# ENGINEERING AND IMPLEMENTATION METHODS SYSTEMS (EIMS)

# DIGITAL HIERARCHY

# CARRIER ENGINEERING

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## 1. GENERAL

**1.01** This document presents an Engineering and Implementation Methods System (EIMS) for Digital Transmission Systems applications. An overview of the overall process required to engineer and implement a metallic Digital Transmission System or Lightwave Digital Transmission System is presented, which provides an overall appreciation of the process and avoids details of specific tasks. ◗Documents covering detailed instructions for the digital hierarchy have been indexed in the following AT&T Practices:

DS1 (T1)—AT&T 365-010-001
DS1C (T1C)—AT&T 365-010-002
DS2 (T2)—AT&T 365-010-003
DS3, FT3 (T3), FT3C, and FTX-180—AT&T 365-010-004
DS4 (T4)—AT&T 365-010-005.

Drawings for all of the above practices have been indexed in AT&T 365-010-006. A digital multiplex (DS3) is indexed according to its highest digital sig-

nal (DS) rate. Hence, an MX3 digital multiplex (DS3) is indexed in AT&T 365-010-004.◀

**1.02** The reasons for reissuing this practice are listed below. Revision arrows are used to emphasize the more significant changes.

- Denote AT&T Practices—not sections
- Remove references to FT4E-432 systems
- Add references to FTX-180 systems.

## 2. DIGITAL HIERARCHY

### DESCRIPTION

**2.01** A T1 digital system begins at a D-type channel bank or similar terminal equipment, such as digital interface, switching system terminal, etc., at one location and ends with a compatible terminal at another location. Each D-type channel bank multiplexes up to 24 voice-frequency or data signals into one digital signal bit stream which is transmitted over a facility to the other terminal. Each channel bank also demultiplexes a bit stream received over a facility back into voice frequency or data. A T1 bit stream is 1.544 Mb/s (megabits per second), which is the DS1 digital signal rate.

**2.02** ▶The evolution of digital transmission beyond T1 has resulted in a number of digital transmission systems (T1C, T2, T3, FT3, FT3C, FTX-180, and T4) of higher capacity being designed to operate at higher bit rates (Fig. 7).◀ Each level of the hierarchy has a fixed bit rate and a maximum number of voice circuits which can be carried by a transmission facility operating at the particular rate.

**2.03** Digital systems which have signal rates higher than the T1 rate usually consist of two multiplexes and a connecting facility. (The D4 channel accepts 48 voice circuits and can feed directly to two DS1 facilities or one DS1C facility, or two D4 channel banks can feed a combined signal into one DS2 facility.) Each multiplex receives signals from lower DS rate systems and multiplexes them into one bit stream which is transmitted over the facility to the other multiplex. Therefore, a digital system beyond DS1 acts as a facility for the systems feeding its multiplex. Each multiplex receives one bit stream from the distant multiplex over the facility and demultiplexes the bit stream into the desired DS signal rate.

**2.04** It is strongly recommended that all digital systems have a DSX (digital signal cross-connect) panel between each multiplex and its facility to provide for patching, rerouting, and maintenance access. ▶In the FT3, FT3C, and FTX-180 Lightwave Digital Transmission Systems, patching, rerouting, and maintenance access are available at the lightwave termination equipment such as light-guide stranded cable interconnection equipment (LSCIE) or equivalent.◀

**2.05** Figures 1 through 5 show the digital signal rates along with the optional connections to higher DS rates.

### DOCUMENT INDEXES

**2.06** Document indexes (AT&T Practices 365-010-001 through 365-010-006) have been designed to provide reference material to complement this EIMS. For this reason a short description of those sections is included here. AT&T Practices 365-010-001 through 365-010-005 have the same format but differ by the digital signal rate covered and as follows:

- Part 1 is a general introduction.
- Part 2 contains a bibliography of official documents in alphanumerical order.
- Part 3 is a permuted title index which lists alphanumerically selected key words in the documents titles.
- Part 4 is the activity and equipment index which provides a list of reference documents for general activites such as plan, install, and maintain. It also provides reference documents for equipment categories such as terminals, DSX cross-connect bays, and outside plant.
- Part 5 is a permuted subject index which uses key words of subjects covered in the document but not included in the title.
- Part 6 lists references to paragraphs in this practice.

## 3. PLANNING PHASE

### TRAFFIC FORECASTS

**3.01** Traffic forecasts, based on usage of the existing network and a knowledge of growth patterns in the communities served, form the basis for a trunk forecast document used as input to planning groups. This trunk forecast should be reissued at least annually through the coordinated efforts of both traffic and network planning groups and should cover current and future circuit requirements for about a 5-year period.

**3.02** Accurate special service forecasts are generally more difficult to provide than trunk forecasts. They should be provided as a separate document by the group or groups most knowledgeable in special customer demands.

**3.03** The forecasts should be summarized in terms of point-to-point requirements for each pair of central offices in the network together with the dates when the requirements must be met. AT&T Practice 790-100-210 can be used to forecast network growth.

### CHOOSING THE RIGHT SYSTEM

**3.04** Once the point-to-point circuit requirements have been determined, the next step is to meet those requirements as economically as possible while allowing for growth, including growth from one digital signal rate to another. Decisions for certain situations may be obvious. For example, slow growth in a certain suburb may call for a T1 facility while the higher capacity T3, FT3, FT3C, FTX-180, or T4 facility may be the obvious choice in a metropolitan area. However, computing the cost per circuit mile for the many situations in between can be very complicated.

### MATFAP

**3.05** The MATFAP (Metropolitan Area Transmission Facility Analysis Program) is a facility planning computer program intended to aid operating companies in planning T-Carrier applications in metropolitan areas. The program has been designed to perform the following functions:

- Provide mechanized facility selection and routing of point-to-point requirements
- Identify projected facility exhaust dates
- Provide the information necessary to analyze facility cross-section situations including existing and projected requirements
- Provide rapid evaluation of various facility relief alternatives
- Produce construction program, facility and equipment requirements, and broad-gauge costs after the relief and deferral strategies have been selected.

A general description of MATFAP is given in AT&T Practice 781-505-100.

### ROUTING

**3.06** The shortest route may or may not be the most cost effective route. There may, for example, be a high-rate digital facility between points A and B and a need for a lower rate digital facility between points A and C. It may be more economical in this situation to route the system over the higher capacity digital rate facility than to go from A to C directly. This method of routing is called "backhauling." Other factors to consider when planning a route are joint use of cable with other carriers, use of existing unused cable pairs, and the number of maintenance trunks needed.

## 4. ENGINEERING PHASE

**4.01** Once the route and choice of facility have been determined, the engineering phase begins. The engineering phase has two parts—outside plant (OSP) and central office (CO).

