T-CARRIER ADMINISTRATION SYSTEM
OVERALL ENGINEERING CONSIDERATIONS

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1. GENERAL

1.01 This practice provides TCAS (T-Carrier Administration System) overall engineering considerations in the following areas:

(a) The T-carrier network characteristics

(b) The application of TCAS to the network

(c) The detailed engineering evaluation procedure required to implement the TCAS in a geographic area served by T-carrier facilities.

1.02 This practice is reissued to incorporate new features provided by generic 4. Revision arrows are used to emphasize the more significant changes. The following are the specific reasons for reissue:

(a) Change references to the TRCC (T-carrier restoration control center) to the FMAC-M (facilities maintenance and administration center-metropolitan)

(b) Add information about the E2A DAS (Digital Alarm Scanner)

(c) Add information about the TCAS/TASC (telecommunication alarm surveillance and control) data link.

(d) Change the maximum capacity to 19,000 systems.

1.03 The TCAS is a combination of computer-based equipment, central office monitoring and access equipment, procedures, and personnel to aid in the efficient control of T-carrier restoration and repair activities and resources. It achieves effective utilization of maintenance lines and repair forces which leads to the reduction of service outages and duration time of outages.

1.04 The TCAS has been developed in such a manner that it allows gradual implementation within a metropolitan area. The various equipment options permit a degree of flexibility in the extent of the system implementation, and this permits the implementation to be done in phases. Progressive implementation of TCAS arrangements allows an orderly growth to the full capabilities of the system consistent with the needs of the user and the growth of the T-carrier network within a metropolitan area.

2. T-CARRIER NETWORK CHARACTERISTICS

A. Overview

2.01 During the past several years, T-Carrier Systems have undergone a rapid growth trend in many metropolitan areas. Projections indicate that T-Carrier Systems will continue to expand and constitute a major portion of the exchange area trunks in the future.

2.02 Because of this rapid growth and the critical nature of many of the new services being provided, many problems in the areas of maintenance and service reliability are being faced by T-Carrier System users. Accompanying the growth has been an increased demand for the timely administration of restoration and the reduction of service outages as the network grows in size and complexity.

2.03 Typically, there are at least 50 T-carrier central offices in a major metropolitan digital network. The digital network is a mixture of T1 lines driven by digital banks D, TSPS (traffic service system position), DDS (Digital Data System) terminals, T1C lines, and multiplexer, higher level digital systems, and restoration lines. The T1-Carrier Systems comprise by far the largest component and require the most maintenance administration because of the failure modes and service outages.

2.04 Each metropolitan digital network is comprised of several thousand T1-Carrier Systems, and these networks are constantly growing in size and complexity. The number of T1 digital terminals (D banks) per office ranges from a few tens to several hundreds within a network. The line between two offices is called a span, with an average of four tandem spans per system and four to five manhole repeaters per span.

2.05 Additional span lines (called maintenance lines) are provided in each route between adjacent offices and can be substituted for a defective span line by means of manual patches, thereby restoring service while repairs to the office repeater, cable, or manhole repeater are made. A number of these maintenance span lines connected in tandem to form a "backbone line" can be used for terminal-to-terminal service restoration patching.

2.06 Although the flexibility offered by span line design is desirable and is the best way to meet service objectives, it does present some maintenance administration problems. The primary problem is that of "sectionalizing" a line failure; that is, finding the particular span line at fault. The design of T1-Carrier Systems is such that system alarms are generated only at the two terminal offices; therefore, manual sectionalization may involve many phone calls and a coordinated series of measurements between offices all along the T-carrier route. The magnitude of this problem becomes evident when one considers that there can be several thousand separate T1-Carrier Systems and several more times as many span lines interconnecting the terminals in any given T-carrier network.

B. T-Carrier Failure Modes

2.07 The T-Carrier System is considered to be a reliable transmission system. However, when failures occur they can be difficult to pinpoint and correct due to the complexity of the network. Studies of the maintenance problems associated with T-carrier indicate that these failures can be grouped into the following categories:

(1) Hard outages

(2) Intermittent (or marginal) outages or hits.

Outages

2.08 Service outages experienced on T-carrier are due to either terminal or line equipment failures or are caused by some manual activity associated with the network. Statistics gathered indicate that most system failures occur during the workday when personnel are involved in activities such as system construction, system rearrangements, trouble isolation, system restoration, routine maintenance, or repairs. The opportunity for personnel-induced outages is evident from the fact that a typical system has appearances in 5 different central office buildings and 12 repeater points and can be exposed to the work activity of 30 different work groups in a given month.

2.09 Extensive data exists in the form of trouble logs and central office trouble tickets for those hard outages which last long enough for restoration activity to begin—8 to 10 minutes on the average. Studies conducted over the past several years indicate that some 60 to 80 percent of "ticketed" failures are line troubles. In addition to trouble tickets, registers are used in many offices to tally the number of intermittent outages or "hits." These register readings show that the intermittent outages—the majority of which are suspected of being caused by work activity—occur 10 to 20 times more frequently than the ticketed troubles.

Hits

2.10 Many very short outages occur which result in disconnecting calls in process and preventing the origination of new calls over the carrier system. These short duration outages are termed "hits" and result in all associated trunks being cut off and kept out of service for about 20 seconds.

2.11 Hits on T-Carrier Systems fall into the following categories:

(1) Those which exceed 300 milliseconds (ms) (2.5 seconds for some D3 and all D4 banks) and cause the operation of the CGA (carrier group alarm)

(2) Those which fall between 25 ms and 300 ms (2.5 seconds for some D3 and all D4 banks).

2.12 The 25 ms and 300 ms category will cause errors and noise to occur on voice circuits but will not necessarily cause the call to be disconnected. About 20 hits per system per month occur in this category.

2.13 On the average, three or four hits per system per month are greater than 300 ms (2.5s for some D3 and all D4 banks) in duration and result in a CGA indication. Each of these hits causes all message connections on the system to be dropped and holds all trunks out of service for a minimum of 18 seconds. Data available from several sources indicates that these hits are not evenly distributed across the systems in an office but are bunched in time on a small percentage of the systems; ie, a particular system may experience frequent random hits for a period of hours or days while other systems will experience no CGA hits. Over 60 percent of the CGA hits are found to be caused by 15 percent of the systems. However, since a portion of these hits are work activity related, the affected systems are not a stationary group that can be isolated and repaired but vary from day to day.

2.14 The system error performance threshold at which an outage occurs is usually totally unacceptable for many data services. Thus, these services can be adversely affected by hit activity which does not bring in any alarms. Additionally, transmission performance on a single voice channel can be degraded but cannot be sectionalized to a terminal without complete substitution of another terminal.

Restoration and Repair

2.15 The difficulty of restoring and repairing systems which are intermittent or suffer from marginal error performance goes hand-in-hand with the difficulty of detection and sectionalization.

2.16 The main reason for delay in restoration of T-carrier service is manual restoration. Sectionalization procedures are time consuming, especially in the event of a line trouble. Trouble must be sectionalized to a particular span before service can be restored using a maintenance (or spare) line. Since spare lines are available only on a span basis, the control office of the failed line cannot always do this rapidly as discussed in the next paragraph.

2.17 If a T1-Carrier System develops a failure and the trouble is determined to be in the line, the direction of transmission of the failure can be determined in relatively little time. In order to determine the faulty span, the personnel at the transmitting terminal end must call intermediate offices along the route and have another person check for pulses and then errors. In cases of unstaffed intermediate offices, offices that have personnel shortages, or offices with new or untrained personnel, the time involved in locating the faulty span and performing the patching functions can be quite long, thereby causing long periods of service outage.

C. FMAC-M Approach

2.18 The establishment and operation of the ➧FMAC-M➧ has been recommended as a means of overcoming some of the problems mentioned above. The function of the FMAC-M is to control T-Carrier System installation and acceptance, restoration, administration, and maintenance.

2.19 Under this concept the FMAC-M is given administrative control over the restoration by controlling the use of backbone and maintenance lines available to restore failed line sections. The organization and responsibilities of the FMAC-M are described in Practice 190-200-001. Briefly, the FMAC-M is in control of, and has responsibility for, the following major operations:

(a) Coordinating the restoration of failed systems caused by line troubles to ensure the most expeditious restoral of service

(b) Administering the use of backbone and maintenance lines in order to minimize the in-service time of these facilities which in turn expedites the repair of failed regular systems

(c) Providing assistance in the form of consultation to all maintenance entities in the T-carrier network

(d) Analyzing line failure trouble patterns in order to isolate and direct correction of line problems which cause recurring line failures

(e) Coordinating repair of the failed line

(f) Maintaining records of outages and restoral information, and preparing reports.

2.20 Although substantial improvements are being accomplished through the use of FMAC-Ms, additional improvements in service are desirable along with attendant reductions in the maintenance effort. The effectiveness of the FMAC-M is greatly dependent upon verbal notification of trouble reports from the central office personnel. The dependence of the FMAC-M on verbal inputs is one of the limiting factors in its ability to further reduce maintenance costs. Other factors which limit the effectiveness of a manual FMAC-M are as follows:

(a) The FMAC-M does not have a real-time knowledge of the status of the maintenance lines it assigns for restoration.

