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Developing Space Planning Aids for Central Office Equipment Systems

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The space planning process for central office switching, transmission, and power systems begins once the equipment need is forecast and the particular type of system is decided. This process is concerned with determining the kinds and quantities of the system equipment to meet ultimate forecast circuit requirements, devising a layout and growth plan for the determined equipment, and planning and coordinating the cable distribution, lighting, and cooling schemes associated with the equipment layout. The entire procedure of establishing a space utilization plan requires many iterations because of the large number of engineering aspects that must be examined in the decision-making process. To simplify, optimize, and streamline space planning for large equipment systems, various planning aids have been developed. We describe the general approach and rationale in developing two of the more fundamental space planning aids: office plan algorithms and office planning guidelines. Office plan algorithms allow a space planning engineer to translate long-range circuit forecasts into specific equipment frame requirements and their associated building space, cooling, and power needs. Office planning guidelines help the engineer to devise an efficient layout of the equipment in the building space, and to help plan and coordinate the cabling, lighting, and cooling schemes for the equipment layout. The general developmental approach of the space planning aids, and their usage benefits, are clarified relative to T1 offices that conform to the New Equipment-Building System (NEBS) standards.

I. INTRODUCTION

Once telephone company planners forecast the need for new communications facilities and select the particular system, the space planning task of the network common systems engineer begins. In this endeavor, this Bell Operating Company engineer is primarily concerned with planning the quantities, placement, and growth of the system equipment in new or cleared building space to meet the ultimate forecast service needs. Many factors must be examined including the relative placement of systems equipment with respect to each other, to other interfacing systems and to building elements such as building columns, walls, cable holes, and the cable entrance facility (CEF). Moreover, this space planner is also partially responsible for planning and coordinating the cable distribution, lighting, and cooling systems for this equipment layout. The entire process of preparing a total office space utilization plan associated with ultimate circuit forecasts requires considerable interaction with the different engineering groups. The primary objectives of this process are to devise an efficient equipment layout with a minimum and manageable amount of interframe cabling, a well-planned growth strategy possessing flexibility for technological or forecast changes, and an attractive and highly functional operating and maintenance environment.

The decision to deploy a specific equipment system is usually made 2 to 4 years before the proposed facilities are scheduled for service.[1] Since the preparation of a total office plan must precede the tasks of detailed equipment engineering and equipment ordering, manufacturing, installation and testing, the space planner is allotted a relatively short time—usually only a few months—to complete the space planning for a given equipment system. Supportive information used in the planning process must be obtained from a host of engineering drawings, floor plan data sheets, engineering letters, and Bell System Practices (BSPs) originally prepared by the equipment system development organization. Since the available time is limited, this space planner can benefit significantly from pre-engineered plans and mechanized information retrieval. Consequently, to assist in the space planning process, office plan algorithms, office planning guidelines, and other computer aids have been developed by Bell Laboratories for the various switching, transmission, and power systems. Such aids shorten and simplify central office equipment planning and ensure more efficient usage of costly equipment, material, and building space.

Figure 1 shows the assistance of planning aids in the space planning process for central office equipment systems. Office plan algorithms translate long-range system circuit forecasts into specific quantities and types of system equipment frames, and also into estimates of total space, cooling, and power requirements for this equipment system. These plan algorithms have been codified for use by telephone company space planners as part of the Telephone Office Planning and Engineering System (TOPES), a computerized time-shared graphics system.[2] This system is available as a Western Electric engineering service. The office planning guidelines provide specific recommenda-

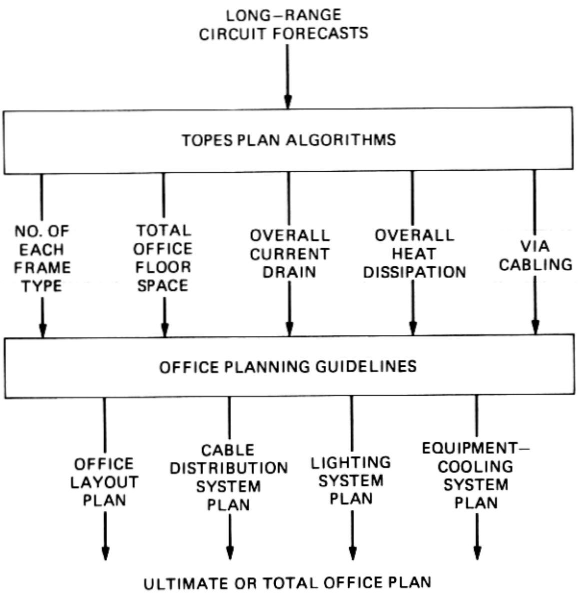


Fig. 1—Space planning aids for central office equipment systems.

tions for arranging and growing the determined equipment frames efficiently within the building structure, and for planning and coordinating the cable distribution, lighting, and cooling systems associated with this equipment arrangement.

This paper describes the methodology of developing office plan algorithms and office planning guidelines, applicable to any switching, transmission, power or other equipment system. Although this methodology applies to any equipment system in general, it is discussed with a slant toward those equipment systems that conform to the New Equipment-Building System (NEBS) standards[3,4]; these standards cover all equipment-building related requirements for new 7-foot-high electronic communications equipment systems. Table I outlines the methodology for developing space planning aids. The process is sequentially divided into three phases: planning information acquisition, office planning guidelines development, and office plan algorithms development. The guidelines development phase precedes the algorithms development phase since the layout arrangements are prerequisite for the floor space estimation equations of the office plan algorithms. These phases are explained with particular reference to the T1 system frames of the Bell System digital transmission network. Finally, an illustrative example is presented describing the use of the developed aids in the office planning process for a large typical T1 office.

Table I—Methodology for developing office planning guidelines and plan algorithms for an equipment system

Planning Information Acquisition:
Identify frames
Determine frame data
Framework, dimensions, weight, heat, current drain, aisle spacings, circuit capacity
Determine interframe cabling
Amount of cable to and from frames, cable distance constraints, lineup rack-frame cable interfaces.
Office Planning Guidelines Development:
Establish standard floor plan arrangements and growth strategies
Select, modify, or design cable distribution, lighting, and cooling systems
Office Plan Algorithms Development:
Formulate algorithms with circuit forecasts as input
Program software for computer system

II. PLANNING INFORMATION ACQUISITION

Before any office planning guidelines and plan algorithms can be established for a given central office equipment system, planning information acquisition must be obtained regarding system frame identification, data, and interframe cabling.

2.1 Frame identification

To identify the frame types associated with a given equipment system, a block diagram of all frame transmission interconnections for the given and closely related systems is first prepared. Schematic drawings prepared by the equipment development organization serve as a basic source for such a diagram. Only the most recent vintage of equipment frame types or those under development are diagrammed to ensure currentness and relevancy when finally used by the space planner. This identification task also requires a basic understanding of those equipment frames that are generally located together in a central office for function, maintenance, and cabling reasons. With this basic understanding, the transmission interconnection diagram can be partitioned into various systems for office planning purposes. After so determining the system-related transmission frames, the system-related power, maintenance, and other common-system frames can be identified from the equipment system application parameters.

The frame identification process can be exemplified with respect to the T1 central office equipment system. Figure 2 diagrams the possible central office transmission interconnections between equipment frames associated with the Bell System digital transmission network.[5] Figure 2 is shown partitioned into system frames normally associated together in T1 (and/or T1/OS) offices. A closer examination of the T1 office transmission interconnection diagram is detailed in Fig. 3. The

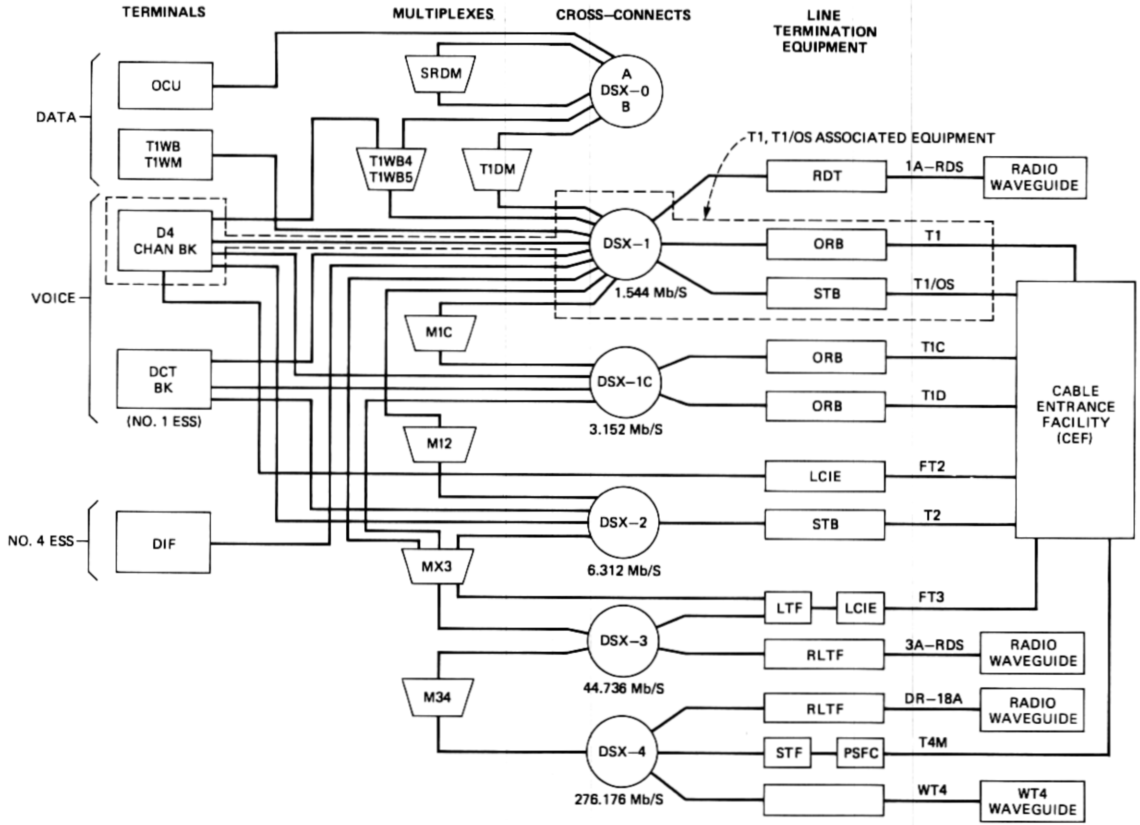


Fig. 2. Possible central office interconnections associated with Bell System digital transmission network.