### OUTSIDE PLANT ENGINEERING

#### Span Concept

**4.02** A digital route consists of one or more tandem maintenance spans. Each maintenance span or tandem maintenance span consists of ducted, buried, aerial cable, or lightguide cable, or digital radio link between maintenance offices with/without repeater stations, or radio relay stations located at specified intervals along the line. There are manholes, CEVs (controlled environment vaults), or above ground stations along the line for splicing as well as for repeaters. Splices and repeaters are usually not located in the same structure. The designing of a digital route can be reduced to designing the indi-

vidual maintenance spans. In lightwave digital transmission systems, each regenerator section is individually engineered to become part of a maintenance span. The locations of maintenance offices are normally in COs and determined during the planning phase. The line repeater station(s) for a lightwave digital transmission system is installed in a central office-type environment which includes CEVs.

### Route Survey

**4.03** An integral part of the engineering of a maintenance span is a field inspection (route survey) of the proposed route to be followed (the proposed route to be followed should have already been determined during the planning process). Certain aspects of the route must be determined before any detailed design can be started. If existing cable is not being used, the engineering of a maintenance span involves cable placements as part of the design (the particular cable size to be used should have already been determined in the planning process). Therefore, the locations, distances, cable run, conduit construction, and any unusual conditions for placing the cable are determined in this route survey. In addition, preliminary splicing manhole and repeater site locations are also located based on the required regenerator spacings. The maximum distance between line regenerators depends on the facility and the specific cable type being used. However, if growth patterns indicate that a T1 digital line may be converted to a T1C or a T1D digital line, care should be taken to make distances between repeaters compatible with both systems. ▶This is also true when converting to an FT3/FT3C/FTX-180 lightwave line.◀ Therefore, placement of repeater stations must be restricted to a distance below this maximum. If existing manholes are being used, they may require enlargement in order to accomodate the apparatus and maintenance cases. In some situations, off-line auxiliary manholes or stations may be required. Regenerator stations for the FT3, FT3C, and FTX-180 systems must have a central office environment. Therefore, construction of controlled environment vaults (CEVs) above or below ground may be necessary. After the various regenerator section lengths are determined, the repeater locations are chosen.

**4.04** ▶Once the above task is accomplished, the information obtained is used to determine formally the route to be followed and to prepare a route layout sheet. Total cable run for lightguide cable requires coordination between the equipment engineer and outside plant engineer since the cable terminates at the terminal equipment such as an LSCIE, or equivalent.◀

### Obtain Legal Right-Of-Way

**4.05** Investigation in such matters as the securing of right-of-way, the general ownership of property, etc., usually follows the preliminary route survey (if existing ducted routes are being used, then right-of-way is not usually required). It is not advisable to undertake detailed route design work before all necessary permits have been secured, since drastic changes in the route could occur as a result of conditions unveiled by the investigation.

### Powering

**4.06** Factors for powering digital lines, other than lightwave, include temperature fluctuations, length of span, type of repeaters, and the number of repeaters in a maintenance span. Powering for short metallic spans may be done from one end while longer spans require offices at both ends of the span to provide power. The T2 digital line has intermediate power stations. The FT3, FT3C, or FTX-180 lightwave digital line repeater station requires local power for the regenerators in a line repeater bay.

### Determine Outside Plant Equipment

**4.07** ▶The type of facility, the initial capacity of the line, and the number of repeater stations determine the type of outside plant equipment and cable requirements. AT&T Technologies offers installation and maintenance for the FT3, FT3C, or FTX-180 lightguide cable.◀

## CENTRAL OFFICE ENGINEERING

**4.08** This section enumerates the major tasks involved in engineering a central office for the installation of digital system equipment. The maintenance office which contains equipment to monitor, maintain, administer, and power (when necessary) a digital line is located in a CO. In addition, the CO contains the multiplex equipment when required. Frequently, lightwave line repeater stations are installed in COs. Lightguide cable requirements in the CO should be closely coordinated with outside plant engineering.

### Central Office Considerations

**4.09** The buildings constructed or selected to serve as maintenance offices or FT3, FT3C, or FTX-180 lightwave line repeater stations should be inspected and an overall office plan developed before the office equipment is installed. The office plan should be planned for the ultimate size of the office and include the following:

- Equipment required for initial service needs—specific configuration
- Floor plan layouts (bay arrangements, procedure for growth)
- Power requirements and distribution
- Cable racking layouts—cabling philosophy
- Air conditioning and lighting
- Earthquake and fire protection
- Conversion from initial equipment installation to later equipment designs.

AT&T Technologies assistance is very helpful in generating this plan since they normally install the CO equipment. Some of the items to be included in the plan are discussed in the following paragraphs.

**4.10** Equipment required for initial service includes line terminating equipment, DSX-( ) cross-connect bays, D-type channel banks, and multiplexes if needed. In short, the items shown in Fig. 1 through 5 apply to the configuration selected. The capacity planned for, divided by the capacity of each piece of equipment, roughly determines the number of pieces needed.

**4.11** Battery-backed dc office power is needed for D-type channel banks, lightwave line repeater stations, multiplexes, DSX-( ) cross-connect bays, line termination equipment, and digital line facilities. Power must be within the operating limits of the equipment being used.

### Floor Plan and Cable Runs

**4.12** A well-thought-out floor plan which allows for growth and/or conversion should be developed. It should be based on the ultimate size of the office. It should consider the maximum distances allowed for various connections (racking and cabling interfaces with other nearby systems) and the relative location of equipment to facilitate maintenance. Where possible, facilities terminating equipment should be located together with its multiplex and intermediate DSX equipment. Floor Plan Data is the primary source of information used in the development of floor plans for central office equipment systems. In addition, AT&T Practices 760-100-084, 760-100-085, and 760-100-086 provide extensive planning guidelines for digital carrier terminal offices. These guidelines cover equipment layout, cabling, lighting, cooling, and total office plans for digital systems that conform to NEBS (New Equipment Building Specifications) for digital systems. (Refer to AT&T Practice 800-610-164 for NEBS description.)

### Office Maintenance Plan

**4.13** In conjunction with the office plan outlined above, an overall maintenance plan should be developed for the system. This maintenance plan should include the following:

- Alarm and maintenance philosophy
- Alarm display and remoting
- Procedures for restoration
- Equipment configuration to implement maintenance plan (including assignment of protection lines)
- Order wire and telemetry, if required, provided by metallic order wire, optical order channel alarm and telemetry (OOCAT) arrangement, or MC-90/180 maintenance communication facility
- Cable pressure monitoring, if applicable.

### Telephone Office Planning and Engineering System (TOPES)

**4.14** The Telephone Office Planning and Engineering System (TOPES) is intended to aid operating companies in the preparation of study and engineering plans for central offices. The TOPES planning aids provide broad-gauge estimates of equipment, floor space, and electrical and mechanical support system requirements. The system enables

rapid preparation of study plans and facilitates consideration of alternative plans. Meetings improve communications between various groups involved in study plan preparation and approval.

