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 9 and the difference for week 7 is subtracted there will be a slight undercorrection. 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 9 and the difference during week 7 is added there will be a slight overcorrection. Therefore, a smaller amount must be loaded into this unit.

5.21 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. These additional moves might have to be compensated for at a later date. Consequently, the computer will scale down all values derived in this manner.

5.22 Any method for scaling the CCS correction to be applied to load units would be fairly arbitrary. The procedure adopted for this practice is to scale the values by a factor based upon the variance of estimated CCS to be added or subtracted. Study results indicate that this procedure produces better load balance than the method used in the current plan.

Line Assignment Guide

5.23 The CCS corrective action, list for purposes of this section, will be referred to as a **Line Assignment Guide**. This is because it provides information to accomplish the ultimate requirement—assigning lines.

5.24 Typically corrective action lists are provided to the network administrator in an ordered

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fashion with the units that are most below average presented first, see below:

Example:

No. 5 Crossbar
Estimated CCS/MS = 4

<u>LLF</u>	<u>HG</u>	<u>CCS to Add</u>	<u>Lines to Add</u>
33	5	70	17
26	9	60	15
13	1	54	13
35	2	54	13
6	1	53	13
8	8	50	13
33	7	46	11
28	6	40	10

5.25 Unfortunately, the 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 the proper amount of lines are not available in each group, and how to use disconnect information.

5.26 This section will detail two alternative mechanized procedures that provide the network administrator with some guidance in answering these questions. Moreover, these procedures are features of the new load balance system (LBS) developed by BTL-BIS.

5.27 The first procedure presumes that the office is predominantly one broad class of service such as residence. This approach should only be taken when any of the following are true:

- (a) The deviation from this average CCS per main station (CCS/MS) is minimal.
- (b) Previous SLU studies are unavailable and approximations of CCS/MS for each class of service are impossible.
- (c) There is a need to reduce the length of the line assignment guide. (Requires some expertise in its application).

5.28 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.

Alternative Procedure No. 1

5.29 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, let us consider a No. 5 crossbar unit with 390 size line link frames, an actual load of 1400 CCS/LLF and 350 MS/LLF. The average CCS/MS would be

$$\text{Average CCS/MS} = \frac{1400 \text{ CCS/LLF}}{350 \text{ MS/LLF}} = 4.0$$

Note: The working main station count must include trunks such as, PBX "Dial 9" trunks which have an appearance on an LLF.

5.30 The line assignment guide is then constructed as illustrated in Table A. A list generated in this fashion provides a desired order of assignments into load units. This is achieved in the computer program by the following:

- (a) Selecting a load unit which needs the largest CCS addition for the next assignment.
- (b) Subtracting the average CCS/MS from the CCS correction of the unit just selected.
- (c) Going back to (a).

5.31 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 equipment selected is recorded in the appropriate columns of the guide as it is 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.

5.32 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 to this disconnect activity impact on CCS. This involves keeping track of the number of disconnects within designated HGs 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 HGs with a consistent low usage trend. As disconnects occur within these HGs, they should be noted on the guide and entered on an assignment list.

— or —

- (b) Shortages of spare equipment (NA's) begin to appear when the traffic unit is working at a high percent 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 there is still a requirement for additional CCS.

5.33 The foregoing procedure specifies the order of assignment of lines by a network administrator. It is still the administrator's responsibility to determine both the class of service of available lines and how many lines should be given to the assignment office.

Alternative Procedure No. 2

5.34 In Procedure No. 1, each customer is assumed to generate approximately the same usage. This is not always the case. Offices that include several broad classes of service or possess a few distinct classes, may not find it effective to load by average office CCS. In this case, Alternative Procedure No. 2 is developed to distinguish between lines with different load characteristics.

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

- (a) Subscriber Line Usage (SLU) studies

- (b) Utilization of CCS/MS for 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 then constructed in a manner somewhat similar to the one for procedure No. 1:

- (a) Select a load unit which needs the largest CCS addition for the next assignment.
- (b) Subtract LCCS from the CCS correction of the unit just selected.
- (c) Go back to (a).

5.38 An example of an assignment list established according to this procedure is shown in Table B. 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 filled in as described in 5.31. 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 is 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 5.32.

Manual Procedure

5.39 In manual data processing environments it is uneconomical to expend clerical time to achieve all four of the features mentioned in 5.16. The approach shown in the next few paragraphs is advanced as a possible compromise for manual offices.

5.40 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

SECTION 5d(4)

recent data more heavily than older data and attempts to correct group loads to average usage without overcorrecting.

5.41 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:

$$\text{CCS Correction} = \frac{\text{QCL} \times \text{Average CCS} \times \text{F}}{3}$$

QCL = Quality Control Limit of the loading division

Avg. CCS = Average load unit load within the loading division during the week in which action will be taken;

$$\frac{\text{Average Load Unit Load}}{\text{No. of Study Hours}}$$

(Note: If this is not available, use the latest actual week's average load unit load.)

F = Factor derived from the scores and knowledge of study intervals.

3 = Fixed factor.

5.42 Form E-6617, Fig. 8, is provided for use in the determination of CCS corrective values on a manual basis for each load unit. An example of the filled out form is shown in Fig. 8.