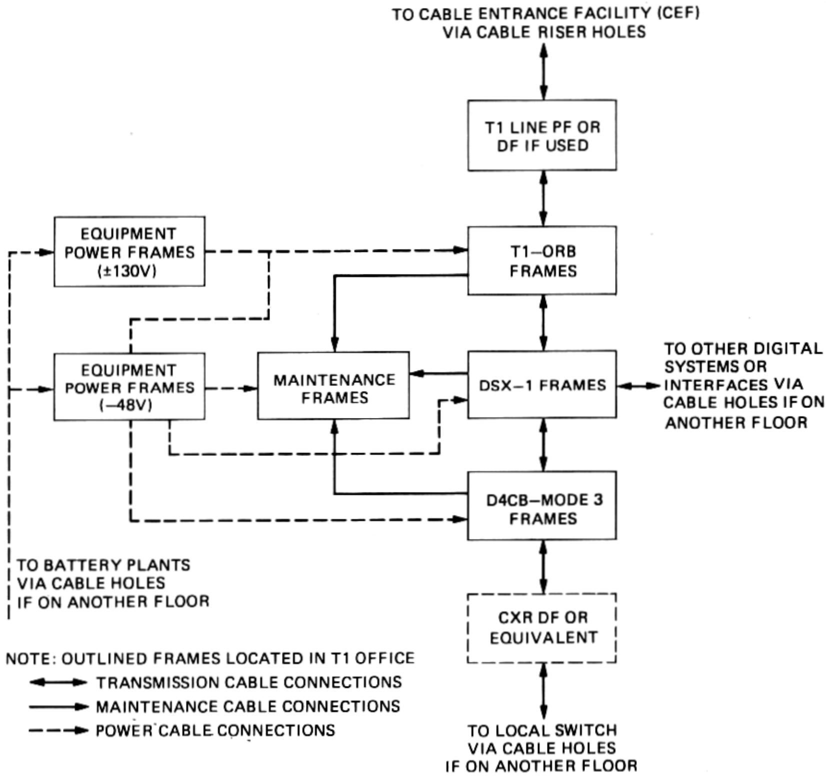


Fig. 3—T1 office interconnection diagram.

transmission frames associated with T1 offices consist of the DSX-1 cross-connect frame, D4 channel bank frame in operational mode 3 (D4CB-mode 3) as one type of terminal frame, and the T1 office repeater bay (T1-ORB) frame as the line termination and powering equipment. Also, the voice side of the D4CB-mode 3 frame connects to a carrier distributing frame (CXR DF) which is frequently located together with its associated local switching system. Moreover, a protector frame (PF) or a distributing frame (DF) is often installed between the T1-ORB frames and T1 lines, and is usually located together with the other T1 equipment frames.

With these basic T1 transmission related frames identified, the T1 associated common-system maintenance-operations and equipment-power frames can next be determined. The maintenance-operations frames and equipment for a T1 office are comprised of those associated with the T-carrier administration system (TCAS); these frames are generally located close to DSX-1 frames, and for large T1 offices, are frequently consolidated to form a T-carrier maintenance center (TCMC). The T1 common-system equipment-power frames include power distribution and power converter frames with −48 and ±130 volt outputs since these are the required input voltages for the T1 frames. The T1 office maintenance and equipment-power frame interconnections are also indicated in Fig. 3.

2.2 Frame data

With the system frames identified, a tabulation is made of the basic frame data consisting of type framework, dimensions, guard rail dimensions, aisle spacings, weight, heat dissipation, current drain, and circuit capacity for all the frames. The frame dimensions and aisle spacings are needed for floor space planning and estimation, frame weights are required to ensure the maximum floor load is not exceeded, heat dissipation and current drain values allow for air conditioning and battery plant sizings, respectively, circuit capacities aid in estimating the number of frames required, and guard rail dimensions and framework type are important in the selection or design of a cable distribution system. These frame data represent a recounting of the appropriate information available on engineering drawings, engineering letters, floor plan data sheets, and BSPs which are initially prepared by the system development organization. A sampling of such a frame data tabulation is shown in Table II.

2.3 Interframe cabling

The final step in the planning information acquisition phase is to determine the interframe cabling details. The necessary information includes the type and amount of cable to and from each frame from all other possible frames and the maximum interframe cable distances. Frequently, the switchboard (nonpower) cable connected to a frame can be divided into three categories: transmission cable from a frame on the line facility side (line-side cable), transmission cable from a frame on the subscriber or terminating side (drop-side cable), and nontransmission cable. These cable data are utilized to ensure that cabling is minimized while cable congestion and excessive cable lengths are avoided in office layouts. Also, these cable data together with the lineup rack-frame cable interface information—the flow and quantity of cable connecting to a frame and whether it connects to the front or rear of the frame—are vital for the selection or design of a cable distribution system. These interframe cabling data can be assimilated from engineering drawings, engineering letters and BSPs originally prepared by the system development organization. An example of transmission interframe cable tabulation is presented in Table III.

Table II—Frame data tabulation

Frame	Framework	℄ – ℄ width (ft-in)	Depth (in)	Guard Rails front/rear (in)	Minimum Aisle Spacing Maintenance/ Wiring (ft-in)	Weight (lbs)	Planning Heat Value (watts)	Required Input Voltage (Vdc)	List 1 Current Drain (amps)	Typical Active Circuit Capacity
T1-ORB	Unequal flange	2–2	12	5/2	2–6/2–0	325	550	−48 or −48, + 130 or −48, ± 130	*	1152

† Depends on input voltage and line powering situation.

Table III—Interframe cabling tabulation

Frame	Drop-Side Transmission Cable Connected to Frame						Line-Side Transmission Cable Connected to Frame					
	Cable Type	Maximum Number of Cables	Amount of Unsecured Cable Rack Space $(in)^2$	Connected Frame	Approx. No. of Connected Frames Required	Maximum Cable Length (ft)	Cable Type	Maximum Number of Cables	Amount of Unsecured Cable Rack Space $(in)^2$	Connected Frame	Approx. No. of Connected Frames Required	Maximum Cable Length (ft)
T1-ORB	609B	4	2.8	DSX-1	0.133	655	609B	4	2.8	T1 line PF or DF if used*	Depends on frame type	—

* If no protection required, cables can go directly to CEF.

Table IV—Objectives of equipment system office layout

Have minimum and manageable cabling
Occupy minimum floor space
Grow in planned orderly manner, in one direction only with a straight growth boundary if possible
Be adaptable to different office sizes and types
Be compatible with other interconnected equipment system layouts
Be flexible in floor space aspect ratio
Provide practical operating and maintenance environment
Adhere to NEBS spatial and environmental standards

III. DEVELOPING GUIDELINES FOR OFFICE PLANNING

After the planning information acquisition phase is completed for an equipment system, the office planning guidelines for that system can then be developed. These guidelines consist of office layout, cable distribution, lighting, and equipment-cooling system recommendations.

3.1 Guidelines for office layout

Floor plan layouts of equipment systems in central offices are designed to satisfy the cabling, floor space, growth, flexibility, compatibility, and operations objectives listed in Table IV. In establishing office layout guidelines and meeting these objectives, several factors must be considered including equipment placement, building interfaces, maintenance, office sizes and types, and office growth. The resultant office layout guidelines propose standard office floor plan arrangements with associated rules and recommendations that can be used directly by the space planner in developing a specific floor-plan layout.

3.1.1 Relative placement of equipment

The first step in developing office layout guidelines is to determine the optimum placement of the equipment system frames relative to each other and relative to other equipment systems. Since cable cost (primarily transmission cable) typically dominates the physical installation costs associated with a floor plan, cable usage as related to relative equipment placement must be given prime consideration. The objective is to determine the relative equipment arrangement with minimized cable usage and therefore cable cost, while abiding by cable length limitations and avoiding cable congestion. Maintenance regards can also influence the relative equipment placement since it is desirable to locate like frames together in the same region for simpler more efficient operations and repair. In fact, some frames like DFs must be located together because of the large amounts of interframe jumper cabling or because of maximum interframe jumper lengths. If certain types of frames are not required to be located together, the high-priority objectives of Table IV related to cabling and growth take precedence. Usually, frames of the same type can at least be installed in lineups dedicated to one type only.

Frame interconnection block diagrams, similar to the one prepared for system frame identification, are quite useful in exploring the various combinations of relative equipment frame placement. For instance, since transmission cabling dominates in a T1 office, Fig. 3 indicates that the T1-ORB frame should be located between the DSX-1 frames and the T1 line PF or DF while the D4CB-mode 3 frames should be positioned between the DSX-1 frames and the CXR DF. Also, the maintenance frames should be located near the DSX-1 frames and the equipment-power frames should be located close to their power-feeding frames. The T1 line DF CXR, DF and DSX-1 frames are the types of frames that must be concentrated close together because of jumper or cross-connect pair constraints.

3.1.2 Equipment placement in equipment room

After determining the preferred relative frame placement with respect to other frames, the next step is to decide on the best location of the frames relative to the equipment room envelope. A multi-story building is usually assumed in establishing office layout guidelines since it presents the more difficult intersystem cabling situation for office planing purposes, and most equipment systems must be capable of being installed in such buildings. The equipment room placement primarily considers walls but is also concerned with cable holes, building columns and main aisles. For example, frame types that are heavily connected to outside plant cable, rising from the CEF via cable risers, should be located adjacent and parallel to the cable riser wall in the building to minimize overall building cabling and interfaces of cable distribution system hardware. PFs and certain kinds of DFs are primarily the type of frames strongly associated with outside plant or riser cable. Frame types that are heavily interconnected to equipment systems on other floors should be placed near cable holes that are usually located between building columns away from walls. Frame types that are heavily interconnected to other frames of the same equipment system should not be located next to a wall since in that case cable distribution can only be in the direction away from the wall.

With reference to the T1 office, the T1 line PF or DF is heavily interconnected to riser cable from the CEF and it should therefore be located near the cable riser wall when it is used. Frequently, the CXR DF is located next to the cable riser wall, although usually on a different floor from the T1 office. Making this assumption in combination with Fig. 3, the relative equipment-building plan for T1 office results as

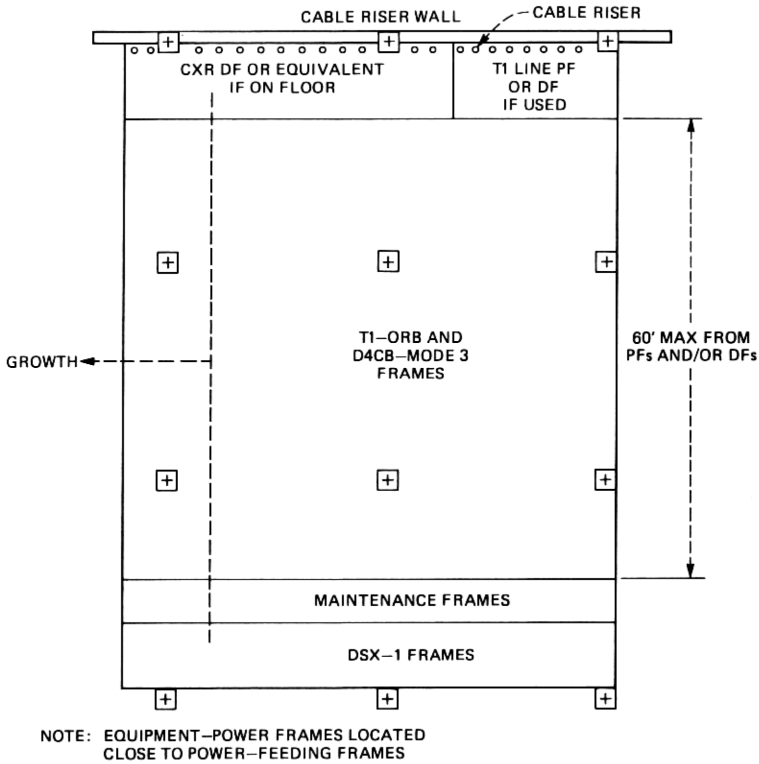


Fig. 4—Basic recommended relative equipment-building plan for T1 office.