## 5. IMPLEMENTATION PHASE

**5.01** The implementation phase outlines the major installation tasks required to transform a route design into a working system and/or facility. It should be emphasized that various interdepartmental coordinations are required so that all interrelated phases of the work can be completed in sufficient time to meet the first service date for the system. The specific job responsibilities of the various departments are described in paragraphs 5.02 through 5.13. The various tasks are divided into three major areas of responsibility: outside plant, central office, and maintenance and administration. This explanation is not intended as a complete description of the specific detailed work operation of any department. Rather, enough department responsibilities are presented to give an appreciation of interdependence during the implementation phase. The specific work operations described may vary depending on the operating company implementing the system.

### ESTIMATE PREPARATION AND APPROVAL

**5.02** A specific estimate authorization (AT&T Practice 935-111-430) for both outside plant and office equipment expenditures should be prepared and approval obtained. (Construction budget provisions for any required construction should have already been made.) Federal Communications Commission (FCC) approval (if required) should be secured prior to the approval of the specific outside plant estimate. Once the authorization has been approved, all other phases of implementation may be started.

### INTERDEPARTMENT MEETING

**5.03** With approval of the specific estimate authorization, it is suggested that meetings with the representatives of at least the following departments be held as often as necessary for coordination to completion:

- Plant
- Equipment Engineering
- Transmission Engineering
- Plant Extension Engineering
- Traffic
- Building Engineering
- Maintenance and Administration.

**5.04** Companies with no prior experience with the installation of a particular digital system selected should initiate the first meeting during the engineering phase. The purpose of this meeting is to alert the various departments of the impending introduction of the system. The final detailed route design should be reviewed, and the concurrence of all departments for the work operation sequence should be obtained. Specific responsibilities for each work operation should be fixed and a time schedule determined.

**5.05** An example schedule that illustrates the chronological relationship of important events and milestones in an FT3, FT3C, or FTX-180 Lightwave Digital Transmission System installation is shown in Fig. 6. The assumptions in determining this example schedule are noted in the figure. It should be noted that this schedule is an FT3 example; schedules for other systems will vary from that shown.

**5.06** Subsequent progress meetings of this interdepartmental committee (and other operating telephone companies, as required) should be held on a scheduled basis during the implementation phase.

### TRAINING

**5.07** The requirements for training within each department must be ***critically*** analyzed based on the complexity of the system being installed. Training is perhaps most critical in the construction, installation, repair, and CO divisions of the plant department. ***Definite times*** for training should be scheduled as carefully as the installation of equipment. It is highly recommended that training should also include craft management in departments whose work activity may affect system operation.

## OUTSIDE PLANT TASK LIST

**5.08** This paragraph and paragraph 5.09 identify the tasks for procurement, installation, and test of the outside plant facilities. The preparation of the digital line, in general, will be the responsibility of the outside plant engineering department. However, AT&T Technologies offers EF&I (engineer, furnish, and install) and maintenance on FT3, FT3C, or FTX-180 lightguide and lightwave line repeater stations. Right-of-way, easement, purchase of site property, and FCC approval (if required) should have already been secured. In addition, for routes where new cable is to be installed, the appropriate cable should be ordered following the required delivery interval.

### Repeater Station Construction and Cabling

**5.09** The nature and extent of conduit and repeater station construction or modification will vary from route to route depending on the particular operating company location. The digital route may require repeater stations at appropriate spacings (regenerator sections). Depending on the system used and the route chosen, repeater stations may be in manholes, central offices, environmentally controlled vaults, pole-mounted apparatus cases, or above-ground repeater huts.

**5.10** The following tasks are performed concerning repeater stations and cabling on an as-required basis:

- Repeater station placed or constructed.
- Cable is placed and spliced (lightguide stranded cable is terminated at the lightguide cable interconnection equipment [LSCIE]).
- Equipment and cable racks are installed in repeater stations.
- Pressurizing equipment is attached to cable, if applicable.
- Cable is tested.
- Plug-in units are installed at repeater stations (regenerators for lightwave line repeater stations are normally installed by CO personnel).

## CENTRAL OFFICE TASK LIST

**5.11** This part identifies the tasks for planning the installation of equipment in a CO.

### Central Office Equipment Order

**5.12** From the detailed route design, a consolidated list of equipment by type is prepared and the appropriate equipment orders forwarded to AT&T Technologies. This should include test sets especially in the lightwave digital transmission system. Ordering information for the digital systems can be found in Common Language AT&T Practices 795-209-XXX. The plug-in type equipment orders should be closely coordinated with the particular agency responsible for the administration of this equipment, such as PICS (Plug-in Inventory Control System) or its equivalent, and should be on the same order as the CO equipment. Plug-in units include line regenerators and all manhole circuit packs as well as units to equip CO equipment bays. In addition to the circuit packs required for the initial system capacity, the order should include the spares percentage required (approximately 10 percent is recommended, but the exact number of spares can usually be found in the J-code specifications). Therefore, initial plug-in stock and spares ratio, as well as appropriate administrative procedures, should be established. This normally requires a joint effort involving outside plant and equipment engineering, the PICS administrator, and plant assignment.

### Central Office Equipment Installation

**5.13** Based upon a company order and floor plan layout, a detailed specification is prepared usually by AT&T Technologies which indicates what equipment is to be installed, where the equipment bays will be located within the office, and where equipment is to terminate. In most cases, the installation of office equipment is performed by AT&T Technologies installers. This consists of installing cable racking and the various equipment bays and plug-in facilities, powering, and interbay cabling. Turnup of office equipment should be coordinated with outside plant. The initial circuit packs are usually installed by installers, whereas future additions are installed by customer personnel. The equipment is normally performance tested by AT&T Technologies, prior to acceptance testing by a customer. The equipment engineer determines how many plug-ins should be installed to meet immediate system re-

quirements and the anticipated growth in the near future. Subsequent installations of plug-in units are made in specific increments.

#### Acceptance Tests

**5.14** Once the line and office equipment is installed, acceptance test procedures are carried out by operating company craft. The details and sequence of how the various tests and acceptance procedures are conducted are described in Task Oriented Practices (TOP) and/or conventional AT&T Practices.