5.43 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 that can be multiplied by each factor F for individual load units. F remains the only unknown and is determined in this manner:

First Study

Step 1:

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

$$\text{Corrective CCS} = \frac{\text{QCL} \times \text{Avg. CCS} \times \text{F}}{3}$$

<u>Score</u>	<u>Factor (F)</u>
± 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 below. 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.

Score	FACTOR (W)			
	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 Fig. 9 for each WSC value, depending upon the collection interval being used.

Step 8

Only seven F factors are possible for the second and subsequent studies: .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 the top of the appropriate column of Form E-6617.

$$\text{Corrective CCS} = \frac{QCL \times \text{Avg. CCS} \times F}{3}$$

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 8.

Step 13

Same as Step 9.

5.44 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 ways 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 5.24. Extreme care must be taken, however, when it is utilized.

5.45 If a score is unavailable for a group in a measurement period, it is suggested that the last study 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 1 and begin the process anew.

Line Transfer Guide

5.46 Line transfer guides are constructed in a manner similar to the line assignment guides and are used primarily for decisions regarding line equipment transfer (LET) activities. However, it starts at the most heavily loaded unit rather than the lightest one. The guide is developed using an ACCS or an LCCS, depending upon the degree of detail required for administrative purposes (see Table C).

5.47 Proceeding in order of removal, the network administrator would enter an indication beside each load unit under the selected column. For a No. 5 crossbar office, this indication would be the vertical group (VG), vertical file (VF) and class of service (CS). Disconnects should be accounted for before choosing lines to be transferred, in order to avoid any overcorrection as discussed in 5.32.

6. THE LOAD BALANCE INDEX (LBI)

6.01 The new load balance index replaces the current load balance index (LBI) and overall balance index (OBI) with a single integrated index called the load balance index (LBI). This new index applies to load units in all office types capable of terminating customer lines, eg, step by step, No. 1 crossbar, No. 5 crossbar, No. 1 ESS, 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. 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 attained. 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 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, +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 are entered into a table to determine the present LBI. The OBI is then ascertained from a table by entering LBI and service (either IML or DTS 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 necessary, 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 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).

LOAD BALANCE QUALITY CONTROL LIMITS BASED ON 10 HOUR DATA																												(MARCH 1975)
NO. 1 & 5 CROSSBAR																												
AVERAGE HOLDING TIME (SECS)	ACTUAL AVERAGE LOAD PERCENTAGE OF ENGINEERING LOAD																											
	30% TO 35%							36% TO 45%							46% TO 55%							56% TO 65%						
	LLF CCS CAPACITY							LLF CCS CAPACITY							LLF CCS CAPACITY							LLF CCS CAPACITY						
	1460 - 1660	1300 - 1459	1160 - 1299	1040 - 1159	940 - 1039	860 - 939	780 - 859	1460 - 1660	1300 - 1459	1160 - 1299	1040 - 1159	940 - 1039	860 - 939	780 - 859	1460 - 1660	1300 - 1459	1160 - 1299	1040 - 1159	940 - 1039	860 - 939	780 - 859	1460 - 1660	1300 - 1459	1160 - 1299	1040 - 1159	940 - 1039	860 - 939	780 - 859
0 - 70	32	34	36	38	40	42	44	28	29	31	33	35	36	38	25	26	28	29	31	33	34	23	24	25	27	28	30	31
71 - 90	37	39	41	44	46	48	51	32	34	36	38	40	42	44	28	30	32	34	36	38	39	26	28	29	31	33	34	36
91 - 110	41	44	46	49	51	54	57	36	38	40	42	45	47	49	32	34	36	38	40	42	44	29	31	33	35	37	38	40
111 - 130	45	48	51	53	56	59	62	39	41	44	46	49	51	54	35	37	39	42	44	46	48	32	34	36	38	40	42	44
131 - 150	48	51	55	58	61	64	67	42	45	47	50	53	55	58	38	40	42	45	47	50	52	34	37	39	41	43	45	47
151 - 170	52	55	58	62	65	68	71	45	48	51	53	56	59	62	40	43	45	48	51	53	55	37	39	41	44	46	48	51
171 - 190	55	58	62	65	69	72	76	48	51	54	57	60	63	66	43	45	48	51	54	56	59	39	41	44	46	49	51	54
191 - 210	58	62	65	69	73	76	80	50	53	57	60	63	66	69	45	48	51	54	56	59	62	41	44	46	49	52	54	57
211 - 230	61	65	68	72	76	80	84	53	56	59	63	66	69	73	47	50	53	56	59	62	65	43	46	49	51	54	57	59
231 - 250	63	67	71	75	80	83	87	55	58	62	65	69	72	76	49	52	55	59	62	65	68	45	48	51	54	56	59	62
251 - 270	66	70	74	79	83	87	91	57	61	64	68	72	75	79	51	54	58	61	64	67	71	47	50	53	56	59	62	65
271 - 290	68	73	77	81	86	90	94	59	63	67	71	75	78	82	53	57	60	63	67	70	73	49	52	55	58	61	64	67
291 - 310	71	75	80	84	89	93	98	61	65	69	73	77	81	85	55	59	62	66	69	72	76	50	53	57	60	63	66	69
311 - 330	73	78	82	87	92	96	*	63	67	71	76	80	84	88	57	60	64	68	71	75	78	52	55	58	62	65	68	72
331 - 350	75	80	85	90	95	99	*	65	70	74	78	82	86	90	59	62	66	70	74	77	81	54	57	60	64	67	70	74
351 - 370	78	82	87	92	97	*	*	67	72	76	80	85	89	93	60	64	68	72	76	79	83	55	59	62	66	69	73	76
371 - 390	80	85	90	95	*	*	*	69	74	78	82	87	91	95	62	66	70	74	78	82	85	57	60	64	67	71	75	78
391 - 410	82	87	92	97	*	*	*	71	75	80	85	89	93	98	64	68	72	76	80	84	88	58	62	65	69	73	76	80
411 - 430	84	89	94	*	*	*	*	73	77	82	87	91	96	*	65	69	73	78	82	86	90	59	63	67	71	75	78	82
431 - 450	86	91	97	*	*	*	*	74	79	84	89	93	98	*	67	71	75	79	84	88	92	61	65	69	73	76	80	84
451 - 470	88	93	99	*	*	*	*	76	81	86	91	96	*	*	68	72	77	81	86	90	94	62	66	70	74	78	82	86
471 - 490	90	95	*	*	*	*	*	78	83	88	93	98	*	*	70	74	78	83	87	92	96	64	68	72	76	80	84	88