(b) There are no improvements in sectionalizing to the defective span.

(c) The size of major route failures is not immediately known.

(d) Not all failures are reported to the FMAC-M; thus, valuable cause and patterning information may be lost.

D. TCAS Approach

2.21 The use of TCAS improves the effectiveness of a FMAC-M operation by providing real-time alarm and status information and rapid trouble sectionalization. The TCAS hardware is designed to provide these general capabilities:

(a) Real-time surveillance and analysis of transmission alarms within the digital network. This feature provides the FMAC-M with a current picture of the status of the digital network.

(b) Sectionalization of system failures to a terminal or span, thereby eliminating manpower now expended on sectionalization.

(c) Monitoring and administration of maintenance lines and backbone lines used for restoration. This includes provision of lists of available maintenance lines, verification of manual patches, and notification of maintenance line failures or unauthorized seizures.

(d) Rapid identification of major route failure caused by cable failures, apparatus case failures, or work activity in a splice. The information provided enables the FMAC-M to effectively implement restoration plans.

(e) Routine periodic measurement of digital transmission performance on all T1-carrier lines being monitored, thereby permitting maintenance effort to be concentrated on systems with marginal performance.

(f) Automatic generation of periodic management reports on the performance of the digital network. These reports provide a current reliable overview of the network which can be used for more effective network management.

2.22 The network-oriented administrative procedures and responsibilities established under the FMAC-M concept are supplemented by implementation of TCAS. As the various phases of TCAS implementation are completed, the FMAC-M assumes a greater role in controlling and administering maintenance activities on the T-carrier network.

2.23 The TCAS is network oriented; therefore, administratively the TCAS must extend as far into the several organizations involved in T-carrier provisioning, operation, and maintenance as is required to achieve the objectives of effective utilization of resources and improvement of service. The successful implementation of TCAS requires a coordinated effort, transcending many traditional organizational (functional and geographic) boundaries, and involving both management and nonmanagement forces. It requires open channels for the flow of information among managers of several organizations' and through the organizations hierarchies.

2.24 The flow of information and control from the center is as important as the flow of information into it. The functions depend heavily on the personnel of the center for effective accomplishment of TCAS objectives through interaction with outside plant and central office personnel.

2.25 The TCAS is an effective tool for FMAC-M to administer and control many of the maintenance problems now experienced by large digital networks. Centralized monitoring provides an overall picture of the status of the network. System failures are automatically detected and can be sectionalized, thereby reducing outage time and manual sectionalization effort. This centralized control together with the ability to measure marginal performance will permit more effective utilization of the available manpower. Finally, the system can provide management with current, accurate information on the status and performance of the T-carrier network.

3. FMAC-M OPERATION WITH TCAS

A. Administration

3.01 As discussed previously, the FMAC-M (without TCAS) must rely on verbal trouble reports from the field to determine the status of the network. With the implementation of TCAS, the FMAC-M is transformed into a control center which can detect system failures and direct corrective action. The type of corrective action needed is based upon the present status of the T-carrier network.

3.02 Prior to implementation of TCAS monitoring, T-Carrier Systems are maintained using a system control concept. The terminating end of a system is responsible for responding to alarms and coordinating the sectionalization and restoration of the system. When the network becomes sufficiently large, administrative control of maintenance backbone lines is given to a FMAC-M to provide more efficient use of these facilities.

Administrative With TCAS Monitoring Only

3.03 The administrative with TCAS monitoring only arrangement permits TCAS to monitor the CGA indicators of T-Carrier Systems. With TCAS monitoring, the MCs (maintenance controllers) at the FMAC-M no longer depend entirely upon reports from the system control offices to determine the status of the network. The major function of the FMAC-M is still that of administering maintenance and backbone lines. The effectiveness of this administration is improved by real-time monitoring of the maintenance and backbone lines and a mechanized patching record. The SCOs (system control offices) must still respond to system alarms and initiate corrective action. In addition, the TCAS central can assist in the isolation of multisystem failures with the aid of the patterning package, follow up on T1-Carrier System failures or intermittents which are not being cleared, and provide failure and restoration data reports necessary for administration of the network. The MC also coordinates the dispatch of repair crews to ensure efficient use of resources.

Administration with TCAS Monitoring and Sectionalization

3.04 The administration with TCAS monitoring and sectionalization application provides capability of TCAS to monitor T-carrier lines for the purpose of sectionalization of failed span lines. This feature also allows the ability to disable office alarms to prevent manual sectionalization by office personnel. This enables the MC to direct the initiation of terminal repair, to coordinate the restoration patch with the span offices and to direct the initiation of fault locating efforts. In addition, the line monitoring arrangements permit positive completion reporting on new systems, thereby ensuring satisfactory performance when the system is turned up for service.

B. Responsibilities

3.05 In a pre-FMAC-M/TCAS environment, the SCO (system control office) is responsible for directing the sectionalization and restoration effort. The span control office is responsible for initiating fault locating and requesting the dispatch of the repair crew. Maintenance lines are administered by the span control office. When a FMAC-M is employed, the administration of maintenance and backbone lines and the coordination of restoration patches are relinquished to the FMAC-M.

3.06 Implementation of TCAS CGA monitoring does not appreciably change the responsibilities of the central offices; however, sectionalization does. The system control and noncontrol offices respond to alarms only if the telemetry facility is inoperative, the alarm disable is specifically inhibited, or a terminal office is not monitored. At all other times, directives for corrective action will come from the FMAC-M. All restorations will be coordinated by the TCAS MCs, and only the offices directly affected by the corrective action will be contacted. Fault location will still be the responsibility of the the span control office but dispatch of repair crews should be coordinated by the FMAC-M.

3.07 The responsibility of the span crews is not directly affected by the implementation of TCAS. The major change is that dispatches will be coordinated by the FMAC-M to maximize the effectiveness of the crews. The MCs will track the progress of the repair and will conduct the testing of the line prior to its return to service.

3.08 With sectionalization, the FMAC-M becomes responsible for directing restoration and corrective action on all system failures. Central office forces respond to directives from the MCs. All repair dispatches are coordinated by the FMAC-M. The center is also responsible for positive completion reporting on new T1-Carrier Systems and for periodic performance monitoring of all T1-Carrier Systems being monitored.

4. COMPONENTS OF TCAS

A. TCAS Hardware

4.01 The equipment developed for TCAS is to be installed in selected remote offices and in a central location. These various locations are then linked together by 4-wire multipoint data networks. The following paragraphs briefly describe the functions of the TCAS equipment used in a remote office and in the TCAS central.

Remote (Central) Office

4.02 The equipment available for use in a remote TCAS office consists of the MLSI (maintenance line status indicator), LMCD (local maintenance center display), DLM (directed line monitor), RAU (repeater access unit), CJP (connector junction panel), ADU (alarm disable unit) and E2A-telemetry equipment. Additionally, various bridging resistor assemblies are required. Refer to Practice 865-201-110 for the ordering information and engineering rules associated with the remote office equipment.

4.03 ***MLSI:*** The MLSI monitors the performance and integrity of all T1 and T1C maintenance and backbone lines appearing in a remote office. It continually checks each monitored line for bipolar violations and excessive pulse absence and provides both a visual and an E-telemetry output as violations occur.

4.04 ***LMCD:*** The LMCD provides the remote office with a centralized lamp display of the CGA status from the systems being monitored. The display gives the remote office forces the ability to quickly identify failed systems from a central location. The display, while not required for TCAS operation, is a recommended item for user consideration.

4.05 ***DLM:*** The DLM identifies the signal (T1 or T1C, all ones, quasi-random signal source

[QRSS], or no signal) and measures the bipolar violation error rate. It is also capable of detecting T1 and T1C framing and YELLOW signal, which determines the direction of failures. Any central office repeater that is connected to the monitoring system can be measured either manually by the central office forces or by the TCAS central via telemetry.

4.06 ***RAU:*** The RAU is basically a small crossbar switch that can access, through bridging resistors, any T1 or T1C line in its associated central office bay. It is used in conjunction with the DLM to select a particular line for measurement.

4.07 ***CJP:*** The CJP is an arrangement used to facilitate interconnection of the TCAS equipment by grouping many status points into a connectorized cable.

4.08 ***E2A Telemetry:*** The E2A APR (alarm processing remote) telemetry equipment installed in each monitored office provides the communications link between the TCAS central and the monitored remote office equipment. The E2A provides the means of transferring alarm and performance information from the remote offices to the TCAS central. The system also provides the central with the ability to send switching commands to the remote office access equipment.

4.09 ***E2A Telemetry with Serial Data Port:*** The newer E2A APR with SDP (serial data port) is capable of performing the same functions as the E2A. In addition to these functions, the newer E2A can monitor CGAs in up to three 1 and 1A ESS* switching machines via bridged access arrangements. An additional cost reduction is mounting both the TCAS equipment and E2A equipment into a single bay.