### OVERALL TESTING AND CIRCUIT ORDER WORK

**5.15** After each major system component becomes functional in each office (acceptance test complete) they must be interconnected and verified operational end to end. This usually proceeds by building from the highest digital rate down to the DS1 rate in the following steps, but eliminating steps involving digital signal rates not included in the route design:

| | |
|---|---|
| ▶DS4 Rate | ***A***—Test from span terminating frame (STF) to STF over T4M digital line |
| | and |
| DS4 Rate | ***B***—Test from M34 multiplex to M34 over ***A***. |
| FT3C Rate | ***C***—Test from MX3C lightwave terminating frame (LTF) to MX3C LTF or FT3C-SX lightwave span terminating frame over an FT3C lightwave line facility (can be FTX-180 to FTX-180 equipment configuration) |
| | or |
| FT3C Rate | ***D***—Test from FT3C-SX lightwave span terminating frame to FT3C-SX or MX3C LTF over an FT3C lightwave line facility (can be FTX-180 to FTX-180 equipment configuration). |
| FT3 Rate | ***E***—Test from FT3 lightwave span terminating assembly (LSTA) to FT3 LSTA over FT3 lightwave line facility |
| | or |
| FT3 Rate | ***F***—Test from MX3 lightwave terminating multiplex assembly (LTMA) to LTMA, or to ***I*** over ***E,*** or to ***G*** over an FT3 lightwave line facility; |
| | or |
| FT3 Rate | ***G***—Test from MX3 lightwave terminating frame (LTF) to MX3 LTF, or to ***I*** over ***E,*** or to ***F*** over an FT3 lightwave line facility. |
| DS3 Rate | ***H***—Test from M13 multiplex to M13 over ***B, C, E, G, I,*** or DS3 digital radio; |
| | or |
| DS3 Rate | ***I***—Test from MX3 multiplex assembly over ***B, C, E, G,*** or DS3 digital radio; |
| | or |
| DS2 Rate | ***J****—Test from M12 multiplex to M12 over ***C, F, G, I,*** or T2 digital line. |
| DS1C Rate | ***K****—Test from M1C multiplex to M1C over ***C, F, G, I,*** T1C digital line, or T1D digital line. |
| DS1 Rate | ***L**** —Test from D-type channel bank over ***C, F, G, H, I, J,*** T1 digital line, or 1ARDS.◀ |

**5.16** Each step is verified for error-free operation before proceeding to the next step. After step-by-step verification of correct operation of the facility and supporting equipment such as fault lines or subsystems, each system can be considered ready for assignment of traffic. Circuits (or systems) can then be patched in for service at the appropriate DSX-( )

* The D4 channel bank accepts 48 voice circuits and can feed directly to two DS1 facilities or one DS1C facility, or two D4 channel banks can feed a combined signal into one DS2 facility.

cross-connect bays according to circuit order requirements.

## 6. MAINTENANCE PHASE

**6.01** The maintenance of a system or facility includes the monitoring of office equipment alarm indicators (audible and visual) and the analysis of alarm patterns in order to sectionalize a failure to a major component of the system. The following paragraphs describe some of the most important maintenance features. Details on how specific maintenance procedures are performed can be found in referenced practices.

### ALARM FEATURES

**6.02** System components are arranged to activate office audible and visual alarms. They may also be arranged for remote control, remote reporting of alarms, and status indications via various facilities such as T-Carrier Administration System (TCAS) or Surveillance and Control of Transmission Systems (SCOTS) to a central location such as a T-Carrier Restoration Control Center (TRCC) or Facility Maintenance and Administration Center (FMAS). The systems use the E2 telemetry facility.

**6.03** There are two classes of alarms, nonservice affecting (NSA) minor alarms or service affecting (SA) major alarms. Service affecting alarms are generally those which indicate a failure has occurred which is adversely affecting service. Nonservice affecting alarms are generally those which indicate a need for maintenance attention, but service quality is not affected.

### TROUBLE SECTIONALIZATION

**6.04** Trouble sectionalization for digital systems is performed by analyzing the alarm patterns from the equipment. Alarm patterns and display panel indicators are covered in the trouble clearing data for each piece of equipment or between different digital signal rate systems.

### RESTORATION OF SERVICE

**6.05** Some systems, especially at higher digital signal rates, have automatic protection switching which cause a switch to a working standby without loss of service whenever there is a failure. Systems without this feature must be patched manually. Patching and restoration procedures are described in engineering maintenance practices.

### RETURN/REPAIR PROCEDURE

**6.06** Return procedures may vary with location. A description of PICS (Plug-in Inventory Control System) is found in AT&T Practice 756-140-120. Forms used in dealing with PICS are described in AT&T Practices 756-14X-XXX.

## 7. REFERENCES

**7.01** The following AT&T Practices are associated with or give additional information (check the appropriate Numerical Index for availability).

| PRACTICE | TITLE |
|---|---|
| 365-010-001 | DS1 Systems Document Indexes, Digital Transmission Systems |
| 365-010-002 | DS1C Systems Document Indexes, Digital Transmission Systems |
| 365-010-003 | DS2 Systems Document Indexes, Digital Transmission Systems |
| 365-010-004 | DS3, FT3, and FT3C Systems Document Indexes, Digital Transmission Systems |
| 365-010-005 | ▶DS4 Systems Document Indexes, Digital Transmission Systems |
| 365-010-006 | DS1, DS1C, DS2, DS3, FT3, FT3C, FTX-180, and DS4 Drawing Indexes, Digital Transmission Systems◀ |
| 756-140-120 | PICS/1 Users Guide, Business Information Systems, Trunks and Special Services |
| 760-100-0XX | Space Planning, Building Engineering |
| 781-505-100 | Metropolitan Area Transmission Facility Analysis Program (MATFAP) General Description, Interoffice Facility Planning, Technical Planning |

| PRACTICE | TITLE |
|---|---|
| 790-100-210 | Forecasting Network Growth and Measuring Network Usage, Central Office Equipment Engineering, Administrative Practices |
| 795-209-XXX | Digital Carrier Systems, Encoders, Common Language |
| ▶800-610-164 | New Equipment-Building System (NEBS) General Equipment Requirements◀ |
| 935-111-430 | Preparation of Specific Estimate Authorizations, Administrative Procedures and Methods, Outside Plant Engineering, Management Organizing. |