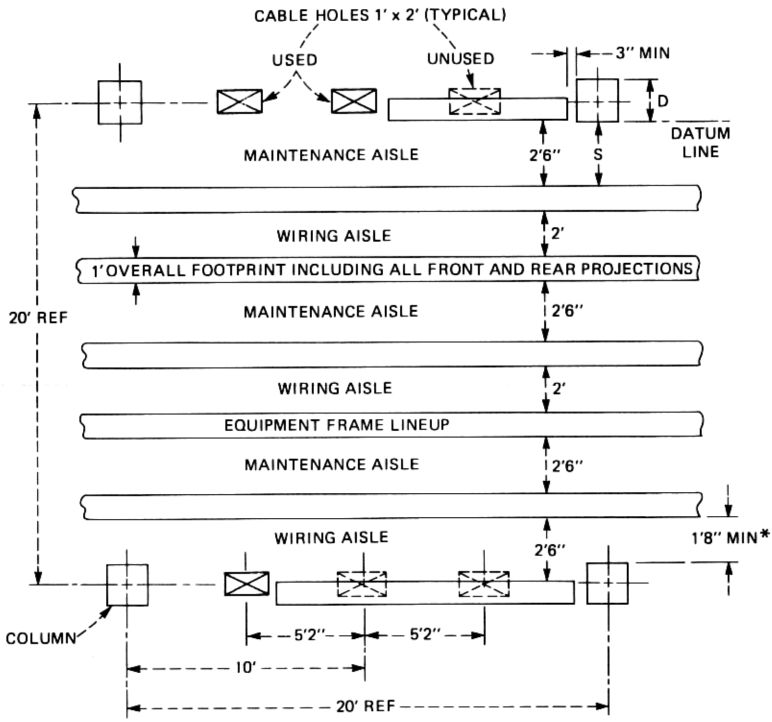
drawn in Fig. 4. The indicated 60-foot limitation results as an equipment-building feedback constraint to avoid exceeding the maximum handling capacity of a cable distribution system.

3.1.3 Arrangement of equipment lineups

Equipment frames in central offices are arranged side-by-side forming lineups with aisle spacings between lineups primarily to facilitate access, installation and safety exiting. For the same reasons, the lineup lengths are limited to 50 feet by a NEBS requirement. Except for PFs or DFs (types of equipment frames with protector or distributing functions), the standard orientation for equipment lineups is parallel to the cable hole alignment to prevent interference and for simpler interfaces. The aisle spaces between lineups are generally standardized depending on equipment frame height and depth. The NEBS standard floor plan for 12-inch-deep (7-foot-high) equipment frames shown in Fig. 5 provides for five lineups per building bay. (A building bay is defined as the space between four rectangularly adjacent building columns.)

Cable holes, process cooler units when the Modular Cooling System (MCS) is used, and miscellaneous frames are located in the sixth lineup between the building columns. The 2-foot 6-inch maintenance aisles and 2-foot wiring aisles allow adequate space for operations, maintenance and cabling access for this arrangement.

The standard floor plan and orientation of PF and DF lineups depends on the application of these frames. As mentioned, DF jumper pair constraints usually require that DFs be located in contiguous single lineups if possible, otherwise adjacent multiple lineups. PFs and DFs normally require larger maintenance and wiring aisles than their



COLUMN DEPTH "D"	SPACE AT COLUMN FACE "S"
1′10″ OR LESS	2′6″
2′	2′4″
2′2″	2′2″
2′4″ OR GREATER*	2′

*FOR COLUMN DEPTHS GREATER THAN 2′4″ IT MAY BE NECESSARY TO OMIT SOME FRAMES IN THE EQUIPMENT LINEUP OPPOSITE COLUMNS (WIRING AISLE SIDE)

Fig. 5—Standard floor plan for 12-inch-deep equipment frames.

Table V—Disadvantages of parallel and perpendicular nonassociated-cable-riser DF lineup relative to other equipment lineups

Parallel Lineups:
Require slightly longer cable length runs from equipment frames to distributing frames; the extra run lengths depend on growth plan
Require multiple equipment lineup growth plan for minimized cable length runs
Perpendicular Lineups:
Block equipment aisles and possibly cable holes
In some cases, lead to extremely short or long equipment lineups for uniform growth plan
Result in more complex cable racking and cabling interfaces at distributing-equipment lineups intersections
Have a more difficult and less frequent interface with cable holes resulting in longer cable-length runs to other floors

equipment frame counterparts, because of their heavy overhead cabling and administrative aisle activity. Such lineups can usually be oriented parallel or perpendicular to the standard equipment lineups. As discussed, PFs and DFs associated with cable risers are oriented parallel, and located adjacent, to the cable riser wall which can be parallel or perpendicular to the standard lineup direction; the latter arrangement is preferred and more common in buildings because of simpler cabling-growth inferences and because this arrangement does not block main aisles no matter how long the DF or PF lineups. For DFs not associated with cable risers, the orientation decision is frequently optional. The disadvantages of each orientation of these latter DF types are listed in Table V and primarily relate to cable-growth considerations. Both parallel and perpendicular orientations demand about the same floor space coverage so neither offers an advantage over the other in this respect.

In T1 offices, the T1-ORB, D4CB-mode 3, maintenance and equipment-power frames are installed in standard equipment lineups. Since the T1 line PF or DF and CXR DF are associated with cable risers, they should be installed in a lineup parallel and adjacent to the cable riser wall. The DSX-1 cross-connect is essentially a digital toll DF at the 1.544 Mb/s rate and therefore fits the nonassociated-cable-riser DF category. Consequently, DSX-1 frames can be arranged in a lineup(s) parallel or perpendicular to the standard equipment lineups and the disadvantages of Table V should be weighed in this orientation decision. (Throughout the remainder of this paper, a general reference to a DSX-1 lineup also refers to the possibility of multiple DSX-1 lineups.)

3.1.4 Office growth

For a given equipment system, the preferred office growth pattern is to have all frame lineups growing together at the same rate in the same direction. This singular boundary with a uniform rate of growth can most satisfactorily account for inaccurate forecasts. If initial ultimate forecasts are never attained, the office growth can be completely stopped without enclosed or disjointed office space. Another equipment system can be installed in the reserved but never reached area. Should ultimate forecasts be exceeded, the uniform office growth plan can be continued provided vacant space exists in the growth direction. Another very important reason for preferring a uniform growth plan is that cabling is minimized with less congestion in such a scheme.

Generally, when DF and equipment frame lineups are oriented parallel with respect to each other, a uniform growth with minimized cabling results when all the lineups grow together at an equal rate—a growth pattern of multiple equipment lineups. When DF and equipment lineups are oriented perpendicular to each other, uniform growth with minimized cabling occurs when the office grows at the same rate in the DF growth direction. In this case, only one equipment lineup grows at once and is referred to as a growth scheme of a single equipment lineup. When two or more DF types are associated with each system, the uniform growth schemes are usually applied relative to the nonassociated-cable-riser types for minimized overall cabling.

Uniform growth plans for a single DSX-1 lineup arranged parallel or perpendicular to equipment lineups are presented in Fig. 6. This uniform growth is accomplished by adjusting the amount of equipment frames in the direction perpendicular to the DSX-1 lineup. As examples of this adjustment, Fig. 7 shows various uniform growth cases for a single DSX-1 lineup oriented perpendicular to equipment lineups.

3.1.5 Different office sizes and types

Once the general office layout and growth scheme is established, the next step is to specifically examine this scheme for major variations over the practical range of office sizes and types. Office size can be related to ultimate office voice circuits, ultimate number of a given office frame type or ultimate office building space occupation. Office type pertains to a major variation in the purpose of the office. For example, for a toll transmission office, office type refers to either a junction office where mostly through circuit rerouting occurs, or a terminating office where many circuits are terminated to voice or switching levels. Of course, a desirable situation would be that office layout guidelines be unaffected by office size and type so that forecasts would not be as critical in the office planning process. However, this independency is the exception rather than the rule.

For T1 offices, five different office sizes are defined, in relation to the ultimate number of DSX-1 frames, since this number largely affects office layout. Table VI summarizes the relationship between standard

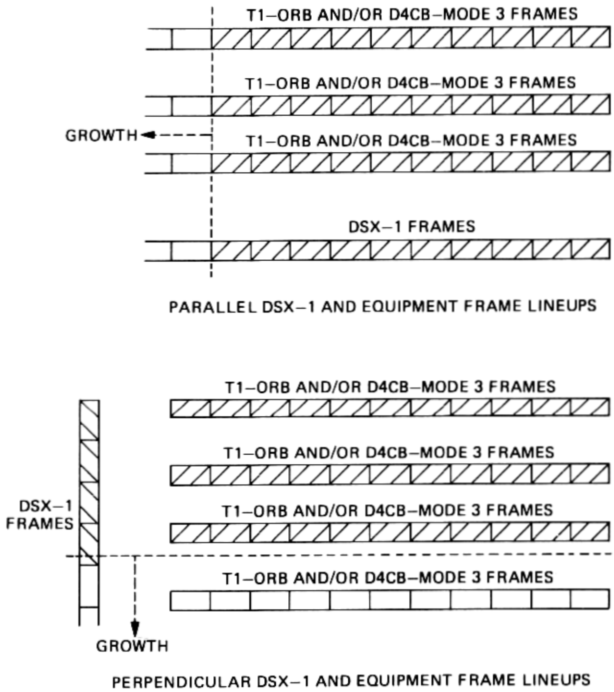


Fig. 6—Uniform growth plans for parallel and perpendicular DSX-1 and equipment frame lineups (single DSX-1 lineup shown).

office sizes and numerical range of DSX-1 frames along with other relevant floor plan information. The motivating factors for each of these numerical frame ranges is due to lineup cable rack size, maximum lineup length of 50 feet, or maximum cross-connect length of 85 feet. The total number of DSX-1 frames for T1 and all other DSX-1 interconnected systems must be considered in determining the overall number of DSX-1 frames required. Table VI indicates that the number of DSX-1 frames (office size) in combination with office type primarily determine the total floor space requirement; here type of office relates to the ratio of terminating circuits to D4CB-mode 3 frames versus those circuits which do not terminate to these frames.

3.1.6 Guidelines for standard layout

Standard office layout guidelines are the resultant combination of all the facets of system frame placement with respect to each other and to building elements, system frame arrangement in lineups, and system frame growth for all office size-type possibilities. These standard layout guidelines are usually expressed in a graphical representation with supportive discussion of the associated rules, recommendations, constraints and assumptions for proper application.

The standard office layout guidelines for a large T1 office, with parallel equipment and DSX-1 lineups, are presented in Fig. 8. Dimension A should be planned so a uniform rate of growth results in the direction of DSX-1 lineups growth. This dimension primarily depends on the ratio of T1-ORB and D4CB-mode 3 frames relative to DSX-1 frames, i.e., type of office. The application of the specifics in utilizing the T1 office layout guidelines are more clearly exemplified in the planning example discussed at the end of this paper.