4.10 ***E2A Digital Alarm Scanner (E2A DAS):*** ▶The E2A DAS performs the same functions as the E2A APR. It monitors intelligent transmission terminals with a serial data interface using TBOS (telemetry byte oriented serial) protocol. The unit provides a limited quantity of discrete alarm monitoring and control points.◀

4.11 ***ADU:*** The ADU disables office audible and visual alarms as long as the TCAS central is monitoring the office. This eliminates the need for the terminal offices to take any maintenance action until it has been determined by the FMAC-M that such action is required.

4.12 ***Data Links:*** The TCAS can monitor digital facilities through a data link connected to a CMS (Circuit Maintenance System), No. 2 SCC (Switching Control Center System), and a ▶ TASC.◀ The TCAS/SCCS data link can monitor CGA messages from 1 ESS or 1A ESS, 2 ESS switching machines. Digital facilities that terminate in a 4 ESS switching machine can be monitored through a TCAS/CMS data link. ▶The TCAS/TASC data link is used to monitor digital facilities that terminate in smaller electromechanical switching offices that cannot justify a TCAS remote unit but are monitored by a TASC.◀

TCAS Central

4.13 The TCAS central equipment consists of the central processor (minicomputer), its operating software and data base, telemetry interface equipment, CDTs (computer display terminals), and associated peripheral equipment. Refer to Practice 865-201-101 for the engineering rules associated with the TCAS central.

4.14 ***Central Processor:*** The Hewlett-Packard 2113 minicomputer is the heart of the TCAS central. A cartridge disc subsystem, magnetic tape subsystem, and input-output extender make up the central computer. A separate CC (computer control) terminal is used for controlling the computer during special functions. The DATASPEED† printers are used as the line printers for recording network status information and report generation.

4.15 ***Telemetry Interface Cabinet:*** The equipment contained in the interface cabinet provides the interface between the processor and the telemetry networks. The cabinet can contain up to ten TCTs (telemetry-computer translators), a test TCT, a TCT patch panel, and mounting space for up to sixteen 202T data sets and channel interface units. The data sets, channel interface units, and the 4-wire data facilities are not part of the TCAS central equipment and must be engineered, ordered, and installed by the user.

* Trademark of AT&T Technologies, Inc.

† Trademark of AT&T

4.16 *CDT:* The CDTs provide the man/machine interface with the monitored network and consist of a DATASPEED 40 terminal set and the optional but recommended printer. Each CDT can be used in any of the following functions:

(a) DBC (data base controller)

(b) EFAC (equipment and facility administration controller)

(c) MC (maintenance controller)

(d) MAC (maintenance alarm controller)

(e) SC (supervisor controller).

B. Equipment Arrangements

4.17 It should be noted that most of the remote office TCAS equipment can be applied in any office regardless of whether or not that office is selected for interconnection via E2A telemetry to a TCAS center. In this application these units function on a stand-alone basis as a means of improving the maintenance capability of the local office personnel.

4.18 The typical equipment interconnections required for TCAS implementation are shown in the following listed illustrations:

(a) Local office arrangement for terminal monitoring - Fig. 1

(b) Local office arrangement for sectionalization - Fig. 2

(c) TCAS to 1 or 1A ESS switching machine arrangement - Fig. 3

(d) TCAS to SCCS data link arrangement - Fig. 4

(e) TCAS to 4 ESS switching machine arrangement - Fig. 5

(f) ➧TCAS to TASC data link arrangement - Fig. 6➧

(g) TCAS central arrangement - Fig. 7.

Centralized Alarm Reporting and Analysis

4.19 Terminal monitoring implementation involves centralization of alarms from a number of terminal offices into a TCAS central for computer processing and pattern analysis. The T-carrier CGA alarms are monitored as is the status of the maintenance lines used for service restoration. This permits detection of T-Carrier System failures, partial sectionalization of a failure by patterning to a common cause when multisystem failures occur, and aiding in the restoration of service.

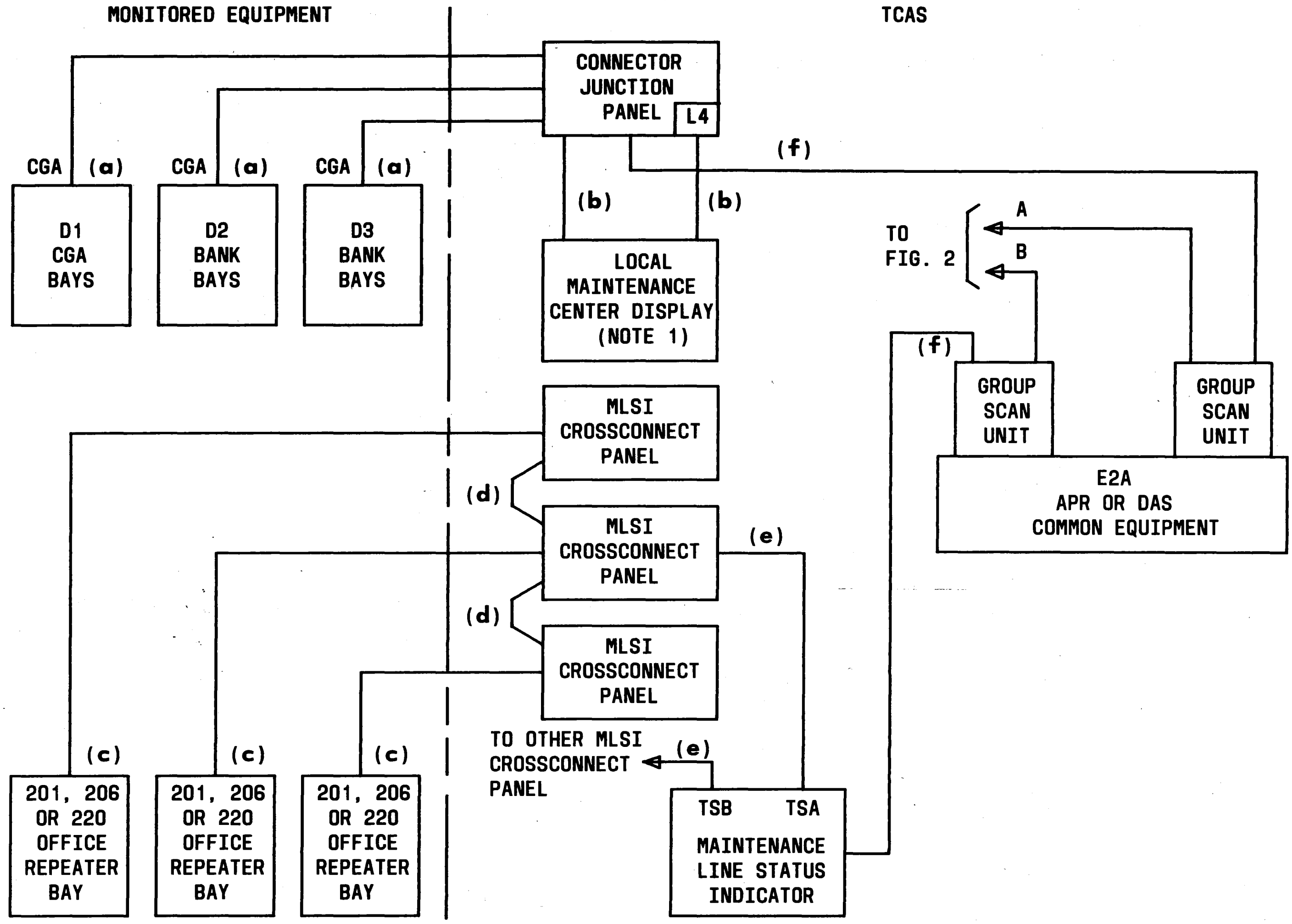
4.20 By receiving the alarms on failed systems and cables, the FMAC-M MC are able to interact with the system to obtain status and failure information and maintenance line availability. The MCs can also determine the system, office, and span as well as post repair progress reports and hazardous condition information.

4.21 Periodic reports generated by the TCAS central listing the systems currently failed, available maintenance lines, and office performance summaries will provide the FMAC-M and management with information needed to more effectively direct restoration and repair.

DLM - Trouble Sectionalization

4.22 The DLM provides the ability to measure the error performance of a T-carrier line at office repeater points. This capability permits sectionalization of a T-Carrier System failure to a terminal or a span. Because this sectionalization is performed centrally, an office alarm disable capability is provided to reduce the maintenance effort at the terminal offices.

4.23 The final phase of TCAS implementation provides the greatest economic return by reducing the maintenance effort required to sectionalize T-carrier failures. Implementation of sectionalization involves the installation of RAUs in office repeater bays and DLMs in each office so equipped. The DLM can be directed by the TCAS via E-telemetry to measure the bipolar violation performance of any T1 or T1C line passing through or terminating in the office. Lines with poor performance will be reported so that routine maintenance can be scheduled. Maintenance activity can then be confined to those systems exhibiting poor performance.