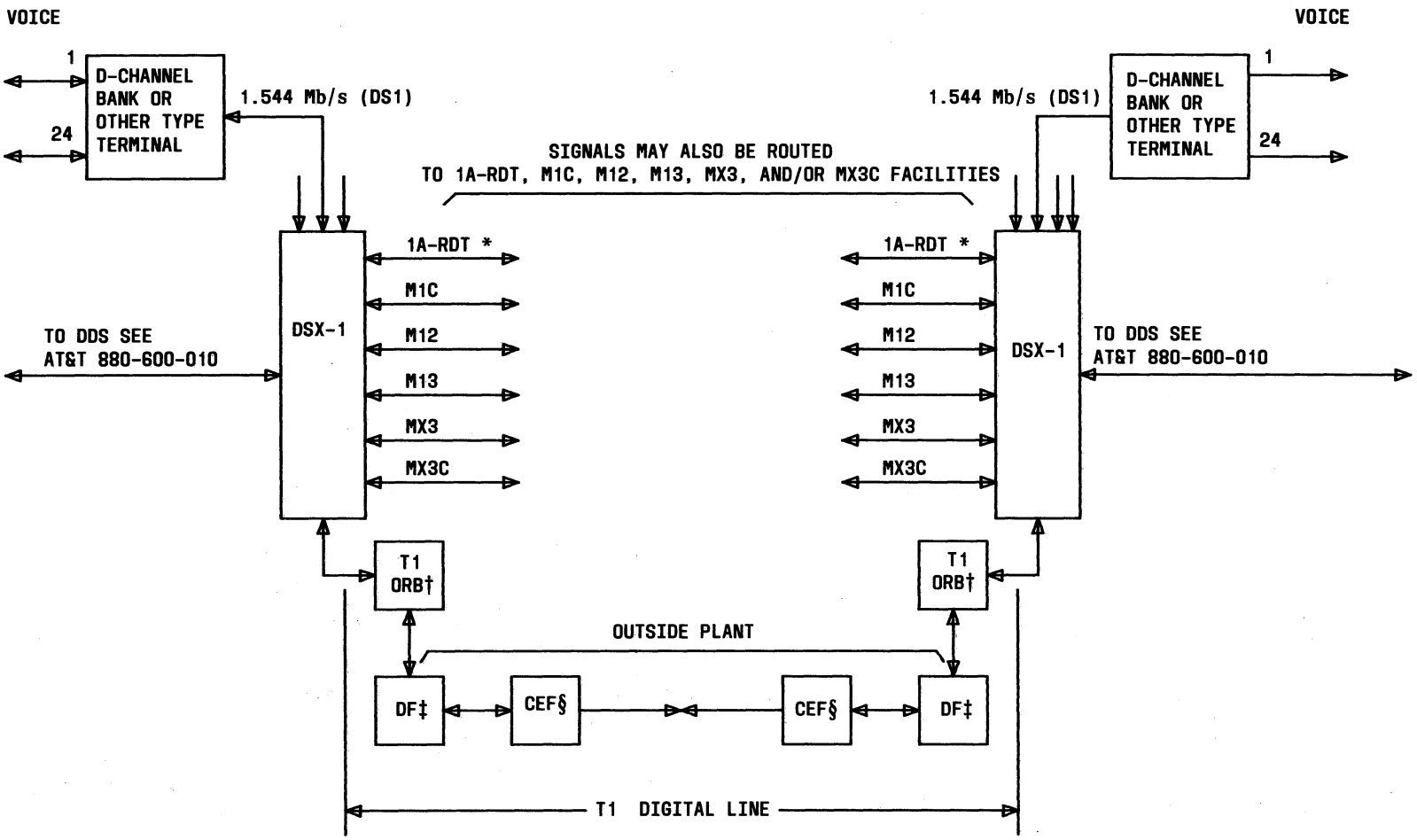



**Fig. 1—T1 Digital System (1.544 Megabits per Second)**