* FOR QCL DATA IN THIS RANGE CONSULT WITH AT&T COMPANY STAFF

LOAD BALANCE QUALITY CONTROL LIMITS BASED ON 10 HOUR DATA																												(MARCH 1975)
NO. 1 & 5 CROSSBAR																												
AVERAGE HOLDING TIME (SECS)	ACTUAL AVERAGE LOAD PERCENTAGE OF ENGINEERING LOAD																											
	66% TO 75%							76% TO 85%							86% TO 95%							96% AND UP						
	LLF CCS CAPACITY							LLF CCS CAPACITY							LLF CCS CAPACITY							LLF CCS CAPACITY						
	1460 - 1660	1300 - 1459	1160 - 1299	1040 - 1159	940 - 1039	860 - 939	780 - 859	1460 - 1660	1300 - 1459	1160 - 1299	1040 - 1159	940 - 1039	860 - 939	780 - 859	1460 - 1660	1300 - 1459	1160 - 1299	1040 - 1159	940 - 1039	860 - 939	780 - 859	1460 - 1660	1300 - 1459	1160 - 1299	1040 - 1159	940 - 1039	860 - 939	780 - 859
0 - 70	21	22	24	25	26	28	29	20	21	22	23	25	26	27	18	20	21	22	23	24	25	18	19	20	21	22	23	24
71 - 90	24	26	27	29	30	32	33	23	24	25	27	28	30	31	21	23	24	25	27	28	29	20	21	23	24	25	27	28
91 - 110	27	29	30	32	34	35	37	25	27	28	30	32	33	35	24	25	27	28	30	31	33	23	24	25	27	28	30	31
111 - 130	29	31	33	35	37	39	41	28	29	31	33	35	36	38	26	28	29	31	33	34	36	25	26	28	29	31	33	34
131 - 150	32	34	36	38	40	42	44	30	32	34	36	37	39	41	28	30	32	33	35	37	39	27	28	30	32	33	35	37
151 - 170	34	36	38	41	43	45	47	32	34	36	38	40	42	44	30	32	34	36	38	40	41	29	30	32	34	36	38	39
171 - 190	36	38	41	43	45	48	50	34	36	38	40	42	44	47	32	34	36	38	40	42	44	30	32	34	36	38	40	42
191 - 210	38	40	43	45	48	50	52	36	38	40	42	45	47	49	34	36	38	40	42	44	46	32	34	36	38	40	42	44
211 - 230	40	42	45	48	50	53	55	37	40	42	44	47	49	52	35	37	40	42	44	46	49	33	36	38	40	42	44	46
231 - 250	42	44	47	50	52	55	57	39	41	44	46	49	51	54	37	39	41	44	46	48	51	35	37	39	42	44	46	48
251 - 270	43	46	49	52	54	57	60	41	43	46	48	51	53	56	38	41	43	46	48	50	53	36	39	41	43	46	48	50
271 - 290	45	48	51	54	57	59	62	42	45	47	50	53	55	58	40	42	45	47	50	52	55	38	40	42	45	47	50	52
291 - 310	47	50	52	55	58	61	64	44	46	49	52	55	57	60	41	44	46	49	52	54	57	39	41	44	46	49	51	54
311 - 330	48	51	54	57	60	63	66	45	48	51	54	57	59	62	42	45	48	51	53	56	59	40	43	45	48	51	53	56
331 - 350	50	53	56	59	62	65	68	46	49	52	55	58	61	64	44	47	49	52	55	58	60	42	44	47	49	52	55	57
351 - 370	51	54	57	61	64	67	70	48	51	54	57	60	63	66	45	48	51	54	57	59	62	43	45	48	51	54	56	59
371 - 390	52	56	59	62	66	69	72	49	52	55	58	62	65	68	46	49	52	55	58	61	64	44	47	49	52	55	58	61
391 - 410	54	57	61	64	68	71	74	50	54	57	60	63	66	69	47	50	53	57	60	63	65	45	48	51	54	57	59	62
411 - 430	55	59	62	66	69	73	76	52	55	58	61	65	68	71	49	52	55	58	61	64	67	46	49	52	55	58	61	64
431 - 450	56	60	64	67	71	74	78	53	56	59	63	66	70	73	50	53	56	59	62	66	69	47	50	53	56	59	62	65
451 - 470	58	61	65	69	72	76	80	54	57	61	64	68	71	74	51	54	57	61	64	67	70	48	51	54	58	61	64	67
471 - 490	59	63	66	70	74	78	81	55	59	62	66	69	73	76	52	55	59	62	65	68	72	49	52	56	59	62	65	68