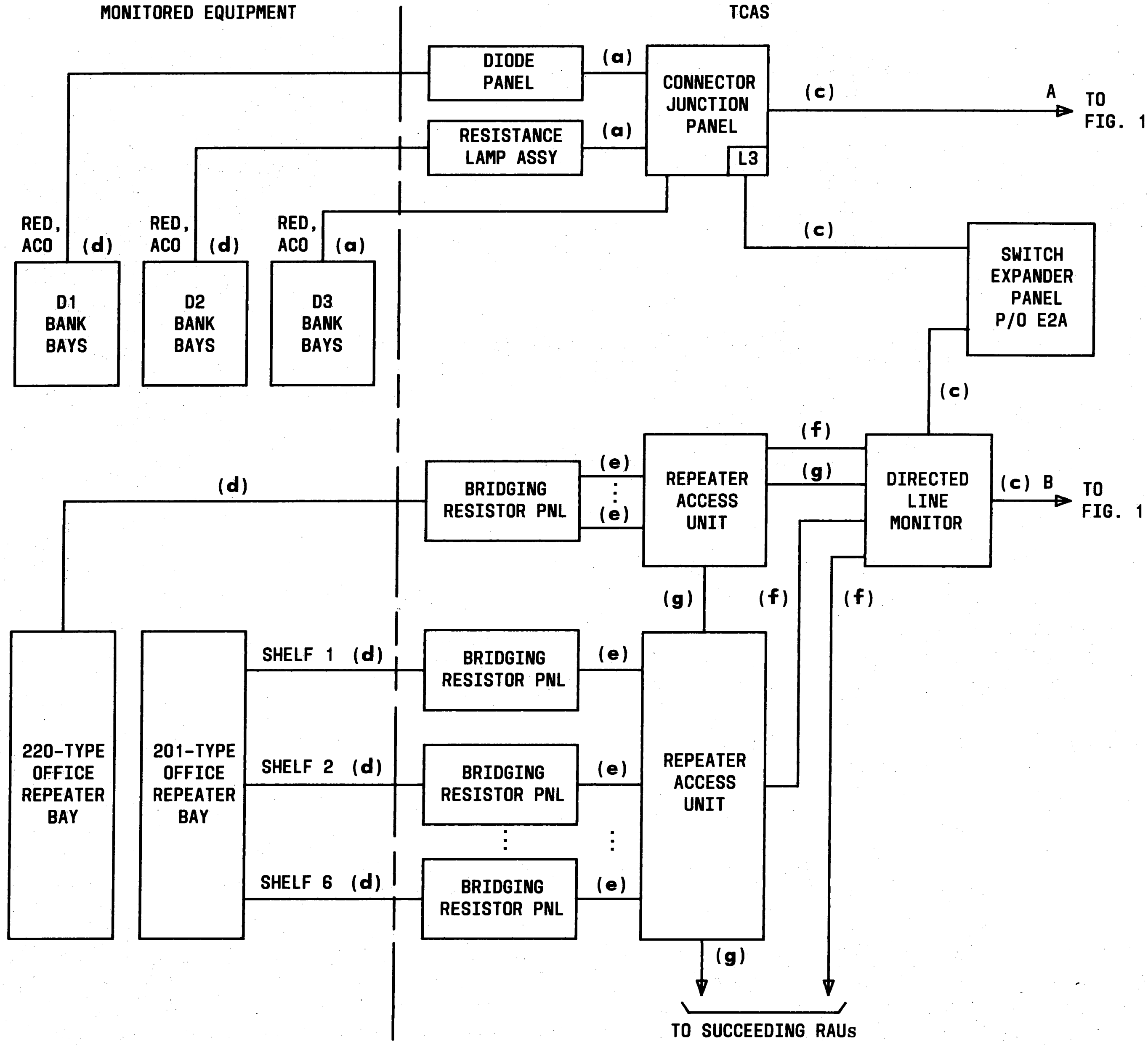
NOTE:

1. Local office option, not required by TCAS.

LEGEND:

(a) SWITCHBOARD CABLE
(b) A32A DOUBLE ENDED CABLE
(c) USER PROVIDED CROSSCONNECT JUMPER (INTRABAY)
(d) USER PROVIDED CROSSCONNECT JUMPER (INTRABAY)
(e) 16 PAIR ABAM CABLE
(f) A32A SINGLE ENDED CABLE

Fig. 1—➧TCAS-Local Office Arrangement for Terminal Monitoring➨



LEGEND:
- (a) SWITCHBOARD CABLE
- (b) A32A DOUBLE ENDED CABLE
- (c) A32A SINGLE ENDED CABLE
- (d) INTRABAY WIRING
- (e) A25C SINGLE ENDED CABLE
- (f) DL1 AND 403A SWITCHBOARD CABLE
- (g) 276A SWITCHBOARD CABLE

Fig. 2—TCAS-Local Office Arrangment for Sectionalization

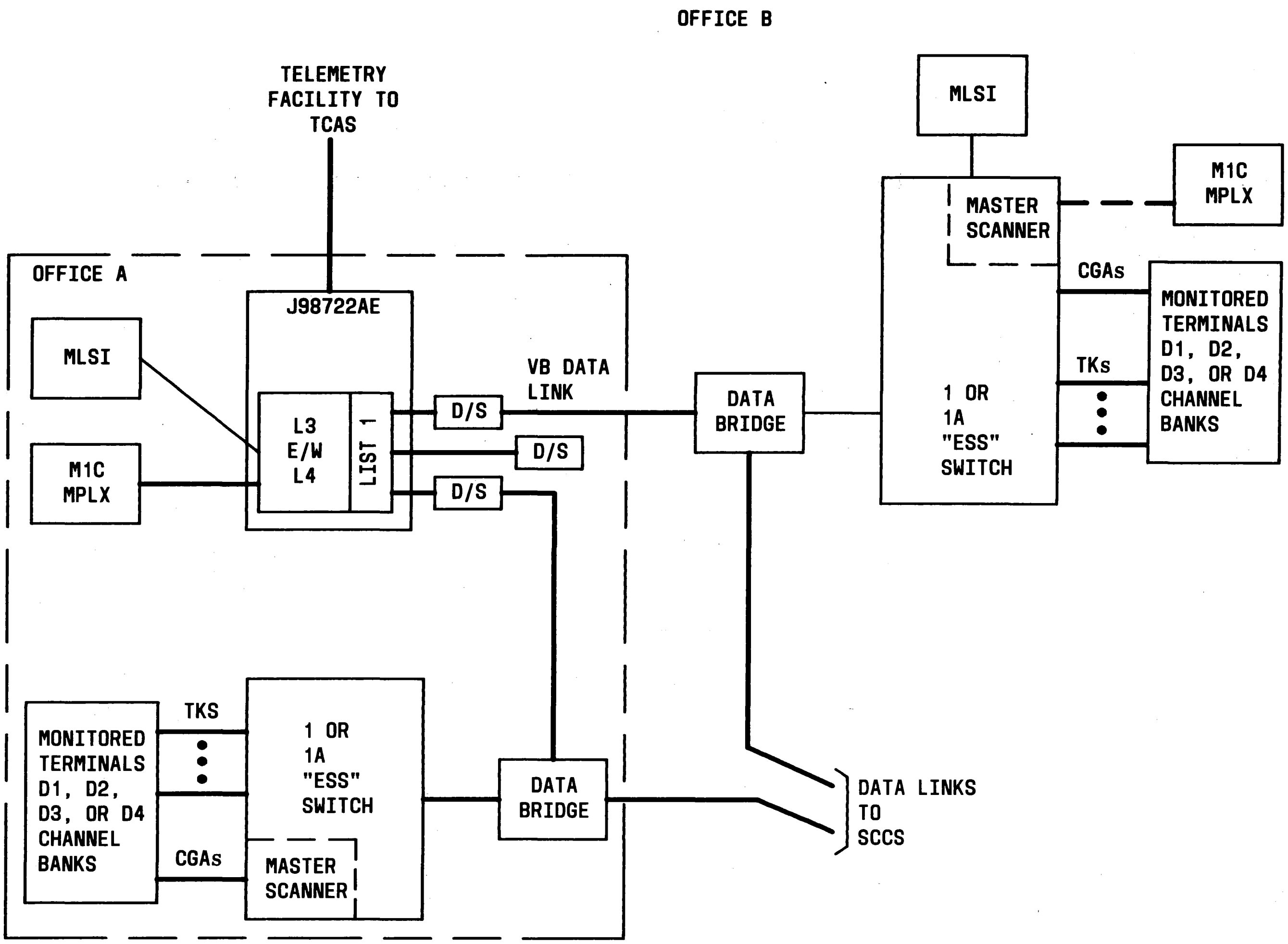


Fig. 3—TCAS to 1 or 1A ESS Switch Arrangment

4.24 When a T-Carrier System failure is detected by the TCAS central, it can direct the DLMs in intermediate offices to measure the line performance. In addition to the DLM, the TCAS senses framing and YELLOW signals to determine direction of failure. This in turn, allows the central to identify the span line or terminal that has failed. Restoration can then be implemented immediately using a maintenance span line without time-consuming manual sectionalization. Since sectionalization is accomplished by the TCAS central, a parallel manual activity directed by the system control office should be avoided. This is accomplished by providing the ability to initiate alarm disable at the terminal office remotely from the TCAS central. This capability further reduces manual sectionalization effort.