3.2 Guidelines for cable distribution system

After the office layout guidelines are established for a particular equipment system, the next procedure in establishing office planning guidelines is to select, modify or design a cable distribution system for the equipment system frames and layout variations. Once this engineering phase is complete, guidelines for cable distribution system

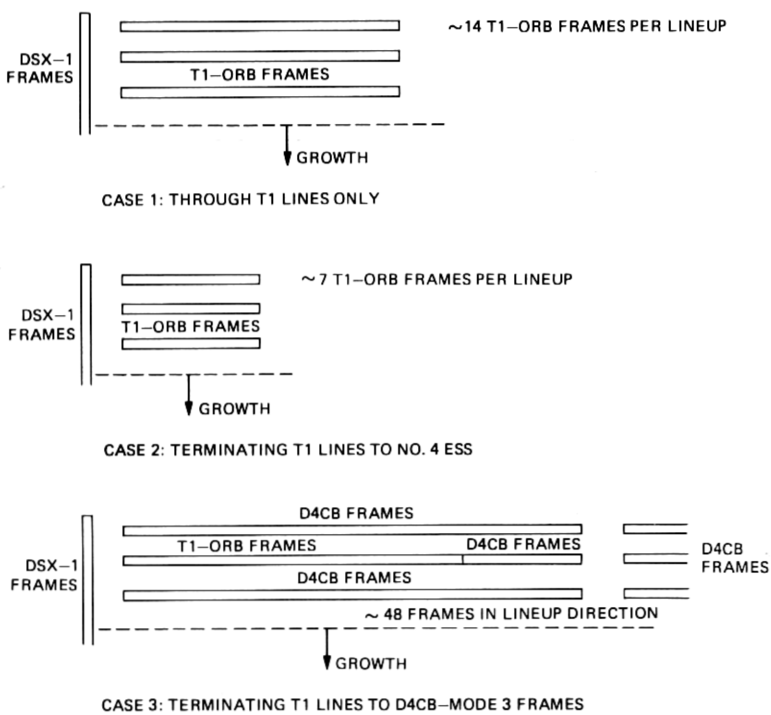


Fig. 7—Various uniform growth plans for single DSX-1 lineup perpendicular to equipment lineups (7-foot-high frames).

Table VI—Standard T1 office sizes and their numerical relationship to DSX-1 frames

Standard Office Size Name	No. of DSX-1 Frames Associated with Office Size (n)	DSX-1 Lineup Arrangement	Maximum DSX-1 Lineup Length (ft-in)	Minimum DSX-1 Frame Aisle Spacing Maintenance/Wiring (ft-in)	DSX-1 Frame Lineup Rack Capacity (in^2)	Formal TCMC Recommendation	Approximate Office Size in Terms of Number of 20′ × 20′ Building Bays* Minimum	Approximate Office Size in Terms of Number of 20′ × 20′ Building Bays* Maximum
Very Small	0	None	0	—	—	No	0	1.2†
Small	1–5	Short single	10–10	2–6/2–6	100	No	0.25n	0.67n
Intermediate	6–23	Single	49–10	3–6/2–6	210	Yes (larger sizes)	0.25n	0.67n + 1§
Large	24–46‡	Double	49–10	5–6/2–6	210	Yes	0.25n	0.67n + 1§
Very Large	47–66‡	Triple	47–8	5–6/2–6	210	Yes	0.25n	0.67n + 1§

* Minimum, maximum values corresond to 0 percent, 100 percent terminations to D4CB-mode 3 frames. Linear extrapolation applies for intermediate percentage terminations.

† Based on the maximum recommendation of four T1-ORB frames at ultimate growth before DSX-1 frames should be used.

‡ Maximum values constrained by engineering rule limiting cross-connects and patching cable lengths between DSX-1 frames to 85 feet.

§ One extra building bay with TCMC installation.

FLOOR SPACE DIMENSION GUIDELINES

PROTECTOR–DISTRIBUTING FRAMES SIDE OF BUILDING	APPROX. NUMBER OF 20–FOOT BUILDING BAY DIMENSIONS				
	$A^{(1)}$	B_1	$B_2^{(2)}$	$C_1^{(3)}$	$C_2^{(2,3)}$
PARALLEL TO DSX–1 LINEUPS	2–4[4]	1.5–2.5	0–1	0–2.5	0–2.5
PERPENDICULAR TO DSX–1 LINEUPS	2–7	1.5–2.5	0–1	0	0

(1) DETERMINE THIS DIMENSION FOR A UNIFORM GROWTH PATTERN. THIS DIMENSION SPREAD INCLUDES EQUIPMENT AND DSX–1 LINEUPS, AND DEPENDS ON THE NUMERICAL RATIO OF EQUIPMENT TO DSX–1 FRAMES REQUIRED

(2) IF NO TCMC, $B_2 = 0$. WITH TCMC, $B_2 + C_2 \leq 2.5$

(3) OVERFLOW DIMENSIONS IF A_{MAX} IS REACHED

(4) $A \leq 3$ IF $C_1 \neq 0$ OR $C_2 \neq 0$

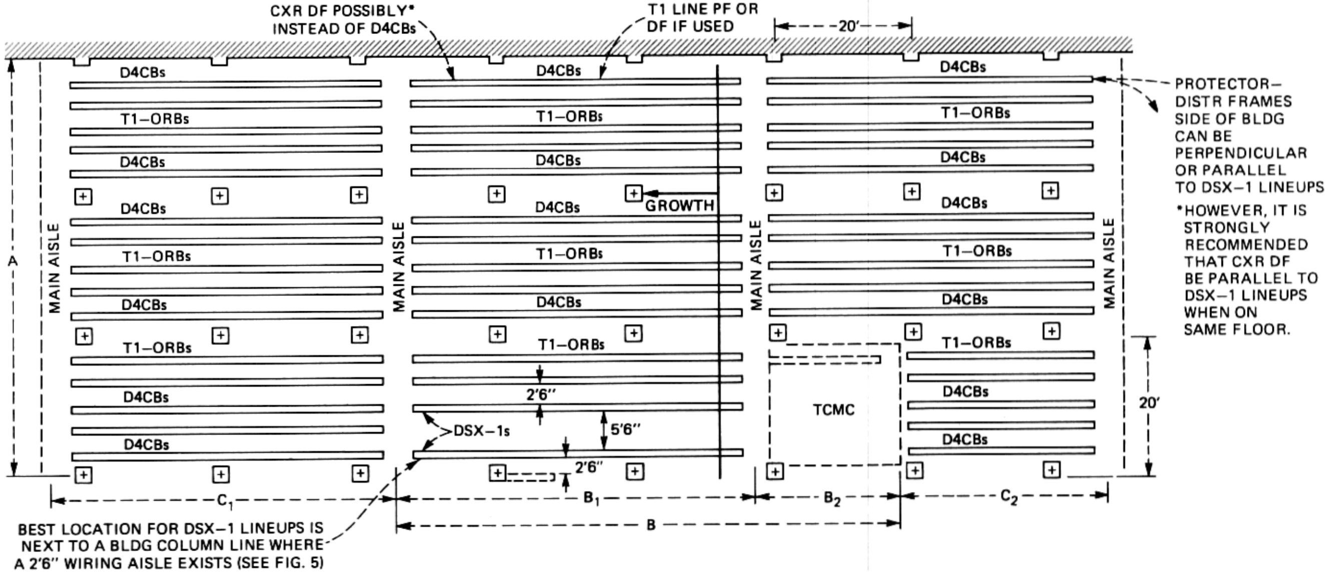


Fig. 8—Standard floor plan layout for large T1 office with parallel DSX-1 and equipment lineups.

application can be documented for referral and preliminary planning by the space planners.

The general objectives of a cable distribution system design for an equipment system are presented in Table VII. A cable distribution system should safely and efficiently support and contain the interframe cable of an equipment system over the course of its life. The Cable Pathways Plan, a spatial standard which allocates the overhead space of equipment system layouts among cable distribution, lighting and cooling systems, is discussed below. Unsecured cable is preferred to secured cable by means of lacing because of its significantly lower installation costs. However, as has been empirically determined, unsecured cable occupies approximately 40 percent more space than secured cable. The other cable distribution system objectives are self-explanatory.

3.2.1 Cable Pathways Plan

The Cable Pathways Plan allocates the vertical space between 7 and 10 feet above the floor between system and via cabling, lights, openings for cooling air, and installer access over the life of the building. Here system cable refers to intra-system cabling while via cable originates outside a particular system and passes over or terminates in it. The Cable Pathways Plan associated with the standard floor plan for 12-inch-deep equipment frames is schematically shown in Fig. 9. In this plan, the dedicated space for the three levels of cable distribution system racks are referred to as pathways. The lights are located under the cross-aisle pathways to conserve energy, minimize cooling air blockage, and maximize access to the cable racks. The plan also coordinates the cross-aisle racks with the building columns and cable holes to eliminate interferences. Moreover, since this plan fixes the air cooling channels with respect to the building columns—between the cross-aisle racks over the maintenance aisles—the cooling air distribution system planning is simplified. This also minimizes major equip-

Table VII—Objectives of an equipment cable distribution system

Support and contain interframe cable without damage over life of equipment system
Be economical to furnish and install
Adhere to Cable Pathways Plan
Employ unsecured cabling
Provide physical segregation or electrical isolation of cable types as required
Have sufficient accessible capacity to manage cable over equipment system
Allow simple interchanging of supporting interim floor stanchions with frames or older frames with newer frames
Apply over all possible equipment system frames and all possible equipment system layout occurrences
Be compatible with cable distribution systems over interconnected equipment systems