Fig. 1—Load Balance Quality Control Limits

INSTRUCTIONS FOR PREPARING FORM E-6618

Multiple Size LLF Class of Service Distribution

- 1 — Enter the name of the building.
- 2 — Enter the identification of the traffic unit.
- 3 — Enter the loading division designation, if applicable.
- 4 — Main Stations (MS) — Enter the projected number of main stations by broad class of service, business (B), residential (R) and coin (C). Coin used for No. 5 crossbar only. Total the main stations for the loading division (LD).
- 5 — CCS/MS — Develop a CCS/MS for each broad category with SLU studies, etc. Utilize the projected LD CCS/MS.
 b = Business CCS/MS r = residential CCS/MS
 c = coin CCS/MS
- 6 — CCS — Enter the product of lines 4 and 5 for each column B, R, C and LD. The sum of B, R and C must equal the CCS for LD. If not, the CCS/MS for each C of S must be reviewed. Approximations may be necessary.
- 7 — LLF Size — Enter the size LLF for each grouping, eg, 290, 390, etc.
- 8 — No. LLFs — Enter the number of LLFs within each group (L(1), L(2), and L(3)) and total LD.
- 9 — Terminations — Product of lines 7 and 8 for each group. Sum groups for a total.
- 10 — Percent Fill — Total Office

$$\% \text{ Fill} = \frac{\text{Projected Main Stations}}{\text{Total Terminations (Line 9)}} \times 100$$
 - Small LLFs (Column 1)
 Assume a maximum percent fill. This value should be as high as possible and is a company option. Values between 95 and 97% are recommended.
 - Larger LLFs (Columns 2 and 3)
 The actual percent fill for these groups will most likely be different than for small LLFs. However, for the purpose of a check to be made according to the instructions of 11d, use the same percentage as used for small LLFs.

11 — Working Terminals/LLF

— Total Loading Division

$$\text{Avg. WT/LLF} = \frac{\text{LD Main Stations}}{\text{Total LLFs}}$$

— Each LLF size group (1, 2 and 3)

$$\text{WT/LLF} = \text{Line 7 X Line 10}$$

- Notes:
- (a) If average WT/LLF is less than the smallest WT/LLF(1) for the smallest LLFs, all frames can be considered as being the same size. No further work is required on this form.
 - (b) If average WT/LLF is more than the smallest LLF WT/LLF (two size frames), further work will be required on this form.
 - (c) If average WT/LLF is more than the smallest LLF WT/LLF (three size frames), an attempt must be made to combine two of the three sizes for this procedure. Further work will be required on this form.

In general, the approach is to keep all LLFs loaded with approximately the same number and type of main stations. This may be accomplished, either by combining the small and medium frames, or combining the medium and large frames. When LLFs are combined into a group, extra terminations on the larger frames are assumed not to exist.

Small and Medium (Designated Small Frames)

$$\begin{aligned} \text{WT}(1, 2) &= \text{WT/LLF}(1) \times (\text{L}(1) + \text{L}(2)) \\ \text{WT}(3) &= \text{Total MS} - \text{WT}(1, 2) \end{aligned}$$

If WT(3) causes L(3) LLFs to be loaded to too high a level, try combining the medium and large frames.

Medium and Large (Designated Large Frames)

$$\begin{aligned} \text{WT}(1) &= \text{WT/LLF}(1) \times \text{L}(1) \\ \text{WT}(2, 3) &= \text{Total MS} - \text{WT}(1) \end{aligned}$$

- (d) If average percent fill is greater than the assumed percent fill (line 10), each frame group may have to possess different characteristics in order to maintain the proper CCS/LLF.