4.25 The LMCD was developed to permit local monitoring of the CGA in the central office. Local CGA monitoring capability is not required for TCAS operation and should not be included in the cost of a TCAS System. However, use of the LMCD for local CGA monitoring capability is recommended in larger offices not expected to be monitored by TCAS in the near future. It permits the centralization of all T-carrier CGAs to a maintenance center location within the office so that the status of all systems terminating in that office is readily apparent. The connections required by the display serve a dual purpose in that they are readily available for possible connection to an E-Telemetry System as part of a future terminal monitoring plan.

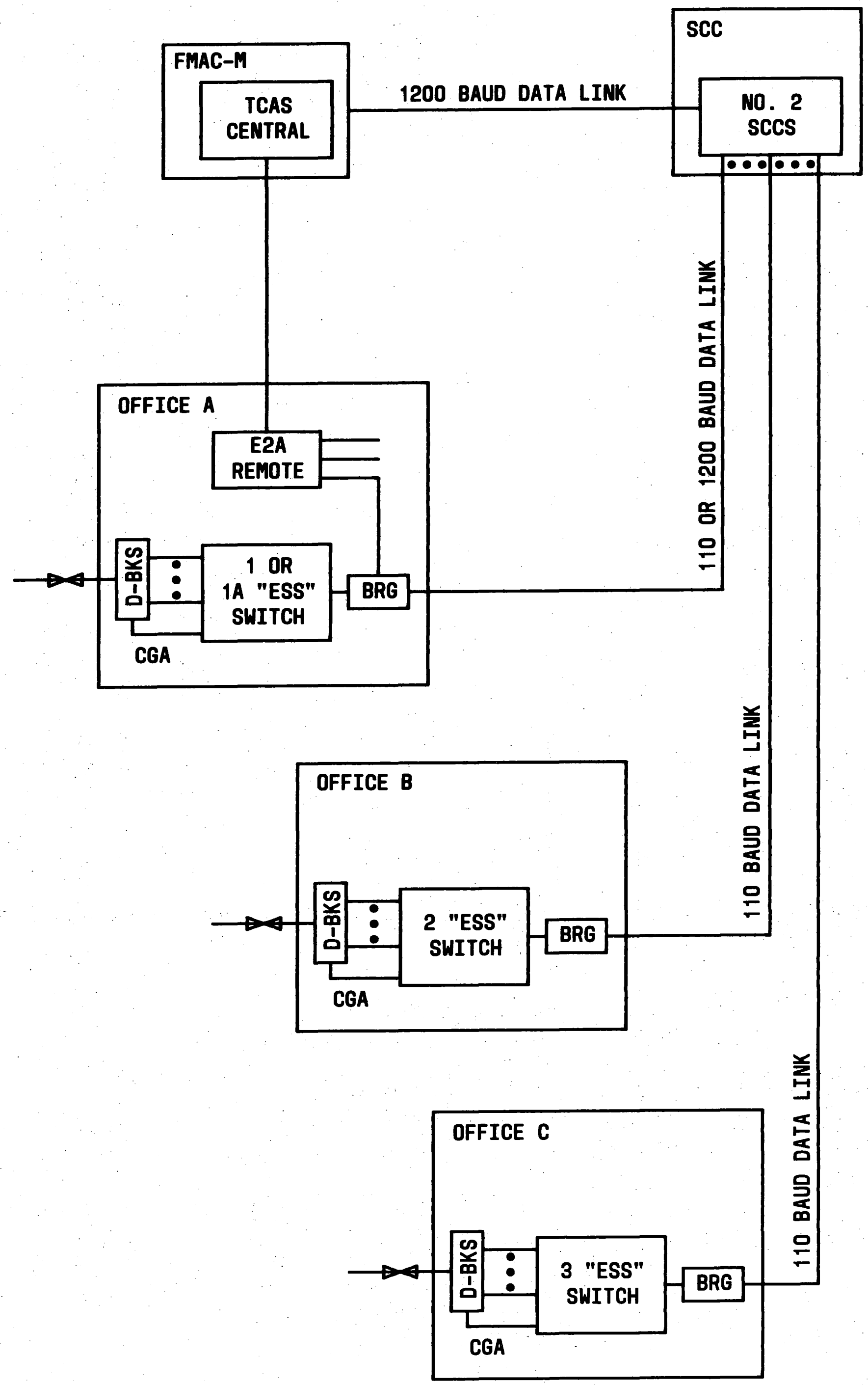


Fig. 4—TCAS to SCCS Data Link Arrangement

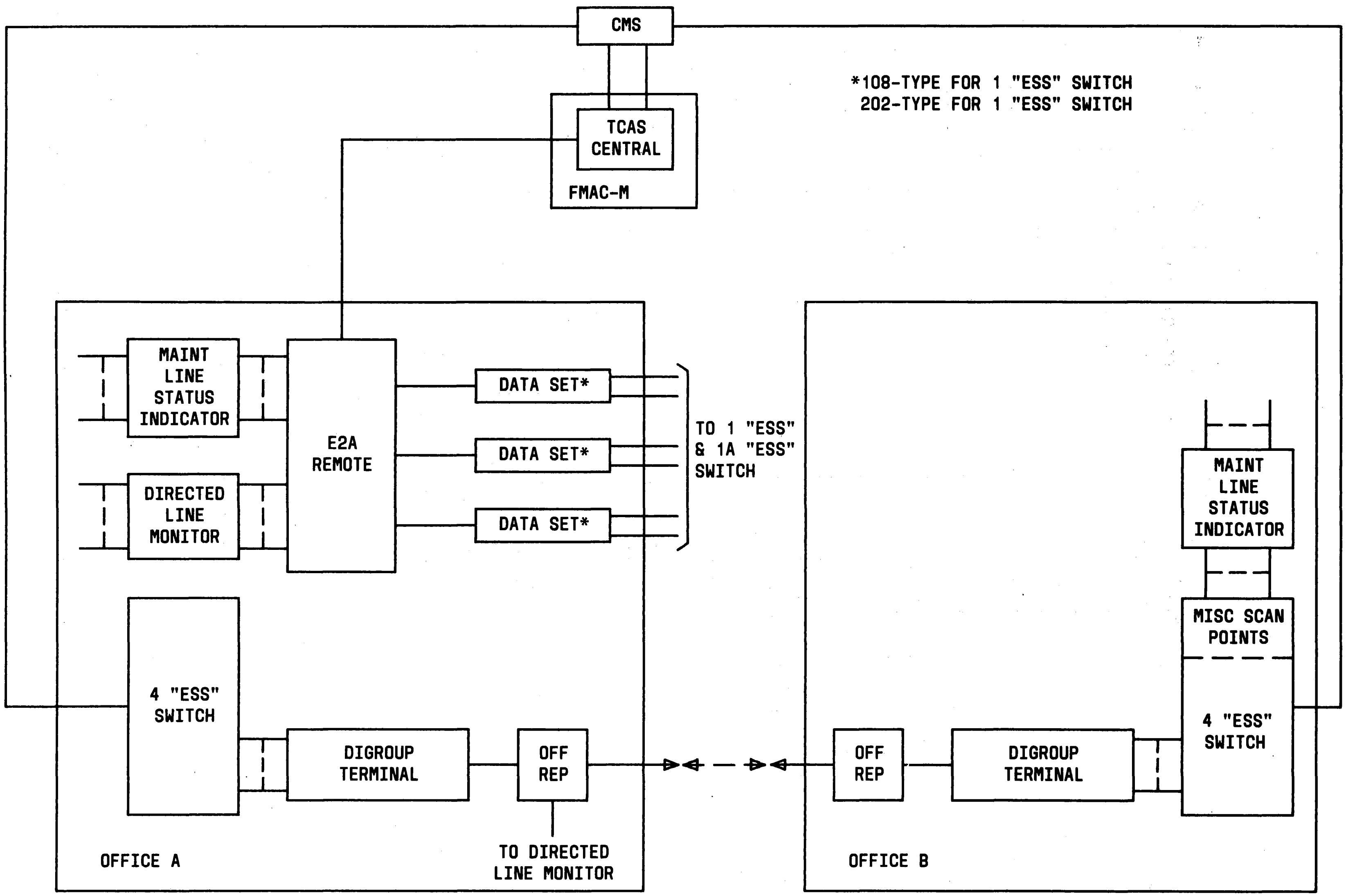


Fig. 5—TCAS to 4 ESS Switching Machine Arrangment

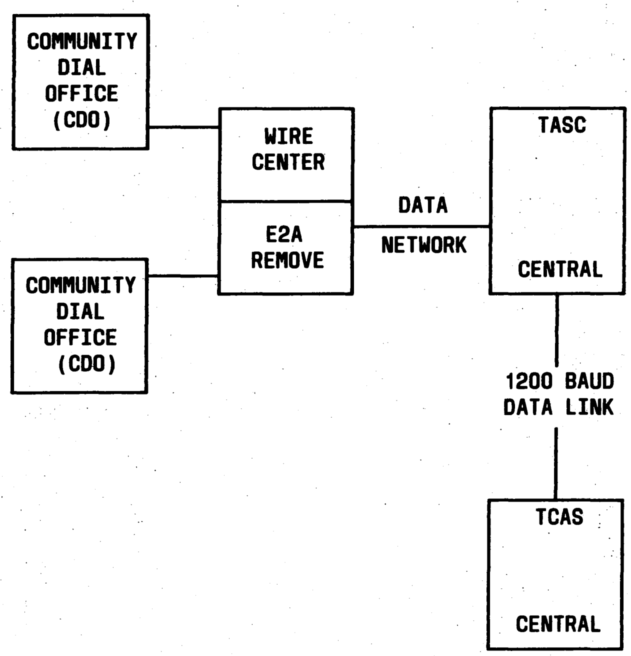


Fig. 6—➧TCAS to TASC Data Link Arrangement➧

C. TCAS Software

4.26 The software contains the information required by the TCAS minicomputer to perform its basic functions. It includes both the programs used to operate the computer and the data required to define the T-carrier network. The TCAS uses the Hewlett-Packard RTE (real-time executive) program as the operating system. The remainder of the software is the special application program routines developed specifically for the TCAS application.

4.27 In addition to the required operating programs, a data base is required for an operating TCAS. The data base encompasses various types of descriptive information used to define the T-carrier network configuration. Refer to Practice 865-201-102 for detailed information on the data base. The data base includes the following information:

(a) Information currently provided on the T-Carrier System circuit layout record

(b) ➧Information currently provided on the I/A (inventory/assignment) mechanized records➧

(c) Assignment data for the E-telemetry, DLM equipment, and physical equipment arrangements.

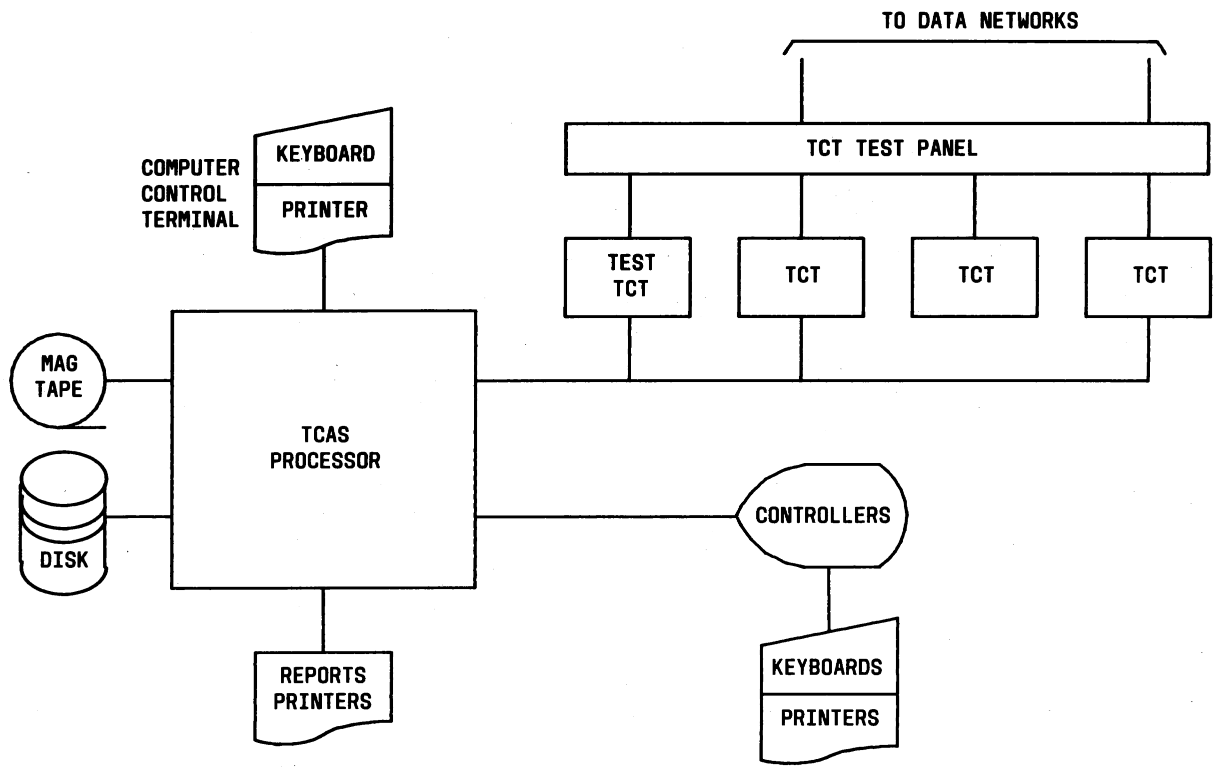


Fig. 7—TCAS Central Arrangement

5. IMPLEMENTATION PHILOSOPHY

A. General

5.01 One of the most important planning steps in considering TCAS for implementation is a determination of the installed cost estimate and the value to be derived from it. The following capital investment is required to implement TCAS:

(a) Cost of installing the various equipment in the offices.

(b) Cost of the TCAS central.

(c) Cost of software and data base preparations.

5.02 The TCAS equipment arrangements have been designed for implementation on a modular basis which simplifies engineering and installation. In addition, this facilitates estimating the cost of an installation since it permits developing a formula for the installed cost of each module.

5.03 The TCAS provides a large degree of flexibility both in the features that can be implemented and the extensiveness to which these features can be applied. Therefore, TCAS can be economically tailored to fit the needs of each T-carrier network by evaluating trade-offs in various implementation plans. The effectiveness of an administrative system such as TCAS requires that it encompass a significant portion of the digital network. However, due to the interconnectivity of most networks, it is not necessary to install monitoring equipment in all offices to obtain access to a significant portion of the network. Typically, it is only necessary to equip from one-third to one-half of the offices with telemetry to effectively monitor 75 to 95 percent of the T-Carrier Systems.