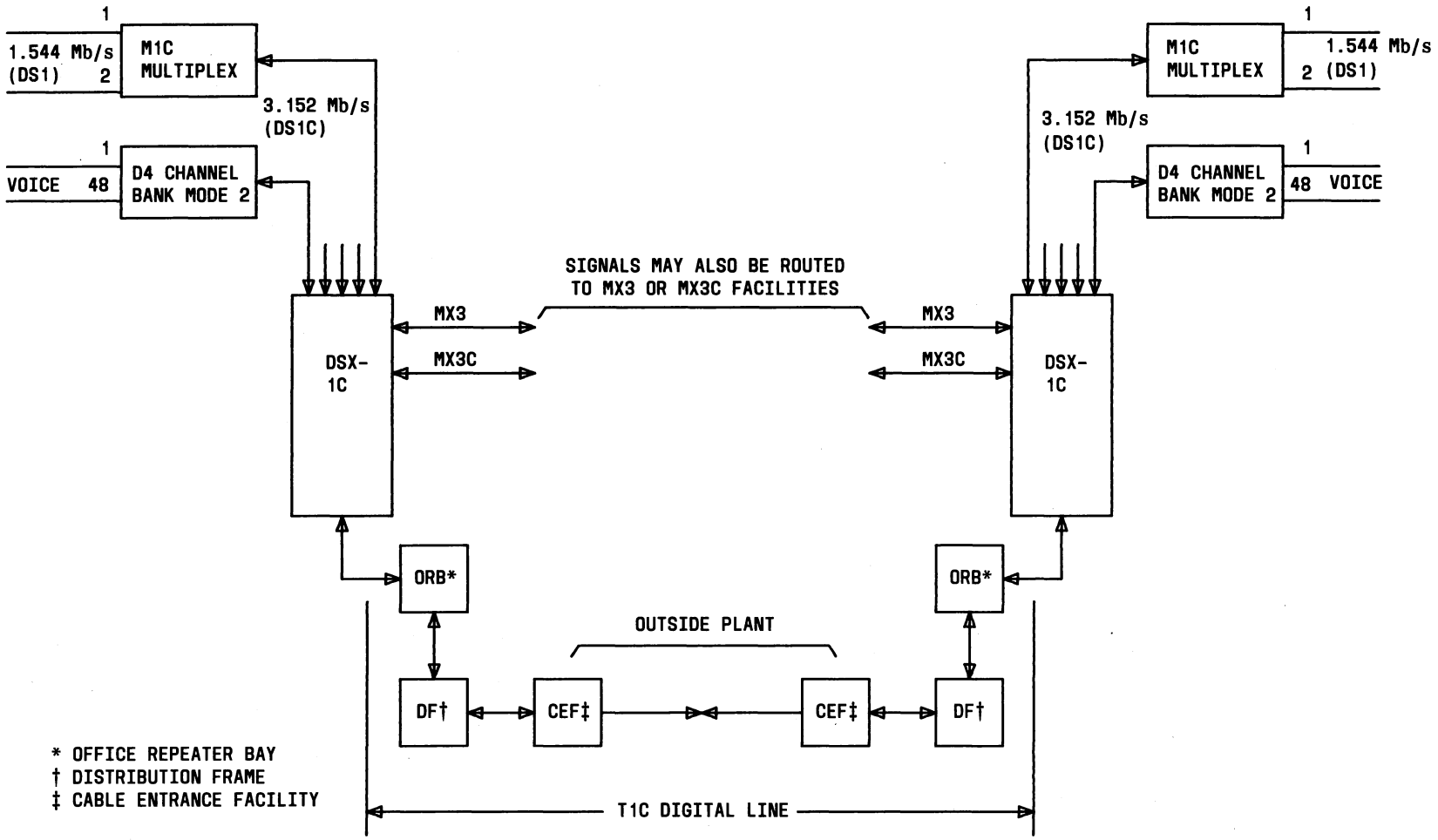



**Fig. 2—T1C Digital System (3.152 Megabits per Second)**