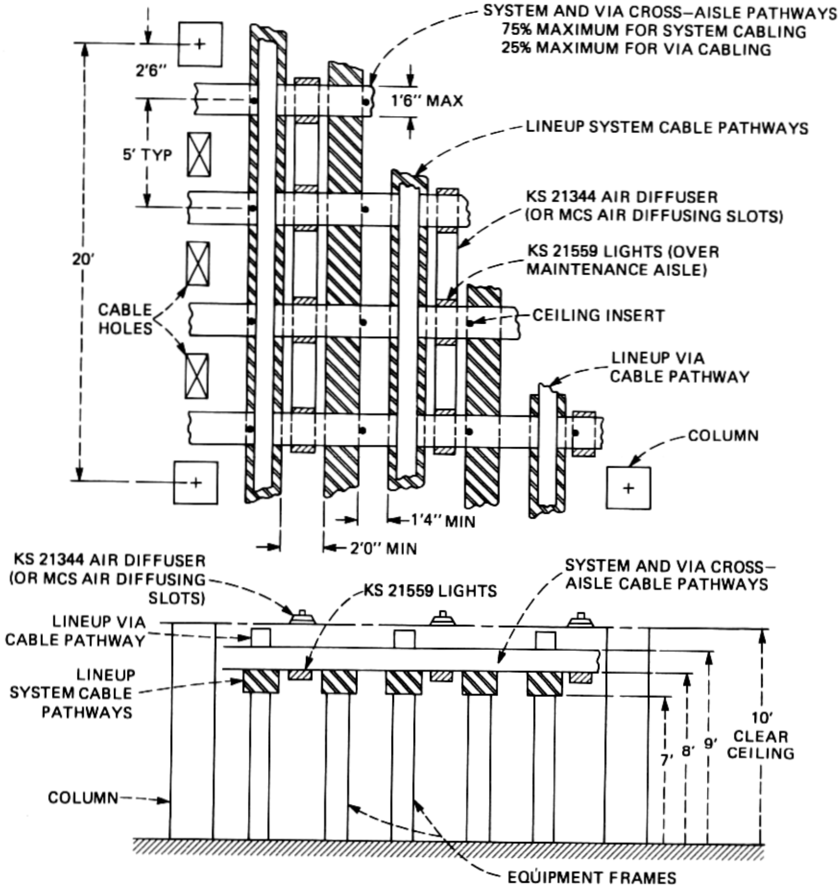


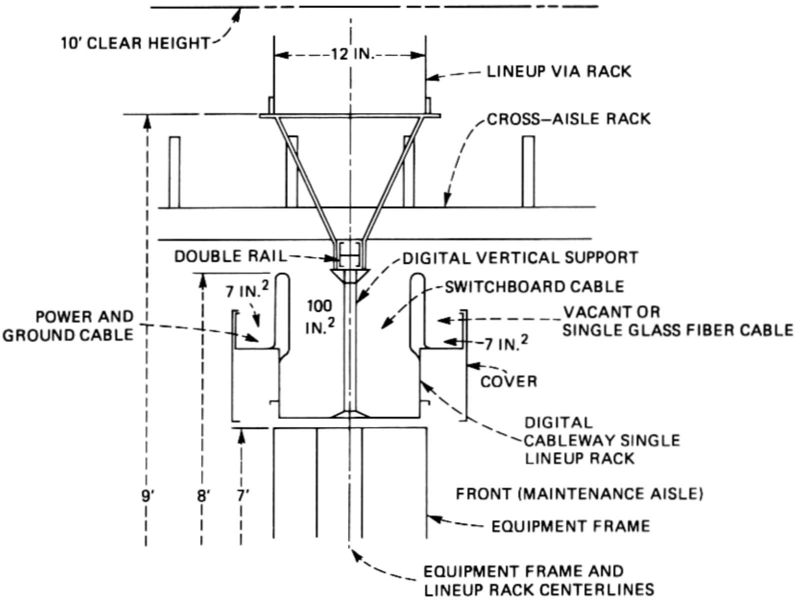
Fig. 9—Cable Pathways Plan for 12-inch-deep equipment frames.

ment-cooling adjustments because of unanticipated changes in the equipment system after the initial installation.

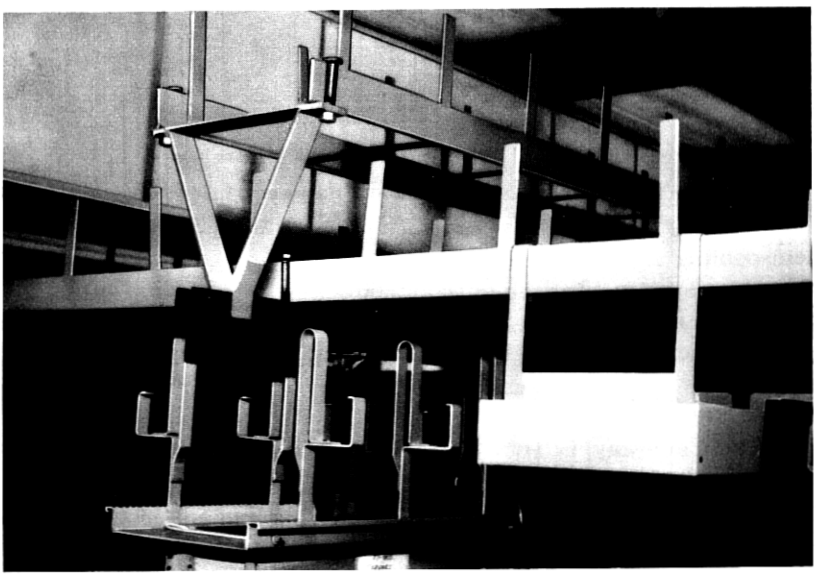
This plan is modified slightly from Fig. 9 over PFs and DFs depending on the particular type and height of frame used.

3.2.2 Digital Cableway

Digital Cableway is an example of a cable distribution system engineered and designed for application with NEBS-conforming T1 and other digital transmission systems. Figures 10a and 10b show an end view and a laboratory photograph of the Digital Cableway single lineup rack configuration used over nearly all the digital transmission equipment frames. The Digital Cableway double lineup rack configuration shown in Fig. 11 is employed over ultimate lineups with six or more DSX-1 and/or DSX-1C frames.

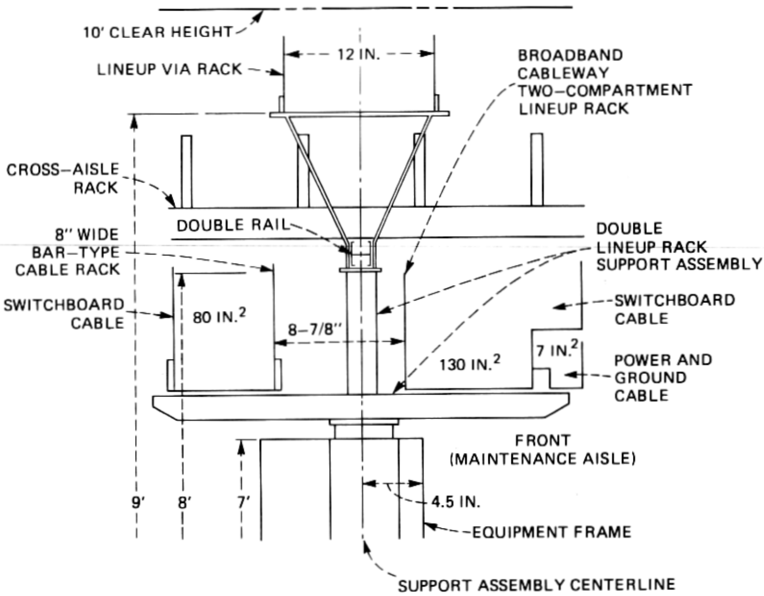


(a)

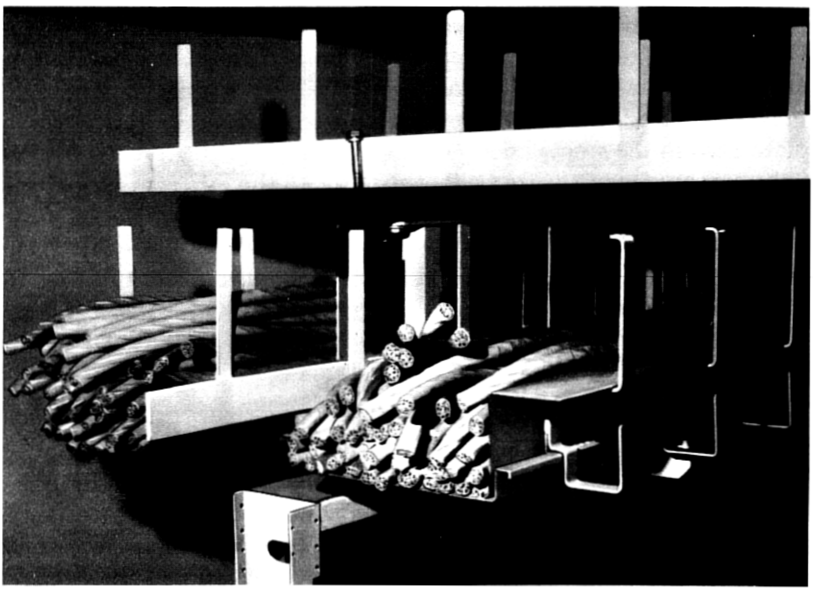


(b)

Fig. 10—(a) End view sketch and (b) laboratory photograph of Digital Cableway single lineup rack arrangement.



(a)



(b)

Fig. 11—(a) End view sketch and (b) laboratory photograph of Digital Cableway double lineup rack arrangement (for lineups of six or more DSX-1 and/or DSX-1C frames.)

The Digital Cableway single and double lineup rack configurations meet all the Table VII objectives. Both configurations economically provide support, containment and protection for interframe cabling. They conform to the Cable Pathways Plan concept. Briefly, the vertical space allocation is met, the continuous double rail allows proper cross-aisle rack positioning, the lights are mounted under the cross-aisle racks, and the minimum distances between adjacent lineup racks of Fig. 9 —necessary for adequate cooling and human access— are not violated with the specified aisle spacings. Both configurations are designed for unsecured cabling. Only power and switchboard cable are required to be segregated. The power and switchboard segregation compartments in the lineup racks are indicated in Figs. 10a and 11a while segregation in cross-aisle and lineup via racks is accomplished by either dedication or using separators. Except for the minor floor space dimension restrictions imposed in Fig. 8, Digital Cableway provides adequate capacity without constraining the office layout guidelines for T1 and other digital transmission systems. Both configurations have full accessibility from the frames underneath, between racking levels and within each racking level. For example, the bar loops separating the small and main compartments in the lineup rack of Fig. 10a allow switchboard cable to exit the upper main compartment without interference by the cable lay in the small side compartments. Interchanging frames or removing interim floor stanchions is a simple undertaking since the lineup rack mounting bolts are accessible at all times no matter what the cable pileup. Digital Cableway is also applicable over all digital transmission frame possibilities and layout variations. Evidence of this applicability is provided by the transition plate used in the single lineup rack version of Fig. 10 allowing the rack to be centered over the frame footprint for all the different frameworks encountered. Because Digital Cableway is employed universally over all digital transmission systems, and because its cross-aisle and lineup via racks are at the standardized levels above the floor for all equipment systems, its interfaces and compatibilities with other cable distribution systems are ensured and simplified.

3.3 Guidelines for a lighting system

The next step in the development of office planning guidelines is to select, modify or design a lighting system to be recommended for application by the space planners. A desirable lighting system for an equipment system should meet the objectives listed in Table VIII.

To illustrate a desirable lighting system design, consider the new economical energy-conserving and simply installed lighting system that has been developed and is recommended for all NEBS equipment

Table VIII—Objectives of an equipment lighting system

Be ecomonical and efficient to furnish, install, and operate
Meet NEBS illumination requirements
Adhere to Cable Pathways Plan
Be universally applicable with all equipment systems

system applications. The light fixture associated with this lighting system provides illumination by use of a U-tube fluorescent light in combination with a reflective grid for light dispersion. In adherence with the Cable Pathways Plan, these lights emit adequate illumination when supported over the maintenance aisles on nominal 5-foot centers under the cross-aisle pathways. The lights and cross-aisle rack coordination according to the Cable Pathways Plan minimize equipment cooling air blockage and allow simple access to the cable racks as shown in Fig. 12. Here, a dropped air diffuser is located at the 10-foot level above the floor directly over the maintenance aisle air flow channel, bordered by the cross-aisle racks with suspended lights underneath on two sides and the lineup racks on the other two sides (refer to Fig. 9).