5.04 As indicated, the flexibility in implementation alternatives with respect to capital investment and projected rate of return will impact the initial investment. To properly select the best alternative for a particular metropolitan area, the features provided by each plan must be taken into consideration and weighed with the investment. For example, terminal monitoring by TCAS addresses the service and administrative aspects by analyzing CGAs to detect failed T-Carrier Systems, patterning major failures, aiding in the restoration of service, and providing statistical reports for maintenance and management personnel. On the other hand, the benefits of sectionalization are directed to reduce personnel requirements needed to respond to and sectionalize T-carrier failures. Thus, each user must determine which features are most important to their particular operation.

5.05 An economic study involves the determination of the optimum set of offices in which TCAS equipment should be installed. It further allows a determination of the installed cost and the estimated value or cost savings that can be realized from implementing TCAS. In order to obtain a better understanding to the approach used to obtain this information, a general description of the economic study is presented in Part 5 while a detailed study example is presented in Part 6.

B. Phases of Implementation

5.06 As previously discussed in this section, The TCAS has two general groupings of features which are the terminal monitoring and sectionalization. Although these features can be implemented to any degree of usefulness by the user, this section will consider the following three basic evaluation alternatives:

(a) Full terminal monitoring and full sectionalization

(b) Full terminal monitoring and partial sectionalization

(c) Full terminal monitoring only.

5.07 These implementation plans represent a variety of installed costs and attendant economic benefits.

5.08 Implementation of TCAS in an office requires a substantial investment that is independent of the size of the office. This investment is primarily in the E-telemetry remote and the DLM. Beyond this basic cost, the implementation cost is then directly proportional to the number of T-Carrier Systems in the office. Since the value derived from terminal monitoring depends upon the number of systems being monitored, the selection criteria stresses concentration on the large terminal offices. This will maximize the coverage with a minimum of investment. The value derived from sectionalization is primarily dependent upon the number of access points available for sectionalization. Offices selected for sectionalization, therefore, should be large "through repeater" offices and may not contain many terminals. Since the selection of a set of these large through repeater offices will provide only a partial sectionalization capability, it is necessary to be able to evaluate the impact of sectionalization access on a cost/benefit basis. To do this it is necessary to define a "sectionalization ratio", that is, the ratio of sectionalization effort saved with TCAS to the sectionalization effort without TCAS. The sectionalization ratio is an indication of the percentage of manual sectionalization costs recovered by using TCAS.

5.09 ***Full Terminal Monitoring and Full Sectionalization:*** With this alternative, all offices selected for TCAS monitoring are equipped for terminal monitoring and sectionalization. The office selection procedure, discussed later, selects the minimum set of offices required to monitor 95 percent of the T-Carrier Systems in the network. The procedure also selects the minimum set of offices needed to provide a sectionalization ratio of 0.90 (90 percent). Attempting to gain access to a greater percentage of systems and/or repeaters is economically unattractive. For this reason TCAS coverage is considered complete when 95 percent of the T-Carrier System is monitored and the sectionalization ratio is .90.