12 — CCS/LLF

— LD Average

$$\text{CCS/LLF} = \frac{\text{Line 6 (LD)}}{\text{Line 8 (Total)}}$$

13 — Working Main Stations/LLF — Small LLFs

No. 5 Crossbar

B(S) = Business Main Stations on small or combined small and medium LLFs

$$\text{Approximate B(S)} = \frac{\text{CCS/LLF} - r(\text{WT/LLF}) + \text{CN MS/LLF}(r-c)}{(b - r)}$$

Note: See instruction 11c for the proper WT/LLF to use for small LLFs in a three LLF size situation.

$$\text{VF(B)} = \frac{\text{Approx. B(S)}}{10} \quad (\text{Round up to the nearest integer})$$

No. 1 and No. 5 Crossbar

$$\text{Actual B(S)} = (\text{line } 10(1)) \times \text{VF(B)} \times 10$$

$$\text{Actual R(S)} = (\text{WT/LLF}) - \text{Actual B(S)} - \text{Actual C(S)}$$

14 — Working Main Stations/LLF — Large LLFs

B(L) = Business Working Main Stations on large or combined medium and large LLFs in a three LLF size situation.

$$B(L) = \frac{B - B(S) \times L(1)}{L(2) + L(3)}$$

R(L) = Residential Working Main Stations on large or combined medium and large LLFs in a three LLF size situation.

$$R(L) = \frac{R - R(S) \times L(1)}{L(2) + L(3)}$$

Note: If small and medium LLFs are combined, use:

$$B(L) = \frac{B - B(S) \times (L(1) + L(2))}{L(3)}$$

$$R(L) = \frac{R - R(S) \times (L(1) + L(2))}{L(3)}$$

15 — Vertical Files — Large LLFs

Note: This procedure is used only to apportion verticals across large LLFs. Actual main stations assigned should not exceed B(L) and R(L) and these stations should be spread evenly across all horizontal groups.

$$\text{Proportion Business} = P(B) = \frac{B(L)}{B(L) + R(L)}$$

$$\text{Proportion Residential} = P(R) = 1 - P(B)$$

$$\text{VF(B)} = \frac{\text{LLF Size}}{10} \times P(B)$$

Note: Round to the next higher integer. When medium and large LLFs are combined, medium LLFs are combined, medium LLFs should be proportioned in the same manner.

16 — Actual CCS/LLF

	<u>Small</u>				<u>Large</u>			
	<u>MS</u>	<u>LLFs</u>	<u>CCS/MS</u>		<u>MS</u>	<u>LLFs</u>	<u>CCS/MS</u>	
Business	B(S)	X	b	= ()	B(L)	X	b	= ()
Residential	R(S)	X	r	= ()	R(L)	X	r	= ()
Coin	<u>C(S)</u>	X	c	= ()	<u>C(L)</u>	X	c	= ()
Total	()			()	()			()

Note: CCS/LLF (s) should be approximately equal to CCS/LLF (L).

NO. 1 & NO. 5 CROSSBAR MULTIPLE SIZE LLF C OF S DISTRIBUTION										FORM E-6618 (MAY 1975)				
1	BUILDING: A						1	2	3					
2	TRAFFIC UNIT: XX4-XX5					7	SIZE	290	-	390				
3	LOADING DIVISION: -					8	NO.	L(1)= 13	L(2)= -	L(3)= 37	50			
		B	R	C	LD	9	TERM.	3770	-	14430	18200			
4	MS	4815	9903	-	14718	10	% FILL	95	-	95	80.9			
5	CCS/MS	b= 4.00	r= 2.40	c= -	2.92	11	WT/LLF	276	-	371	364			
6	CCS	19200	23800	-	43000	12	CCS/LLF				860			
13	SMALL LLF					$\text{APPROXIMATE B(S)} = \frac{(860) - [(2.40)(276)] + [(-)(-)]}{(4.00 - 2.40)} = 124$								
APPROX. B(S) ÷ 10 = 12.4							VF(B) = 14							
ACTUAL B(S) = (14) × (.95) × 10 = 133							ACT. R(S) = (276) - (133) - [-] = 143							
14	LARGE LLF					$B(L) = \frac{(4815) - (133)(13)}{(37)} = 84$ $R(L) = \frac{(9903) - (143)(13)}{(37)} = 217$								
15	VERTICAL FILES-LARGE LLF					$P(B) = \frac{(84)}{(84) + (217)} = .28$ $P(R) = 1 - (.28) = .72$ $VF(B) = \frac{(390)(.28)}{10} = 11$								
16	CCS/LLF					SMALL LLF			LARGE LLF					
		MS	x	CCS/MS	=	CCS		MS	x	CCS/MS	=	CCS		
	BUSINESS	-		133	x	4.0	=	532		84	x	4.0	=	336
	RESIDENTIAL	-		143	x	2.0	=	343		217	x	2.4	=	521
	COIN	-		-	x	-	=	-		-	x	-	=	-
	TOTAL	-		276		-		875		301		-		857

Fig. 2—Multiple Size LLF Class-of-Service Distribution (Form E-6618)