3.4 Guidelines for an equipment-cooling system

To complete the development of office planning guidelines, an equipment-cooling system must be selected, modified or designed for

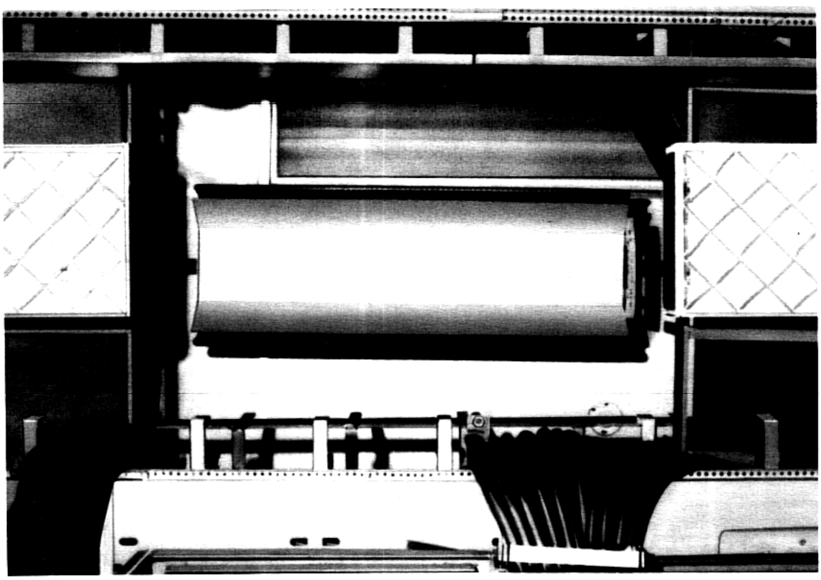


Fig. 12—Laboratory photograph of KS-21599 lights and KS-21344 dropped air diffuser located according to Cable Pathways Plan (viewed from floor to ceiling).

Table IX—Objectives of an equipment cooling system

Have capacity to maintain equipment within NEBS specified temperature range (40° to 100°F, 80°F nominal) and humidity range (20 to 55%) for long component life and comfortable working environment
Be economical and efficient to furnish, install, and operate
Possess flexibility to adapt to changing technology
Adhere to Cable Pathways Plan
Be universally compatible with all equipment systems

recommended application with the equipment system. The goals of an equipment-cooling system design are outlined in Table IX.

Well-engineered equipment cooling systems are exemplified by two types which are typically used for equipment layouts exceeding 20 watts per square foot averaged over the entire equipment spread. These two technically different air-distribution systems are referred to as a Conventional Cooling System (CCS) and the Modular Cooling System (MCS). Both the CCS and MCS cool equipment by diffusing air from the 10-foot level down across the equipment frame fronts. The all-air CCS includes a central fan room, supply and return ducting, and ceiling-supported air diffusers. The MCS uses chilled water distribution from a main chiller to and from process cooler units located between building columns. In turn, the fan-coil units of the process coolers continually recirculate air from the equipment area; the air is supplied by means of either a suspended-ceiling plenum with diffusing slots or a local ducting system, and it is returned through either a raised floor plenum or by point returns on the front of the process cooler units. The CCS system is effective in the 20 to 60 watts per square foot range for average floor heat load. The MCS becomes cost competitive at 20 watts per square foot average floor heat load and can handle an average floor heat load over 80 watts per square foot.

In choosing between these two types of cooling systems in their overlapping heat load range (e.g., T1 offices range from 25 to 55 watts per square foot), the other factors of Table IX should be compared. The MCS is particularly adaptable to changes in requirements and layout at any time during the life of the building without major costs. This flexibility frequently proves cost effective, especially in offices with steadily advancing equipment technology modifications or variations in circuit forecasts. Both types of equipment-cooling systems can be applied over all types of equipment systems with compliance to the Cable Pathways Plan. Figure 12 shows an example of a properly installed dropped air diffuser according to this plan.

IV. TOPES PLAN ALGORITHMS DEVELOPMENT

Plan algorithms can be constructed for an equipment system after the establishment of its office planning guidelines. They functionally relate central office space planning factors to circuit forecasts. In particular, the estimated number of equipment frames required at ultimate growth for a given office directly depends on the ultimate number of forecast voice circuits. Each equipment frame has an associated effective floor space occupation (determinable from the office layout guidelines), current drain, heat dissipation and via cabling. Consequently, the types of equipment frames, their overall floor space, current drain, heat dissipation and via cabling can be predicted once ultimate voice circuit forecasts are known as indicated in Fig. 1.

4.1 Possible circuit connections

The first step in developing plan algorithms for an equipment system relating voice circuits to office characteristics is to identify all the possible voice circuit connections to the given equipment system. Such an interconnection diagram makes the functional relationship of voice circuits to frames more readily apparent. The same transmission interconnection diagram used to identify and associate frames with equipment systems can be used. However, a more detailed transmission interconnection diagram categorized according to terminating and through circuits is generally more useful. As an example, Fig. 13 labels the more prominent T1 office terminating and through circuit connections, derived with reference to Fig. 2.

4.2 Mathematical equations

The formulation of plan algorithms equations can be easily written for an equipment system once all possible circuit connections are known. By combining the frame circuit capacity values from the frame data table with the possible circuit connections, the correlation between the frame quantities and voice circuits can be mathematically equated. The frame quantities can be written in the form

$$f_i = \sum_j a_{ij} t_j + \sum_k b_{ik}\, th_k,$$

where t_j and th_k are terminating and through voice circuit connections and a_{ij} and b_{ik} are coefficients relating frame capacity to circuits. The equivalent floor space required for each frame can be functionally related using the office layout guidelines. The floor space values should account for main aisle, between-building-column, and maintenance center space in addition to the frame footprint and equipment aisle spacings. With these values, the total office floor space can be formulated as

$$S = \sum_i s_i \left(f_i + c_i \right),$$

where s_i is the equivalent floor space of the ith frame and c_i is a

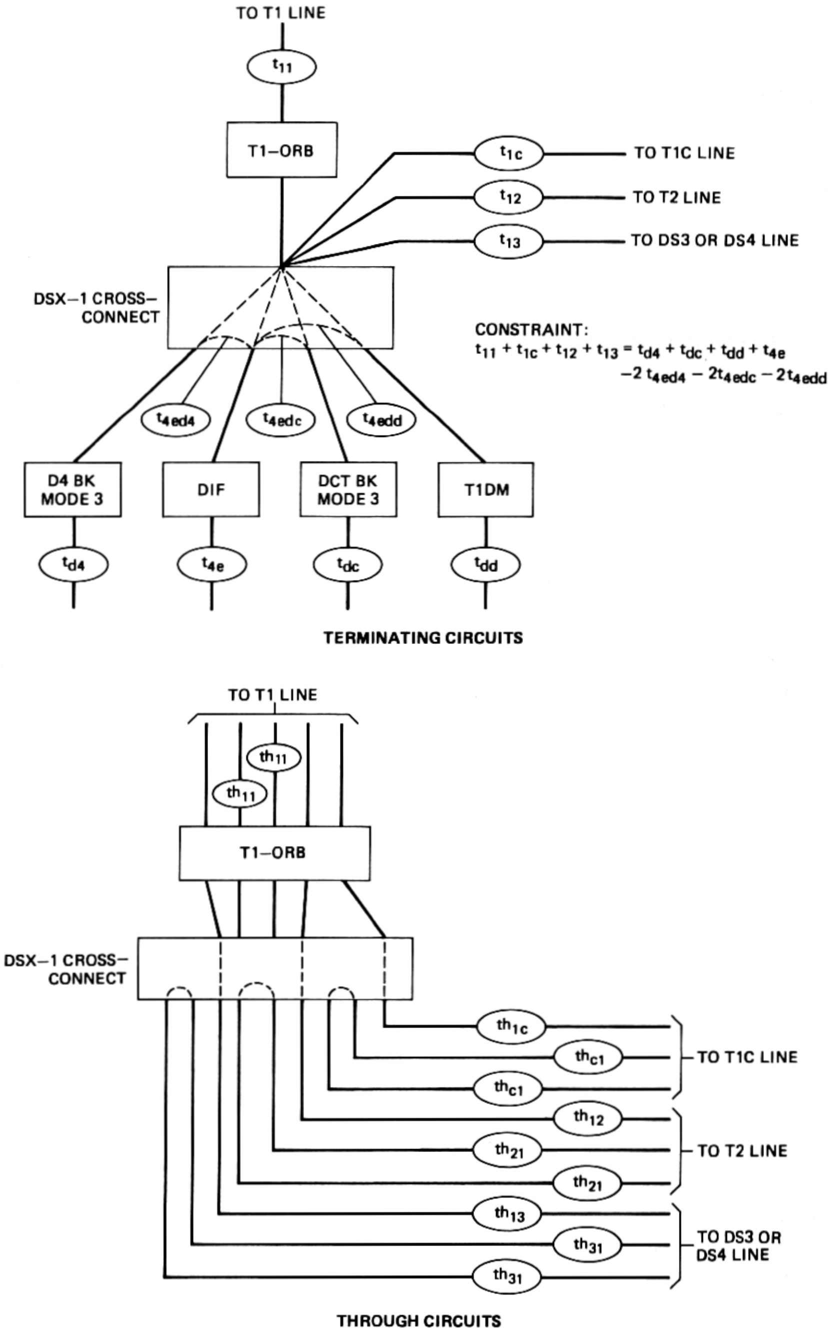


Fig. 13—Possible terminating and through voice-circuit connections for T1 office.

constant. The current drain and heat dissipation values per frame are just a reflection of the frame data tabulation. The via cabling per frame values are the interframe cabling data distinguished to be via cabling utilizing the transmission interconnection diagram. The total overall office current drain, heat dissipation, and via cabling can each be written in equation form identical to the total office space equation but with $c_i = 0$.

The general mathematical equations can be illustrated by a couple of the plan algorithm equations for a T1 office. With reference to the terminating and through voice circuit definitions of Fig. 13, the number of T1-ORB frames is given by

$$\text{T1-ORB frames} = (t_{11} + 2th_{11} + th_{1c} + th_{12} + th_{13})/1152.$$

The total office space required for a T1 office (excluding distributing frames) can be estimated by substituting into the equation

$$\begin{aligned}\text{T1 office space} = 9.8\ [&\text{T1-ORB frames} + \text{D4CB-mode 3 frames} \\ &+ \text{maintenance frames}] \\ &+ 16.5\ [\text{DSX-1 frames} + 2].\end{aligned}$$

The last term assumes double DSX-1 lineups or 24 to 46 DSX-1 frames at ultimate office growth.

4.3 Programming algorithms

The programming of plan algorithms is basically straightforward, comprised of input, calculation, and output stages. The input stage requests the user-specified independent circuit values for all possible circuit connections and any line facility options that affect office layout. Any constraints on these requested values are imposed during this stage. The mathematical calculations of the algorithm equations follow the input stage. During the output stage, a summary of all the user-specified input and the resulting computations are printed in a self-explanatory format.