5.10 ***Terminal Monitoring and Partial Sectionalization:*** This alternative selects the same set of offices for 95 percent T-Carrier System coverage. A subset of the sectionalization offices chosen is then selected for line monitoring to realize a lower sectionalization ratio; eg, 0.60. Examining various sectionalization ratios during the study will allow tailoring the implementation costs to available capital.

5.11 ***Terminal Monitoring:*** In this alternative, all offices selected for TCAS monitoring are equipped for terminal monitoring only. The procedure used selects the minimum set of offices required to realize a T-Carrier System coverage of 95 percent.

C. Implementation Methodology

5.12 The first step necessary in planning for the implementation of TCAS in a metropolitan area is to select the set of offices in which TCAS equipment should be installed. The most efficient implementation of terminal monitoring requires that the number of systems monitored be maximized for a given implementation cost. Since a T-Carrier System is considered monitored if one or both terminals are monitored, the implementation costs may be minimized by equipping that set of offices which contains the largest number of banks.

5.13 One method of examining the tradeoff between the number of offices monitored and the resultant coverage obtained is to rank order the offices by the number of working banks—largest first. If this information is plotted versus the cumulative percent of systems monitored, the resultant curves will provide a guide as to which offices should be equipped to provide a desired level of coverage.

5.14 For sectionalization, the governing criteria is one of maximizing the number of line access points for a given investment. In addition, data from the TCAS trials indicate that line failures occur more frequently than terminal failures. Thus, the access points at the terminal ends of a system should carry less weight than those at intermediate span offices. A first approximation of the tradeoffs between offices can be obtained by rank ordering the offices by through repeaters (total repeaters minus banks). The offices with the largest number of through repeaters will provide the greatest return on the investment. Often, less than a quarter of the offices in a metropolitan area need be equipped with line monitoring to realize a respectable sectionalization ratio.

5.15 When the desired set of offices is determined, the installed costs can be computed. Additional calculations can provide the estimated savings, return on investment, the cost per monitored system, and the annual charges.

5.16 It should be noted that this implementation methodology is based upon economic considerations only. In an actual implementation, other factors such as the presence of critical special services, possible isolation of an office due to a single cable failure, or defining a demarkation line with independent telephone companies may dictate that TCAS be implemented in an office that would not be selected on an economic basis. For study purposes, it is recommended that these considerations not be included since tangible economic benefits are usually difficult to associate with these factors. However, such factors should be considered as part of the actual engineering evaluation for implementing TCAS.

5.17 From an economic standpoint, TCAS is applicable to any metropolitan area which has at least 1000 T-Carrier Systems. Since TCAS has an ultimate monitoring capacity of about ▶19,000◀ T-Carrier Systems, several metropolitan areas may be served by a single TCAS central.

5.18 Studies indicate that the maximum cost effectiveness of TCAS can be achieved only by full implementation of TCAS. A multiplicity of related factors must be considered in determining the economic and service value of TCAS. Areas in which TCAS savings can be realized are:

(a) Manpower

(b) Facility utilization

(c) Service cost

(d) Improved transmission performance.

5.19 It should be noted that all of these areas of potential savings may not be applicable to each user. No attempt has been made to quantify the value of the expected transmission improvements achieved by TCAS.

D. Evaluating the Alternatives

5.20 To properly evaluate the alternatives, the purposes of terminal and line monitoring with TCAS should be investigated. Terminal monitoring addresses the service aspect of T-carrier administration. That is, terminal monitoring analyzes CGAs to detect failed T-Carrier Systems, aids the restoration of service, and provides CGA statistics required to provide overall T-carrier network performance information for maintenance and management personnel. Sectionalization, on the other hand, addresses the savings of manpower required to sectionalize the cause of a failed T-Carrier System. A user should set priorities on the various benefits when evaluating the alternatives.

5.21 The terminal monitoring with full sectionalization alternative has the highest cost because of the cost of providing sectionalization access to most of the span lines, but it maximizes the utility of TCAS. The net annual savings is also highest because of the large amount of sectionalization manpower saved. However, due to the substantial investment, the projected rate of return is somewhat lower than the other alternatives. Terminal monitoring and partial sectionalization provides the same capabilities as full sectionalization except in the extent of sectionalization savings achieved (60 percent versus 90 percent). However, there is a substantial reduction in the sectionalization investment resulting in a higher projected rate of return. Note that a partial terminal monitoring implementation can be expanded through the addition of line monitoring equipment in selected offices to increase the sectionalization savings if desired at a later time.

5.22 A substantial portion of the investment in the previous alternatives is due to the line monitoring equipment. Implementation of only the terminal monitoring alternative provides a substantial reduction in capital investment but also results in a substantial reduction in the estimated savings because of the lack of sectionalization capability. However, it should be noted that the rate of return for this alternative is as good as the full terminal and partial line monitoring alternative. Thus, terminal monitoring with or without sectionalization must be compared on the basis of the capital available and the relative priority placed on service-related savings versus sectionalization manpower savings.

5.23 Using the methodology described in Part 6, each user can select the implementation plan that best fits its desired operation. These plans can easily be upgraded at a later date to provide more complete coverage or additional features.

6. ENGINEERING EVALUATION

A. General

6.01 The example, which will be provided later in this part, describes the methodology for engineering configurations for a given TCAS application and for estimating the associated cost and economic benefits. It also discusses some factors a user should consider when choosing one of the configurations. The description is supported by an example that exercises the computation of cost data related to engineering TCAS for a given set of offices.

6.02 The economic study method used in this example is equivalent to the use of CUCRIT (capital utilization criteria) summary 3. It is expected that this example will impart sufficient understanding to allow similar planning studies to be made in any given metropolitan area.

6.03 All pricing information used in the example is not the actual prices. The pricing used is for explanation purposes only. The AT&T Technologies Bulletin Price List should be consulted for any updated material pricing information prior to preparing the installed cost estimates. Updated pricing information should be substituted in the provided formulas.

6.04 The following describes the various degrees of implementation:

(a) ***Terminal Monitoring and Full Sectionalization:*** Since the CGA of a T-Carrier System operates at both terminals when a failure is detected at either end, it is necessary to monitor only one end of the system to know its status. Many T-Carrier System in a metropolitan network originate in large downtown offices and terminate in smaller end offices on the fringe of the metropolitan area. Most of the T-Carrier System (about 95 percent) can be monitored by placing TCAS equipment in these large offices. Gaining access to the remaining banks is very expensive because each system is essentially monitored at both ends. Similarly, gaining sectionalization access to every repeater on a system is very costly since it would require providing telemetry and DLMs in all of the small fringe offices. A significant decrease in line monitoring cost can be achieved by a modest reduction in the sectionalization ratio—the ratio of the manual sectionalization effort eliminated by

TCAS to the total manual sectionalization effort without TCAS. Thus, monitoring 95 percent of the T-Carrier System is considered complete terminal coverage, and a sectionalization ratio of 0.90 is considered complete TCAS coverage.

(b) ***Terminal Monitoring With Partial Sectionalization:*** Depending upon the nature of the T-carrier network, a further reduction in the sectionalization ratio may be desirable to substantially reduce the line monitoring costs. This is particularly true in hub-type networks because of the high concentration of through repeaters in a few offices. For example, a 30 percent reduction in the sectionalization ratio can often effect a line monitoring implementation cost reduction of 75 percent. It is recommended that a user consider a number of implementation plans, each with a different sectionalization ratio.

(c) ***Terminal Monitoring Only:*** Since terminal monitoring of CGAs allows surveillance of the performance of the T-Carrier Systems and the generation of performance reports on the T-Carrier System, it is recommended that the minimum TCAS implementation considered be complete terminal monitoring only (95 percent T-Carrier System coverage).

6.05 Since the full implementation plan requires computation of cost data for the largest number of offices, the example addresses this implementation plan first. The remaining implementation plans are then summarized using portions of this data. For the purposes of this example it is assumed that the user will study the economic benefits for a 10-year period. It is further assumed that TCAS implementation will take place over a 3-year period. Also, the example does not include monitoring of M1C muldems or interaction with CMS.

B. Evaluation Example

6.06 The following paragraphs contain an example of developing an engineering evaluation. It is based upon data collected from several users from which a model of a typical digital network has been developed. The following is the criteria used for the evaluation:

(a) 4800 T1-Carrier Systems terminating in 60 central offices.

(b) A spider web configuration is assumed which combines both star and grid structure characteristics.

(c) About half of the central offices are small end offices.

(d) Growth of the network over the recommended 10-year study period is assumed to be in terms of the number of systems per office rather than by the addition of new offices.

6.07 The following are the procedures and types of office data used in the example to select the set of offices which will optimize the terminal and line monitoring coverage (95 percent systems monitored, 0.90 sectionalization ratio):

(a) An inventory was prepared of the offices within the digital network under consideration. The following information was used:

(1) List of office names

(2) List of the type of switching equipment located in each office

(3) Total number and type of banks per office (keep in-service totals and (unassigned totals)

(4) Total number of through repeaters in each office

(5) Total number of repeaters per office (keep in-service totals and unassigned totals)

(6) Number of office repeater bays

(7) Total number of incoming maintenance or backbone line appearances per office.