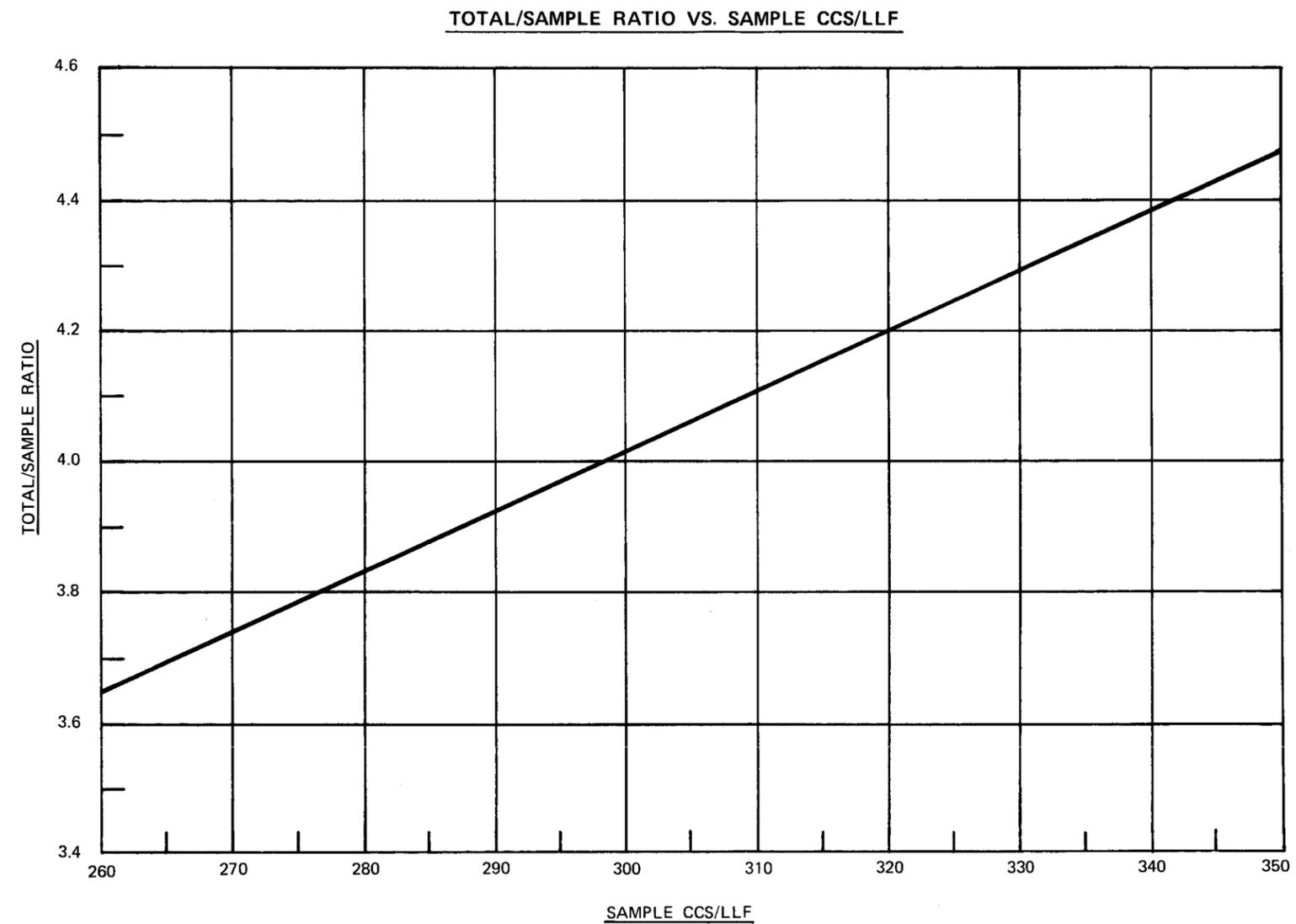


Fig. 3—Graph-Total-to-Sample (T/S) Ratio vs Sample CCS/LLF

INSTRUCTIONS FOR PREPARING FORM E-6663

Trunk Load Unit Summary

- Building: Identify the building location.
- Traffic Unit: Identify the traffic unit; e.g., 241-MGO
- 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.
- Page of : Number each page consecutively beginning with 1 (one) and show total pages to list all studies for the year.
- Study Date: Enter the beginning and ending date of each study; eg, 7-20 through 7-26-75.
- 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 Avg CCS by the number LUs measured. The result will be the average session load per load unit.
- % of Capacity Divide the Avg. CCS by the number of study hours and by the LU CCS capacity. Then multiply by 100.
- % IML: Enter the % incoming matching loss for the study week.
- Avg X .85: Multiply the Avg. CCS by 85 percent.
- Avg X 1.15: Multiply the Avg. CCS by 115 percent.
- # of LUs: Enter the number of trunk load units over 115%. 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 # of LU's (over 115% of Average) by the LUs Meas. and multiply by 100.

TRUNK LOAD UNIT SUMMARY							Form E-6663 (7-75)
Building: MESQUITE		Traffic Unit: DLLSTXMG279			Page of		
LU Installed:		LU CCS Capacity: 250 (BH) 2500 (10 Hz Semag)					
STUDY DATE	7/20-7/26/75						
LU MEAS	200						
TOTAL CCS	489800						
AVG CCS	2449						
% OF CAPACITY	98						
% IML	1.7						
AVG X .85	2094						
AVG X 1.15	2816						
LOADS OVER 115% OF AVERAGE							
# OF LU	18						
% OF LU	9						

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. 4—Trunk Load Unit Summary (Form E-6663)

INSTRUCTIONS FOR PREPARING FORM E-6664

Trunk Load Unit Analysis

- Building: Identify the building location
- Traffic Unit: Identify the traffic unit; e.g., 241-MGO
- Page of : Number each page consecutively beginning with 1 (one) 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; e.g., 7—20 through 7—26—75.
- LU Ident. #: Identify the trunk load unit abbreviation such as the trunk link frame (TLF) and Switch (SW) in the two blank columns. List the LU identification numbers in sequential order.
- 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.