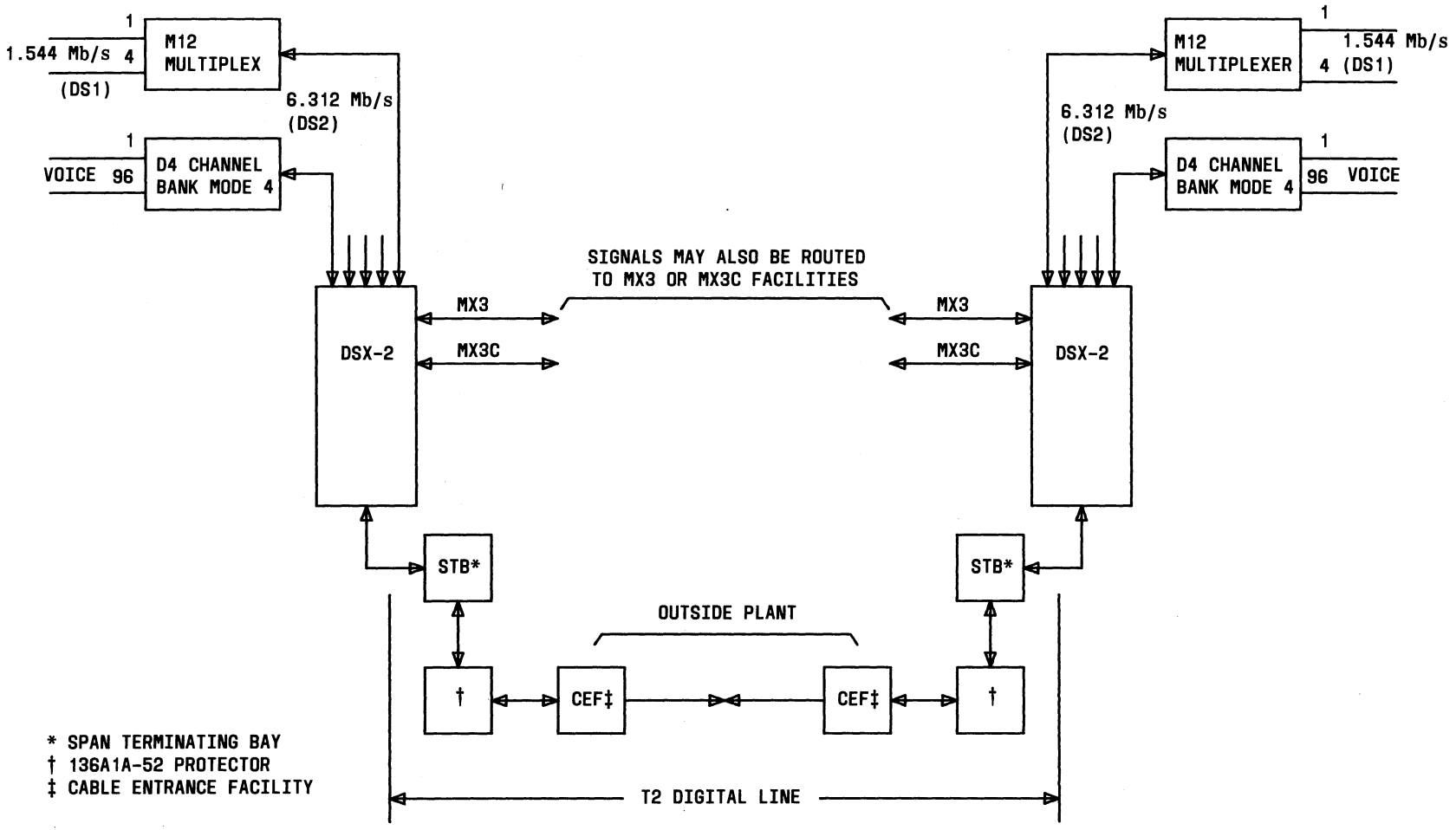
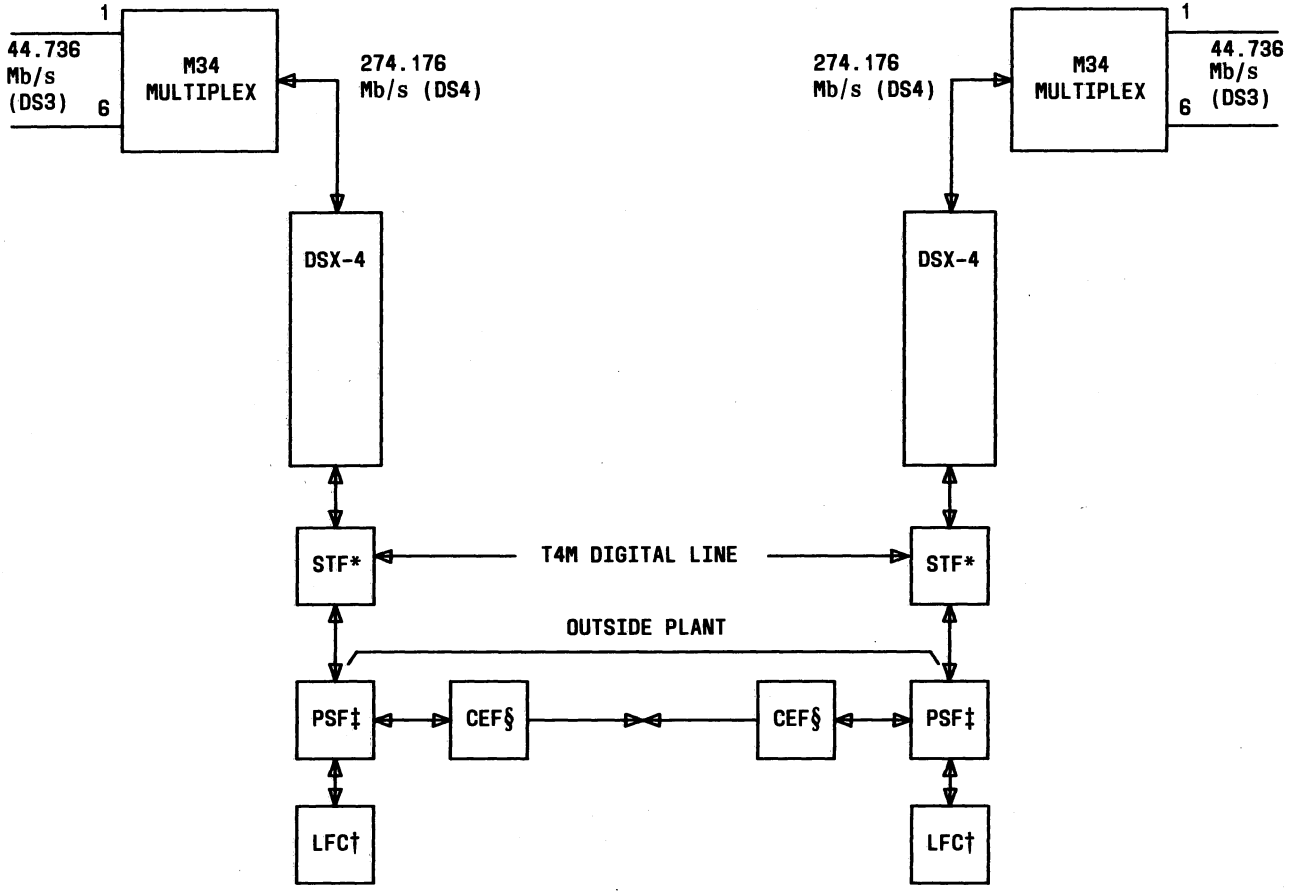
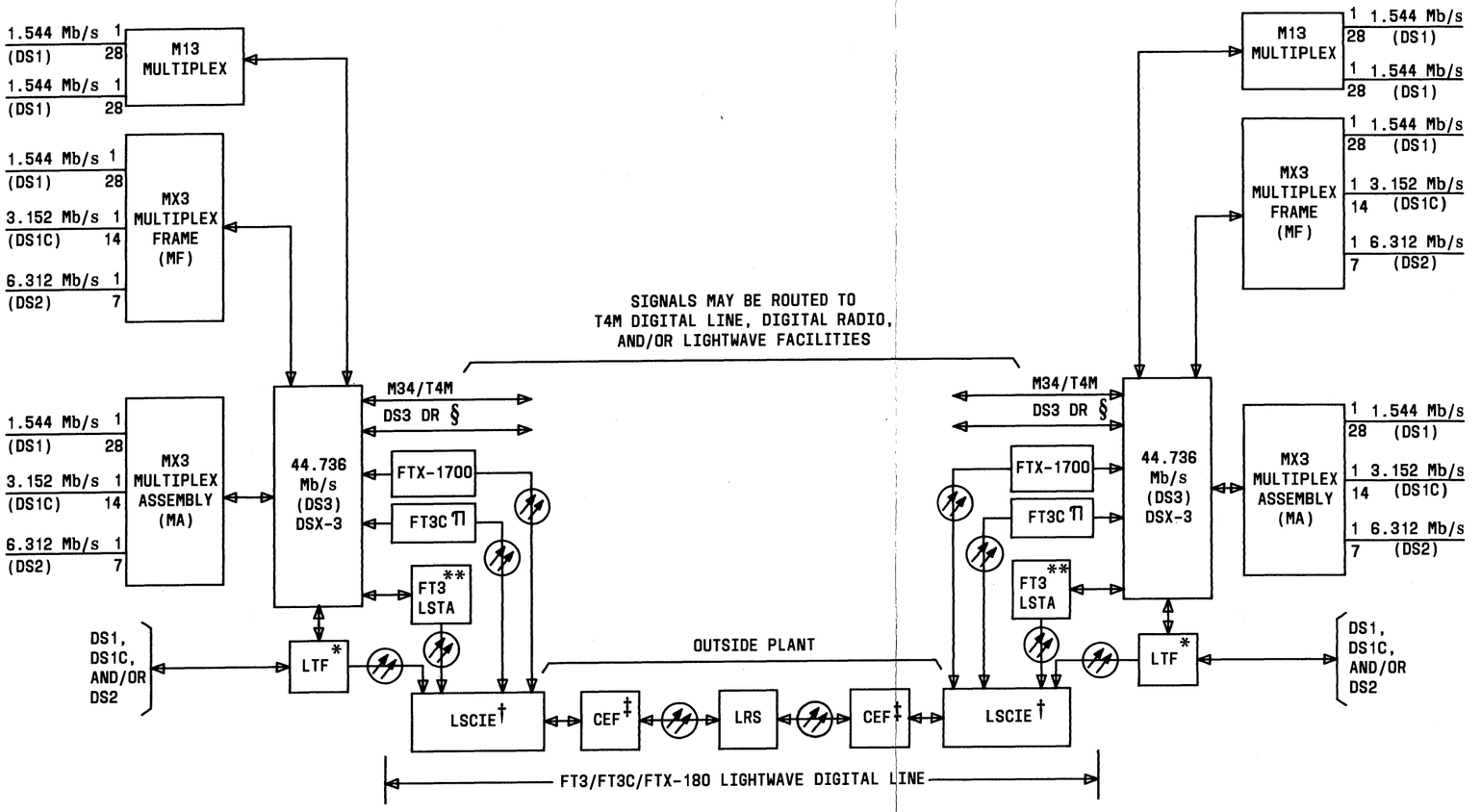