For T1 offices, the necessary user-specified voice circuits are symbolized in Fig. 13. The voice circuit sum of t_{11}, t_{1c}, t_{12}, and t_{13} is constrained according to the indicated equation during the input stage. The input, mathematical computations, and output of the T1 office plan algorithms are provided on TOPES. An example of the human interactions during the TOPES input and output stages for T1 offices are presented in the following section.

V. PLANNING EXAMPLE

The application of office planning guidelines and plan algorithms, and their complementation of each other, are exemplified in this section for a large T1 office. This exercise simulates the process a space planner would follow in planning such an office using these developed aids.

5.1 Long-range circuit forecasts

Suppose a T1 terminal office is being planned for a given central office building, and this building also has an existing or has planned a No. 4 ESS switching system and an FT3 lightwave transmission system at ultimate growth. Other than these systems and interfaces, no other digital facilities are to be installed in this building. A TCMC area is to be reserved for most of the maintenance frames and other equipment but, for simplicity, assume the TCAS maintenance system is not to be employed. In particular, suppose telephone company long-range circuit forecasts predict 25,000 voice circuits are required to be connected to D4CB-mode 3 frames and 75,000 digital voice circuits are to interface with DIF frames of the No. 4 ESS switch, of which 2500 voice circuits are common to both frame types. Furthermore, suppose 75,000 of these terminating voice circuits are to be carried by T1 line facilities while the remainder are to be transmitted over FT3 lightwave facilities. Lastly, assume that the T1 and FT3 through circuits turned around at the DSX-1 are predicted to be 30,000 and 8,000 voice circuits, respectively, with no common T1-FT3 through circuits.

5.2 TOPES plan algorithms input

On the user's computer terminal, various command instructions can be used to access the TOPES plan algorithm for T1, T1C and/or T2 offices. This plan program sequentially requests all the necessary input information, and then displays (or prints) the output on the graphics (or nongraphics) terminal.

The input sequence, and responses after the prompting "?:" indications, for this T1 office example are listed in Fig. 14 just as they appear on a TOPES graphics terminal screen. Here, the user entered "T1 office example" as an identification description of the program run, indicated preferences for a T1 office with a TCMC center but without TCAS maintenance, and input the ultimate predicted circuit forecasts and line facility choices for this assumed example. Lastly, the typical situation of 25 per cent T1 line powering, each by −48, +130, −48 and +130, and +130 and −130 volts, is chosen.

5.3 TOPES plan algorithms output

Figure 15 presents the graphics terminal output for the T1 office example. With reference to the numerical indicators in this figure, the output format contains the following information:

① Date of plan run and user identification description,

② Description and assumptions of plan algorithms,

```
ENTER DESCRIPTION (UP TO 40 CHARACTERS)
?:T1 OFFICE EXAMPLE

T1, AND/OR T1C, AND/OR T2 DIGITAL CARRIER OFFICE PLANNING
INPUTS (USE ULTIMATE VALUES FOR PLANNING INPUTS)


OFFICE TYPES AND OPTIONS

LIST ALL TYPE OFFICES BEING PLANNED - T1 AND/OR T1C AND/OR T2
(LIST T1 WITH NO. 4 ESS DIGITAL CIRCUITS):
?:T1
IS A FORMAL T CARRIER MAINTENANCE CENTER (TCMC) PLANNED, NEXT
TO THE DSX-1 LINEUP? YES OR NO:
?:YES
IS T CARRIER ADMINISTRATION SYSTEM (TCAS) - PHASE III PLANNED
FOR THE OFFICE(S)? YES OR NO:
?:NO

T1 DIGITAL CARRIER OFFICE CIRCUIT INPUTS

ULTIMATE DIGITAL CIRCUITS CONNECTED TO NO. 4 ESS:
?:75000
ULTIMATE CIRCUITS CONNECTED TO D4 CHANNEL BANKS IN MODE 3:
?:25000
ULTIMATE D4 CHANNEL BANK-MODE 3 CIRCUITS CROSS-CONNECTED AT
DSX-1 TO NO. 4 ESS:
?:2500
ULTIMATE CIRCUITS CONNECTED TO DCT BANKS IN MODE 3:
?:0
ULTIMATE DS-0B DIGITAL DATA CIRCUITS CONNECTED TO DSX-1 FRAMES:
?:0
ULTIMATE THRU T1 LINE CIRCUITS TURNED AROUND AT DSX-1:
?:30000
ULTIMATE THRU T1 LINE CIRCUITS CONNECTED TO DS3 RATE (HIGH-
SPEED DIGITAL SYSTEMS):
?:0
ULTIMATE THRU HIGH-SPEED DIGITAL LINE CIRCUITS TURNED AROUND
AT DSX-1:
?:8000

LINE CIRCUIT CARRYING OPTIONS

A MINIMUM OF  95000 ACTIVE LINE CIRCUITS ARE REQUIRED FOR THE
LINE TERMINATIONS FROM THE DSX-1 TO D4,DCT,4E AND/OR DDS FRAMES.
HOW MANY OF THESE ACTIVE LINE CIRCUITS ARE TO BE CARRIED BY T1,
AND HIGH-SPEED DIGITAL LINES,RESPECTIVELY? (MUST ADD UP):
?:75000,20000

LINE VOLTAGE POWERING OPTIONS

WHAT PERCENT OF THE T1 LINES ARE TO BE RESPECTIVELY POWERED BY
A)NO, B)-48, C)130, D)-48 & 130, E)130 & -130 VOLT SUPPLIES?
?:0,25,25,25,25
```

Fig. 14—TOPES plan input algorithms for T1 office example.

③ Summary of user-supplied input responses,
④ Via cabling output in secured or unsecured assemblies,
⑤ Numerical frame requirement output,
⑥ Office space requirement output,
⑦ Office current drain requirement output,
⑧ Office heat dissipation output,
⑨ Office layout guidelines reference output,
⑩ Copy and continuation requests.

```
*TOPES PLANNING DATA FOR T1 DIGITAL CARRIER OFFICE**

 INCLUDED ARE TERMINAL,CROSS-CONNECT AND LINE TERMINATING
 FRAMES AND MAINTENANCE SPACE. NOT INCLUDED ARE EQUIPMENT
 POWER AND VOICE-FREQUENCY DISTRIBUTING FRAMES.
 SEE TOPES OPERATING MANUAL - PA-800501 FOR ASSUMPTIONS
 USED IN THESE CALCULATIONS.          ISSUE 2       10/79

 OFFICE OPTIONS
   FORMAL TCMC PLANNED NEXT TO DSX-1                          YES
   TCAS-PHASE III PLANNED FOR T1 OFFICE                       NO

 DS1 CIRCUIT REQUIREMENTS
   CIRCUITS CONNECTED TO NO. 4 ESS                         75000.
   CIRCUITS CONNECTED TO D4 CHANNEL BANKS-MODE 3           25000.
   CIRCUITS COMMON TO NO. 4 ESS AND D4-MODE 3 BANKS         2500.
   CIRCUITS CONNECTED TO DCT BANKS-MODE 3                      0.
   CIRCUITS COMMON TO NO. 4 ESS AND DCT-MODE 3 BANKS           0.
   DS-0B DDS CIRCUITS CONNECTED TO DSX-1 FRAMES                0.
   CIRCUITS COMMON TO NO. 4 ESS AND DDS FRAMES                 0.
   T1 LINE CIRCUITS FOR TERMINATIONS FROM DSX-1            75000.
   T1 THRU LINE CIRCUITS TURNED AROUND AT DSX-1            30000.

 INTERCONNECTED DIGITAL SIGNAL LEVEL CIRCUIT REQUIREMENTS
   T1C LINE CIRCUITS FOR TERMINATIONS FROM DSX-1               0.
   T2 LINE CIRCUITS FOR TERMINATIONS FROM DSX-1                0.
   HIGH-SPEED CIRCUITS FOR TERMINATIONS FROM DSX-1         20000.
   T1C THRU LINE CIRCUITS TURNED AROUND AT DSX-1               0.
   T2 THRU LINE CIRCUITS TURNED AROUND AT DSX-1                0.
   HIGH-SPEED THRU CIRCUITS TURNED AROUND AT DSX-1          8000.
   T1 LINE CIRCUITS CONNECTED TO T1C LINE CIRCUITS             0.
   T1 LINE CIRCUITS CONNECTED TO T2 LINE CIRCUITS              0.
   T1 LINE CIRCUITS CONNECTED TO HIGH-SPEED LINES              0.

 T1 OFFICE OVERALL LINE FACILITY CIRCUIT REQUIREMENTS
   T1 LINE CIRCUITS REQUIRED                              135000.
   T1C LINE CIRCUITS REQUIRED FOR DSX-1 CONNECTIONS            0.
   T2 LINE CIRCUITS REQUIRED FOR DSX-1 CONNECTIONS             0.
   HIGH-SPEED LINE CIRCUITS REQ'D FOR DSX-1 CONNECTS       36000.

 T1 OFFICE MAJOR VIA CABLING CONNECTIONS
         FROM FRAMES               TO FRAMES           AREA (SQ. IN.)
                                                     SECURED  UNSECURED
    D4 CHAN BANK-MODE 3    CARRIER DISTR              384.       537.
    T1 OFFICE REPEATER     LINE PROTECTOR             253.       354.
    DSX-1 CROSS-CONNECT    DT(DIF) - NO. 4ESS         160.       224.
    DSX-1 CROSS-CONNECT    DCT BANK-MODE 3              0.         0.
    DSX-1 CROSS-CONNECT    DDS INTERFACE                0.         0.
    DSX-1 CROSS-CONNECT    M1C MULTIPLEX                0.         0.
    DSX-1 CROSS-CONNECT    M12 MULTIPLEX                0.         0.
    DSX-1 CROSS-CONNECT    M13(MX3) MULTIPLEX          77.       108.

MAKE HARDCOPY IF DESIRED.  HIT [RETURN] TO CONTINUE OR ENTER 'STOP'
?!
```

```
                                            TOPES GENERATED   27-Feb-80
                T1 OFFICE EXAMPLE

T1 OFFICE EQUIPMENT FRAME REQUIREMENTS
   FRAME NAME          FRAME FUNCTION                          NO. FRAMES
   D4BC    3     D4 CHANNEL BANKS-MODE 3                         131.
   T1BR    1     T1 RPTR,NO LINE POWER                             0.
   T1BR    2     T1 RPTR,-48 VOLT LINE POWER                      29.
   T1BR    3     T1 RPTR,130 VOLT LINE POWER                      29.
   T1BR    4     T1 RPTR,-48&130 VOLT LINE POWER                  30.
   T1BR    5     T1 RPTR,130&-130 VOLT LINE POWER                 30.
   DDF1    2     DSX-1 CROSS-CONNECT                              33.
   MLSI 1,2,3    MAINTENANCE LINE STATUS INDICATOR         0.,0.,0.
   LMCD 1,2,3    LOCAL MAINTENANCE CENTER DISPLAY          0.,0.,0.
   E2BR    1     E2A ALARM REMOTE                                  0.
   (NONE)        MISC - CONNECTOR JUNCTION PANELS                  0.
   (NONE)        MISC - RPTR ACCESS UNITS                          0.
   (NONE)        MISC - T1 AUTOMATIC STANDBY UNITS                 0.

T1 OFFICE EQUIPMENT SPACE REQUIREMENTS
          3234. SQ. FT.

T1 OFFICE OVERALL LIST 1 CURRENT DRAINS
        -48 VOLTS            130 VOLTS              -130 VOLTS
      2615. AMPS             712. AMPS              240. AMPS

T1 OFFICE OVERALL HEAT DISSIPATION
          108470. WATTS

T1 OFFICE LAYOUT GUIDELINES
  STANDARD FLOOR PLAN LAYOUT FOR LARGE T1,T1C OR T2 OFFICE
  SHOULD BE USED FOR T1  OFFICE.
  REFER TO BSP 760-100-084 FOR THE T1,T1C OR T2 STANDARD
  FLOOR PLAN LAYOUTS AND GUIDELINES.
```

Fig. 15—TOPES plan algorithms output for T1 office example.