<u>Choice</u>	<u>Trunk Load Unit</u>
1	Below 85% of average
2	Between 85 and 100% of average
3	Between 100 and 115% of average
4	Over 115% of average

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

The % 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: MESQUITE					Traffic Unit: DLLSTXMQ279					Page of					
LU Installed: 200															
LU Ident.		STUDY: 7/20-7/26/75				STUDY:				REMARKS					
TLF	SW	CCS	CHOICE				% CAP	CCS	CHOICE				% CAP		
			1	2	3	4			1			2		3	4
00	00	2233		✓											
	01	2410		✓											
	02	1922	✓												
	03	2493			✓										
	04	3055				✓	122								
	05	2888				✓	116								
	06	2810			✓										
	07	1877	✓												
	09	2054	✓												
01	00	2934				✓	117								
	01	2917				✓	117								
	02	2726			✓										
	03	1996	✓												
	04	2375		✓											
	05	2111		✓											

Fig. 5—Trunk Load Unit Analysis (Form E-6664)

INSTRUCTIONS FOR PREPARING FORM E-6615

SCORE CONTROL RECORD

Traffic Unit — Identify the traffic unit, eg, 241-MG0.

Loading Division — Identify the loading division.

LUs 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 to 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.

LUs Meas. — Enter the quantity of load units with valid data for the study.

% Eng. Cap. — Enter the percent the actual load is of the engineered capacity. The method for computing this percentage is outlined in paragraph 2.F of this practice:

- 1)
$$\frac{\text{Total CCS}}{\text{LU's Meas.}} = \text{Average Weekly Load}$$
- 2)
$$\frac{\text{Average Weekly Load}}{\text{No. of Study Hours}} = \text{Average Load (AL)}$$
- 3)
$$\frac{\text{Average Load}}{\text{LU Eng. CCS}} \times 100 = \% \text{ Eng. Cap.}$$

Avg. H.T. — Enter the average holding time used on the study to select quality control limits.
The method is outlined in paragraph 2F of this practice.

% Column

+2 — The average CCS will be considered as 100%. Add the quality control limit figure (percent) 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.

Sheet 2 of 2

-2 – Subtract the quality control 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 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.

Note: Actual 10 hour sample usage readings may be substituted for CCS values, if preferred.

LOAD BALANCE SCORE CONTROL RECORD														Form E6615 (5-75)	
Building: A				Traffic Unit: XX4				Page				of			
LOADING DIVISION _____				LU's INSTALLED 240				LU ENG. CCS 126							
STUDY DATE							4/13-4/19								
STUDY NO.	1	2	3	4	5	6	7								
TOTAL CCS				241000											
LU's MEAS.				240											
% ENG. CAP.				79.3											
AVG. H.T.				19.2											
	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS	%	CCS	
+2							190	1906							
+1							120	1205							
0	AVG.		AVG.		AVG.		AVG.	1004	AVG.		AVG.		AVG.		
-1							80	803							
-2							60	602							
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. 6—Score Control Record (Form E-6615)

INSTRUCTIONS FOR PREPARING FORM E-6616

LOAD UNIT LINE LOAD BALANCE CHART

Loading Division — Identify the loading division.

Traffic Unit — Identify the traffic unit.

LU Installed — Enter quantity of load units installed in the loading division.

Page of — Number each page consecutively beginning with 1 (one) 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 to 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.

LLN-LLF — Enter the line link network or frame number when required to distinguish between load units.

LG-HG-Conc. — Cross out the two not applicable. Enter the line group, horizontal group or concentrator identification.

CCS — Enter the weeks usage reading for the load unit (LG, HG or Conc.) on the study.

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.

Sheet 2 of 2

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

Note: Actual 10 hour sample usage readings may be substituted for CCS values if preferred. However, this will require the Hot Spot threshold value to be converted to reflect this approach. See Division A, Section 5b.

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: A			Traffic Unit: XX4				Page			of		
Loading Division: -			LU Installed: 240									
FR	HG	STUDY DATE	2/9-2/15		3/2-3/8		3/9-3/15		4/13-4/19			
			STUDY NO.	1.	2.	3.	4.	5.	6.	7.		
10	0	CCS	1421	1400	1433	1450						
		S P H	+4	+2	+4	+4						
	1	CCS	1005	1101	1132	1158						
		S P H	+1	+1	+1	+1						
	2	CCS	1022	1010	995	983						
		S P H	+1	+1	-1	-1						
	3	CCS	610	593	576	521						
		S P H	-2	-4	-4	-4						
	4	CCS	1511	1321	1296	1229						
		S P H	+4	+2	+2	+2						
	5	CCS	1432	1405	1472	1502						
		S P H	+4	+2	+4	+4						
	6	CCS	810	903	926	911						
		S P H	-1	-1	-1	-1						
	7	CCS	1321	1331	1325	1329						
		S P H	+2	+2	+2	+2						
	8	CCS	796	780	802	717						
		S P H	-2	-2	-1	-2						
	9	CCS	670	592	611	602						
		S P H	-2	-4	-2	-2						
		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