**Fig. 3—T2 Digital System (6.312 Megabits per Second)**




* SPAN TERMINATING FRAME
† LINE FEED CONVERTER
‡ POWER SEPARATION FILTER
§ CABLE ENTRANCE FACILITY

**Fig. 4—T4 Digital System (274.176 Megabits per Second)**




* MX3 LTMA, MX3 LTF, MX3C LTF, OR FTX-180 (LTF)

† LIGHTGUIDE STRANDED CABLE INTERCONNECTION EQUIPMENT

‡ CABLE ENTRANCE FACILITY

§ SEE AT&T 417-000-000 FOR DIGITAL RADIO

¶ FT3C-SX OR FTX-180 (SX)

** FT3 LIGHTWAVE SPAN TERMINATING ASSEMBLY

**Fig. 5—T3, FT3, FT3C, or FTX-180 Digital System (44.736 Megabits per Second up to 180 Megabits per Second)**

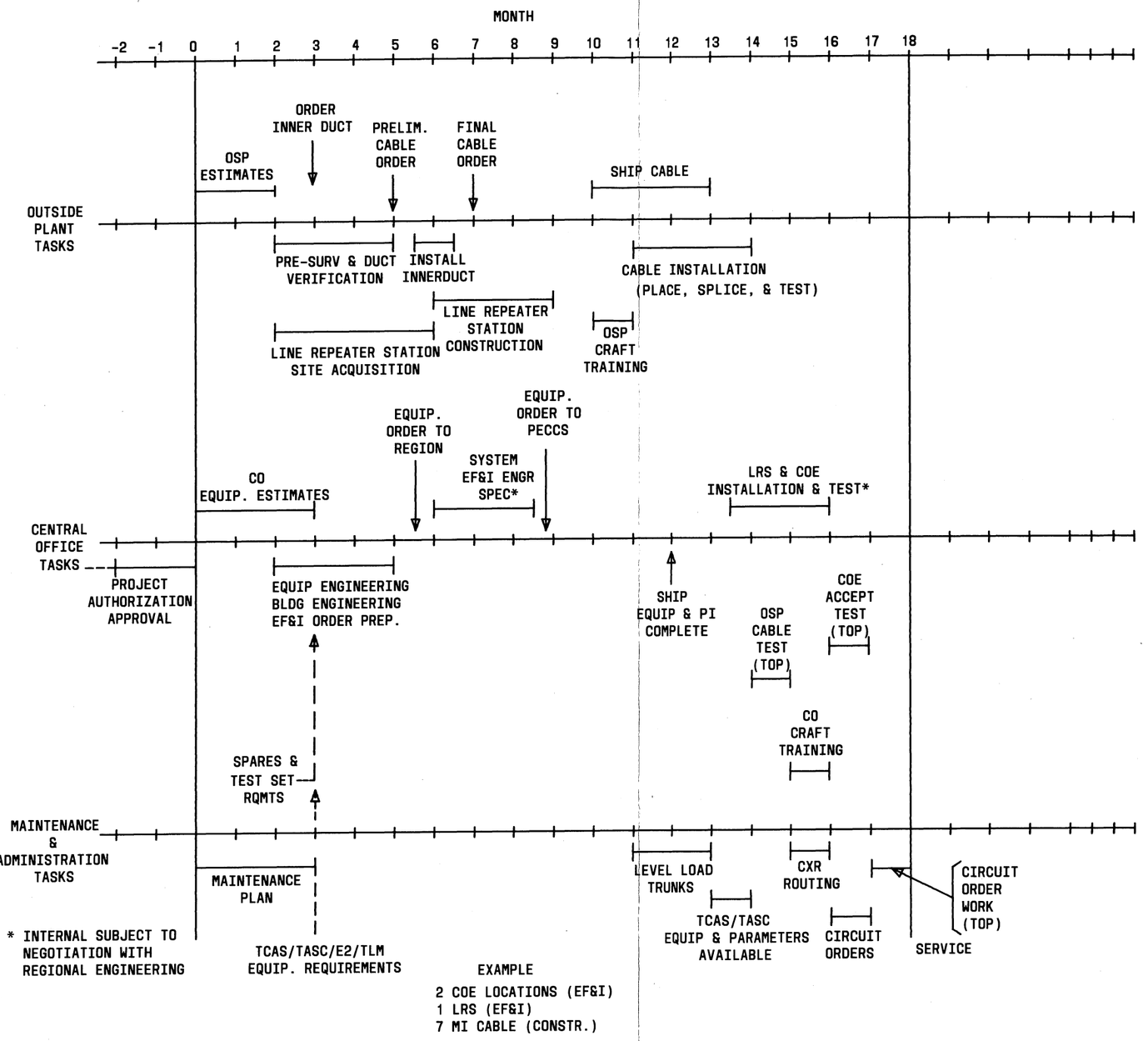



**Fig. 6—Example Initial Service Implementation Schedule**

* REPRESENTS AN MX3 MA, MF, LTMA, OR LTF

† WAVELENGTH DIVISION MULTIPLEX ASSEMBLY

‡ REPRESENTS AN M1C OR M1CA

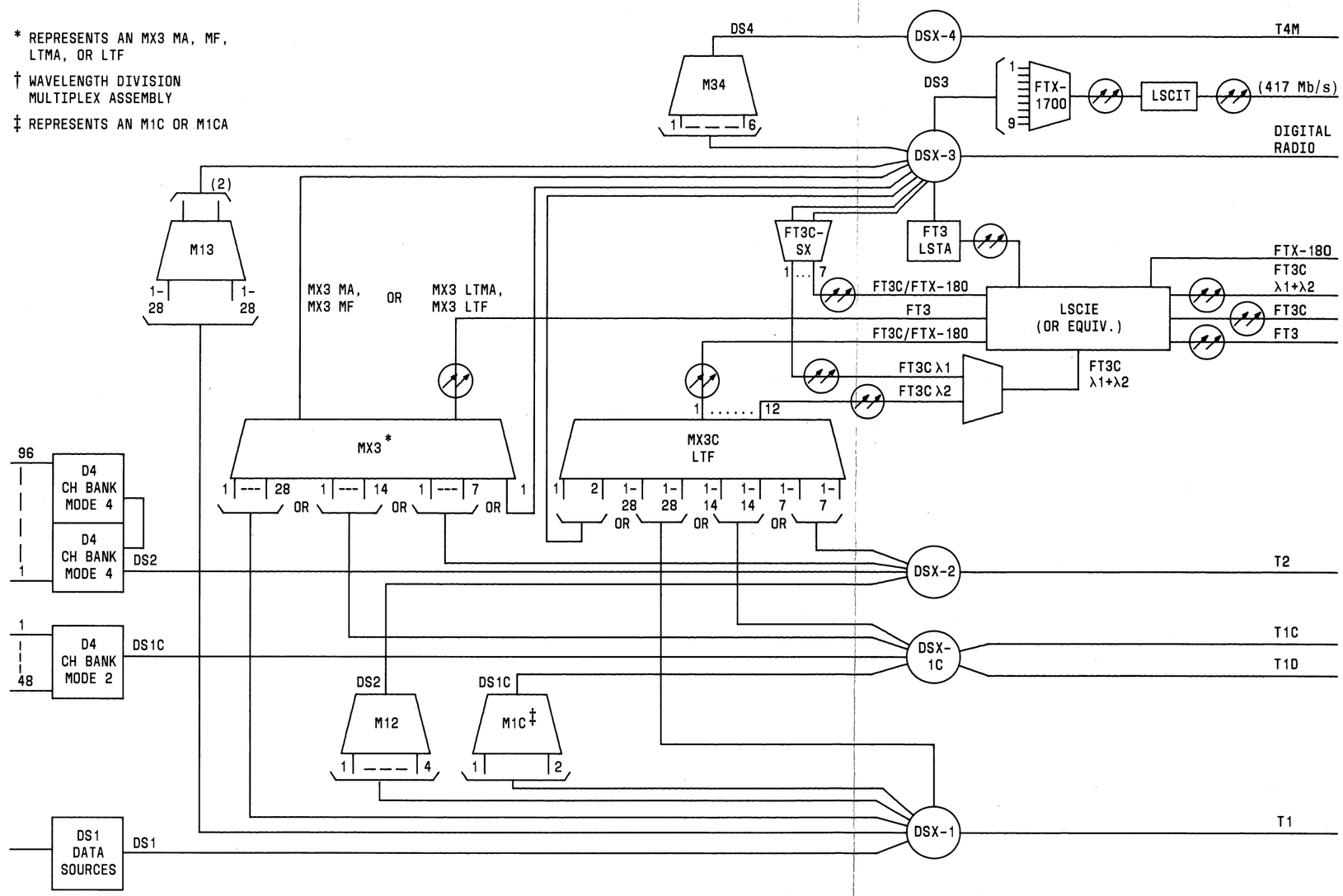



**Fig. 7—Digital Hierarchy**