The program pauses after displaying the above information allowing the user to make a hard copy if a display terminal is used, and then to make additional runs or enter stop to terminate use of the plan unit.

As evidenced in the output of Fig. 15, this office example requires 131 D4CB-mode 3 frames, 118 T1-ORB frames, and 33 DSX-1 frames. These frames together with the TCMC demand an estimated 3230 square feet of office space.

5.4 Total office plan

With the TOPES plan algorithms output, the space planner can locate and arrange the necessary equipment for the given office. Assuming that the DSX-1 lineups are desired parallel to other equipment lineups, the appropriate standard office layout is that of Fig. 8. Dimension B of this figure is required to be around 57 feet considering 17 DSX-1 frames per lineup and about a 20-foot width for the TCMC. Dividing the predicted office space occupation value by this dimension, dimension A is predicted to be about 57 feet also. Consequently, a fairly square office space about 3 building bays by 3 building bays in size is required,

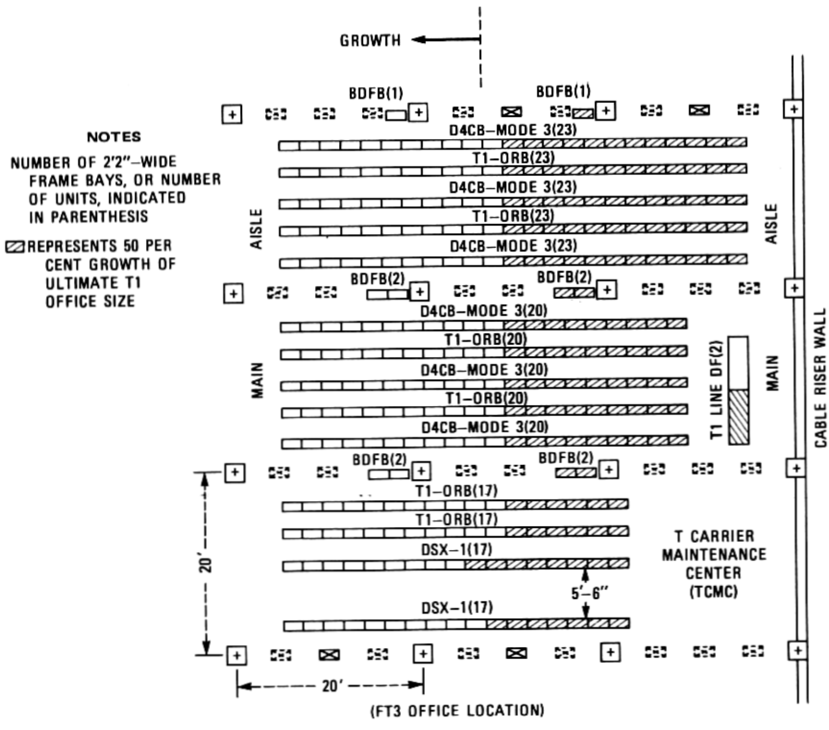


Fig. 16a—Floor plan layout for T1 office example.

assuming 20-foot center-to-center dimensions between building columns.

Suppose the space planner selects a 3 building bay by 3 building bay vacant floor space area in the building such that the intersystem via cable maximum lengths are not violated and this overall cabling is minimized as much as practical. Suppose this space is next to the cable riser wall that is perpendicular to the standard equipment lineup direction. Furthermore, assume that a T1 line DF is to be associated with this office. With these assumptions and the guidelines of Fig. 8, it is a simple matter for the space planner to locate the T1 equipment frames correctly.

Figure 16a presents a proper equipment layout for this example using the Fig. 8 guidelines. The actual floor space occupation between mid-main aisles, excluding the T1 line DF space, approximately equals 3200 square feet. This is almost identical to the space predicted by the TOPES plan algorithms. Figuring power sources of −48, +130, and −130 volts, the number of battery distributing fuse board (BDFB) frames are determined by dividing the overall current drain values by current drain per frame. These frames are shown distributed throughout the

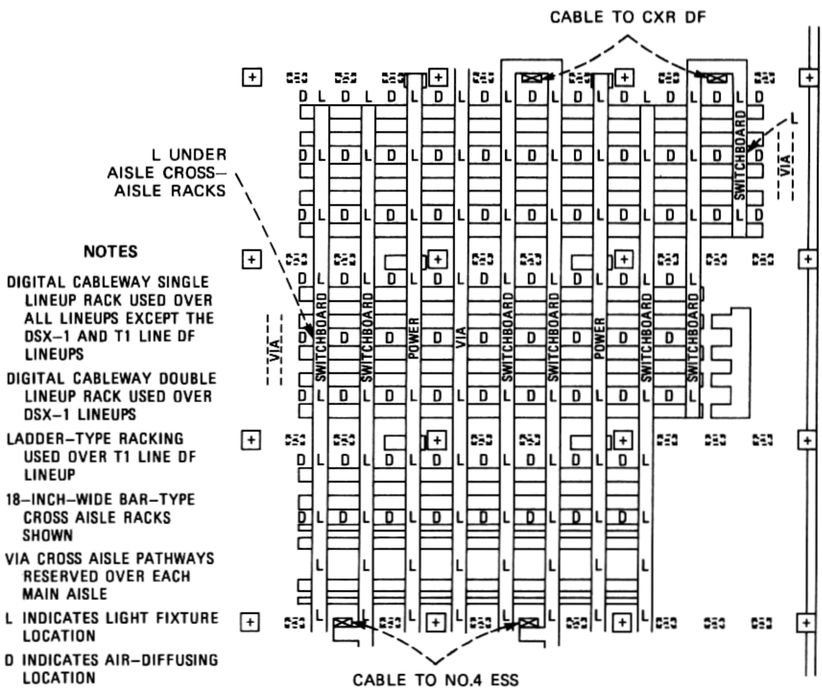


Fig. 16b—Cable distribution, lighting, and equipment-cooling system plans for T1 office example.

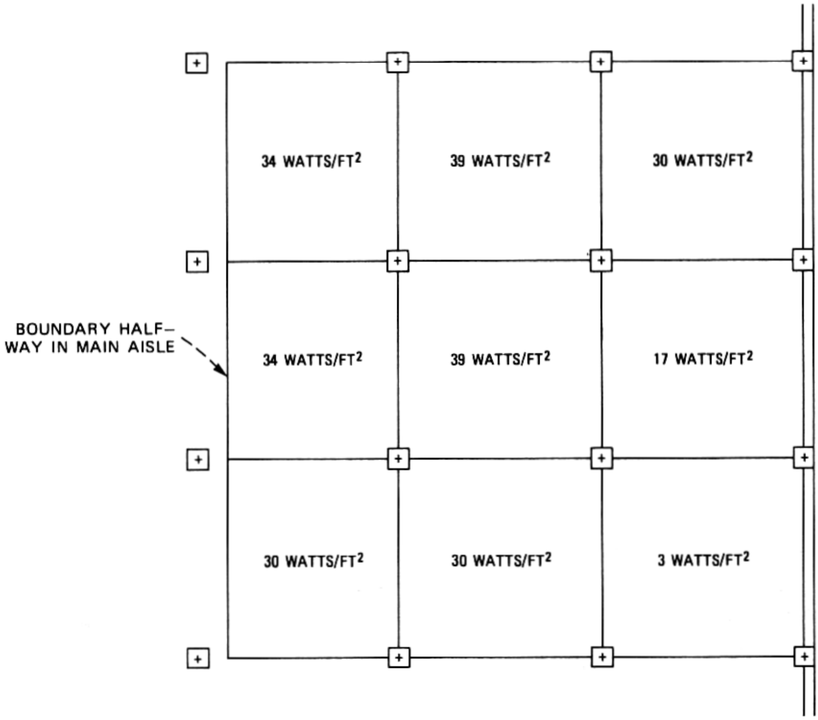


Fig. 16c—Averge heat dissipation per building bay for T1 office example.

office in their preferred location between building columns. The overall growth of this office layout when about 50 percent of ultimate growth is reached is indicated by slant lines in Fig. 16a. Note throughout growth, the DSX-1 lineups and the connected T1-ORB and D4CB-mode 3 frames are slightly offset relative to each other implying a uniform growth plan is not ideally attained, but nearly so.

Figure 16b presents the cable distribution, lighting and equipment-cooling system plans corresponding to the floor plan layout of Fig. 16a. It is assumed that the CXR DF and No. 4 ESS are on another floor while the FT3 layout is located on the same floor on the opposite side of the DSX-1 lineups from the T1 frames. The minimum number of cable holes is easily computed from the plan algorithms via cabling output, considering the fact that only 200 square inches of secured cable can be routed through a 1-foot by 2-foot cable hole with adequate fire stop protection. The lights are located at each cross-aisle pathway position over the maintenance aisles and also the DSX-1 wiring aisle. The air diffusing positions of the selected equipment-cooling system are indicated between the cross-aisle pathway positions over D4CB-mode 3 and T1-ORB maintenance aisles.

The heat dissipation of the T1 frames on a building bay basis that must be cooled are shown in Fig. 16c. The maximum heat dissipations per building bay are kept below 40 watts per square foot since the high-heat T1-ORB lineups are interspersed with the lower-heat D4CB-mode 3 and DSX-1 lineups. Either the CCS or MCS can accommodate these heat loads, and the other factors in Table IX should be compared in choosing between these two equipment-cooling systems.

VI. SUMMARY

We have presented a general methodology for developing central office planning guidelines and plan algorithms for transmission, switching, power, or other equipment systems. The development method for office planning guidelines efficiently arranges equipment in central offices with respect to cable usage, floor space, equipment growth, and equipment maintenance while providing flexibility for technological or forecast changes and compatibility with interfacing equipment systems. This development is also concerned with the preliminary planning of cable distribution, lighting, and equipment-cooling systems for application with this equipment. The development method for office plan algorithms derives mathematical equations and codifies an associated computer program based on these equations, for translating long-range circuit forecasts into numbers and types of frames, and their estimated floor space, current drain, heat dissipation, and via cabling. The benefits of these two developed aids to Bell operating company network common systems engineers in space planning tasks is demonstrated for a large typical T1 office.

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