Fig. 7—Load Unit—Load Balance Chart (Form E-6616)

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						

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. 9—Factors (W) and (F)

TABLE A

LINE ASSIGNMENT GUIDE — PROCEDURE 1

CCS Capacity = 144
 Type of Frame = 390
 Estimated CCS/MS = 4

Desired Order of Assignment	CCS to			Assigned			Disconnect		
	ADD	LLF	HG	VG	VF	CS	VG	VF	CS
1	70	33	5	03	1				
2	66	33	5	04	2				
3	62	33	5	05	3				
4	60	26	9	03	1				
5	58	33	5	NA	NA				
6	56	26	9	04	2				
7	54	33	5	NA	NA				
8	54	13	1	01	1				
9	54	35	2	NA	NA				
10	53	6	1	01	1				
11	52	26	9	06	3				
12	50	33	5	NA	NA				
13	50	13	1	04	2				
14	50	35	2	NA	NA				
15	50	8	8	06	1		05	3	
16	49	6	1	04	2				
17	48	26	9	NA	NA				
18	46	33	5	NA	NA				
19	46	13	1	NA	NA				
20	46	35	2	NA	NA				

Table A

TABLE B

LINE ASSIGNMENT GUIDE — PROCEDURE 2

CCS Capacity = 144 LCCS = 3
 Type of Frame = 390 MCCS = 6
 HCCS = 9

Desired Order of Assignment	CCS to			Assigned			Disconnected		
	ADD	LLF	HG	VG	VF	CS	VG	VF	CS
1	70	33	5	L 03	1				
2	67	33	5						
3	64	33	5	M 04	2				
4	61	33	5						
5	60	26	9	L 03	1				
6	58	33	5						
7	57	26	9						
8	55	33	5	H 05	3				
9	54	26	9	M 04	2				
10	54	13	1	L 01	1				
11	54	35	2	NA	NA				
12	53	6	1	L 01	1				
13	52	33	5	NA	NA				
14	51	26	9						
15	51	13	1						
16	51	35	2	NA	NA				
17	50	6	1						
18	50	8	8	L 06	1		06	3	
19	49	33	5	NA	NA				
20	48	26	9						
21	48	13	1	M 04	2		05	3	

Table B

TABLE C

LINE TRANSFER GUIDE

CCS Capacity = 144
 Type of Frame = 390
 Estimated CCS/MS = 4

Desired Order of Assignment	CCS to			Selected			Disconnected		
	Remove	LLF	HG	VG	VF	CS	VG	VF	CS
1	70	25	5	03	1				
2	66	25	5	04	2				
3	62	25	5	05	3				
4	60	16	9	03	1				
5	58	25	5	—	—		03	4	
6	56	16	9	04	2				
7	54	25	5	—	—		01	2	
8	54	23	1	01	1				
9	54	40	2	—	—		02	1	
10	53	8	1	01	1				
11	52	16	9	06	3				
12	50	25	5	—	—		04	3	
13	50	13	1	04	2				
14	50	40	2	—	—		05	3	
15	50	10	8	06	1				
16	49	8	1	04	2				
17	48	16	9	06	4				
18	46	25	5	02	3				
19	46	23	1	03	4				
20	46	45	2	04	2				

Table C

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								
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		CCS								
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		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

**NO. 1 & NO. 5 CROSSBAR
MULTIPLE SIZE LLF C OF S DISTRIBUTION**

FORM E-6618
(MAY 1975)

1	BUILDING:					
2	TRAFFIC UNIT:	7	SIZE			
3	LOADING DIVISION:	8	NO.	L(1)=	L(2)=	L(3)=
	B	R	C	LD	9	TERM.
4	MS				10	% FILL
5	CCS/MS	b=	r=	c=	11	WT/LLF
6	CCS				12	CCS/LLF

13 SMALL LLF

APPROXIMATE B(S) =
$$\frac{(\quad) - [(\quad)(\quad)] + [(\quad)(\quad - \quad)]}{(\quad - \quad)} =$$

APPROX. B(S) ÷ 10 = _____ VF(B)= _____

ACTUAL B(S) = () x () x 10 = _____ ACT. R(S) = () - () - [] = _____

14 LARGE LLF

$$B(L) = \frac{(\quad) - (\quad)(\quad)}{(\quad)} =$$

$$R(L) = \frac{(\quad) - (\quad)(\quad)}{(\quad)} =$$

15 VERTICAL FILES—LARGE LLF

$$P(B) = \frac{(\quad)}{(\quad) + (\quad)} =$$

$$P(R) = 1 - (\quad) =$$

$$VF(B) = \frac{(\quad)(\quad)}{10} =$$

16 CCS/LLF	SMALL LLF	LARGE LLF
	<u>MS</u> x <u>CCS/MS</u> = <u>CCS</u>	<u>MS</u> x <u>CCS/MS</u> = <u>CCS</u>
BUSINESS —	x =	x =
RESIDENTIAL —	x =	x =
COIN —	x =	x =
TOTAL —	x =	x =