(b) A model of a T-Carrier Network in a Metropolitan Area Table, as shown in Fig. 8, was prepared by ranking the offices in descending order of in-service bank size and total in-service repeaters appearing in each office.

(c) The Selected Offices Ordered by Through Repeaters Table, as shown in Fig. 9, was prepared by ranking offices in descending order of through repeaters (total repeaters minus banks).

(d) The optimum set of offices was determined by developing a set of curves for the monitored systems and monitored banks, as shown in Fig. 10. The curve for the cumulative monitored banks is obtained directly from the Model of T-Carrier Network Table created in Step (b) by carrying forward the cumulative totals. The other curve represents the offices as ranked in the Model of T-Carrier Network Table versus the cumulative percent of systems monitored. The following are the methods used to develop the curves:

(1) The plot of cumulative monitored systems versus offices can be best obtained by mechanized processing of the list of systems in the network.

(2) The systems are sorted for all systems for which the first office on the list is the A or Z terminal.

(3) The sorting procedure is repeated with the remaining systems for those systems in which the next office on the list is the A or Z terminal.

(4) This procedure is repeated until all systems have been associated with an office.

(5) The resulting density function is plotted on a cumulative basis to obtain the curve shown in Fig. 10.

Note: Since a system is considered monitored when one or both terminals are monitored, the number of systems monitored by the first office equals the number of D-banks in the office. The second office, however, may terminate some systems that also terminate in the first office. Hence, the additional systems monitored when the second office is added will be less than the number of D-banks in that office.

(e) The offices that are ranked in the Selected Offices Ordered By Through Repeaters Table, as shown in Fig. 9, are plotted against the ratio of monitored repeaters that appear in these offices to total repeaters in all offices. Figure 11 is an example of this cumulative plot. Note that the list of offices is reordered by largest through repeaters.

(f) An appropriate sectionalization ratio is chosen through the use of Fig. 12. For this example, assume .9 for full sectionalization and .6 for partial sectionalization. Using the corresponding ratio of monitored repeaters to total repeaters, the corresponding set of offices are found on Fig. 11. Note that this corresponds to office B2 for sectionalization ratio of .9. The line sectionalization arrangement and the alarm disable feature should be implemented in the office to the left of this office.

(g) The method of monitoring was determined through the use of Fig. 13. The following are considerations needed in making the method of monitoring determination:

(1) If an office chosen in Step (f) is a 1 or 1A ESS switching office, monitor the CGAs in the office using the E2A/ESS switch arrangement.

(2) If an office will be converted to ESS switch within three years, plan monitoring CGAs through future E2A/ESS arrangement. Monitor MLSIs and M1Cs directly via the E-telemetry. Implement the alarm disable feature using direct connection to the E2A remote.

(3) In the remainder of the offices chosen in Step (f), monitor the CGAs, MLSIs, and M1Cs directly via an E2A APR or E2A DAS remote.

(4) If the ultimate size of this office is less than 450 banks, an E2A APR SDP or E2A DAS may be used to maximize the number of bridging ports available for other ESS switching offices. Implement the alarm disable feature using direct connection to the E2A remote.

(5) All offices selected for line sectionalization should be deleted from the list selected for terminal monitoring.

(6) If any of the remaining offices are electromechanical and will not be converted to ESS switches within three years, monitor CGAs, MLSIs, and M1Cs directly. Use either E2A APR, or maybe use E2A APR SDP, or maybe use E2A DAS, depending on the size of the office. Implement alarm disable feature using direct connection to the E2A remote.

(7) In the remainder of the offices, monitor CGAs, MLSI, and M1Cs in the remaining

ESS switching offices via the bridging arrangement from an E2A/ESS switching arrangement remote in offices. Implement the alarm disable feature using the E and M signaling arrangements.

(8) If any ESS switching offices remain unmonitored provide a data link between TCAS and the No. 2 SCCS serving those offices. Consideration should be given to monitoring MLSIs and M1Cs in the same manner as Step (7), but the alarm disable feature should not be provided.

C. Cost of Implementation

Determining Cost

6.08 The first step in determining the cost of implementation is to determine the type of switching in each office and the amount of equipment required in each remote office. For each set of offices

OFFICE NAME	IN-SERVICE BANKS	IN-SERVICE REPEATERS	OFFICE NAME	IN-SERVICE BANKS	IN-SERVICE REPEATERS
A	1000	2900	W	150	650
B	700	4200	X	150	650
C	650	5100	Y	140	150
D	450	940	Z	140	720
E	400	500	A1	140	360
F	375	1000	A2	140	425
G	350	800	A3	120	575
H	350	2675	A4	100	1225
I	325	2600	B1-4	75	360
J	310	1875	C1-4	60	90
K	300	1375	D1-4	50	60
L	275	1200	E1-4	40	40
M	250	650	F1-4	30	30
N	230	360	G1-4	20	20
O	220	500	H1-6	10	10
P	210	1800	TOTAL 60	9580	40,010
Q	200	1200			
R	200	1000			
S	180	200			
T	180	500			
U	160	1200			
V	150	220			

Fig. 8—Example of a Model of T-Carrier Network in a Metropolitan Area Table

OFFICE NAME	THROUGH REPEATERS	OFFICE NAME	THROUGH REPEATERS
C	4450	M	400
B	3600	T	320
H	2325	A2	285*
I	2275	B1-2	285*
A	1900	O	280
P	1590		
J	1565	N	130
A4	1125*	E	100
K	1075	S	20
U	1040		
Q	1000		
L	925		
R	800		
F	625		
Z	580*		
W	500		
X	500		
D	490		
A3	455*		
G	450		

***Offices not selected by terminal monitoring selection procedure.**

Fig. 9—Example of a Selected Offices Ordered by Through Repeaters Table

selected, the user must compute the following values on a Variables For Selected Offices Table (example shown in Fig. 14):

(a) Total number of D1 and D2 banks (Ni)

(b) Total number of D3 banks (Rn)

(c) Number of MLSI shelves required (Sn)

(d) Number of MLSI detector cards required (Pn)

(e) Number of bank bays (Nb).

6.09 The following are some assumptions and guidelines associated with developing these values:

(a) In this model network study it is assumed that 50 percent of the banks are D1 and 50 percent are D3.

(b) This further assumes that the number of D2 banks is negligible.

(c) If the number of D2 banks is not negligible it should be included with the D1 bank total.

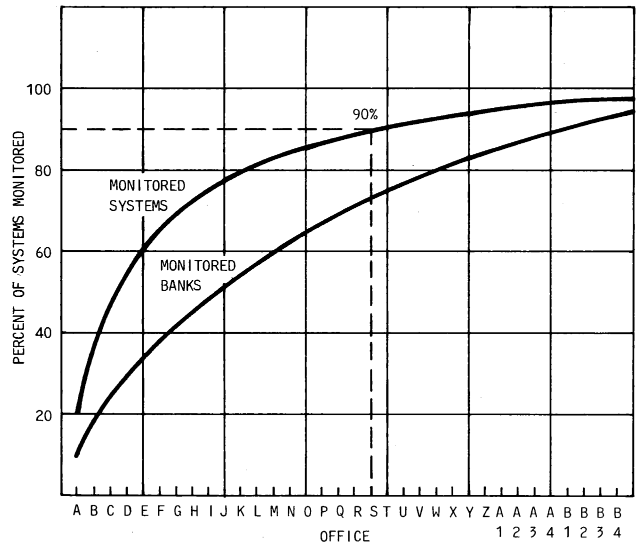


Fig. 10—Example of a Bank Ranked Curve Graph

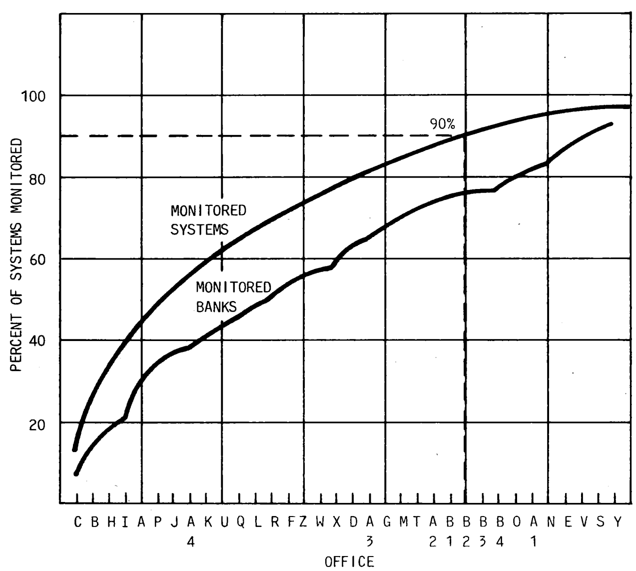


Fig. 11—Example of a Repeater Ranked Curve Graph

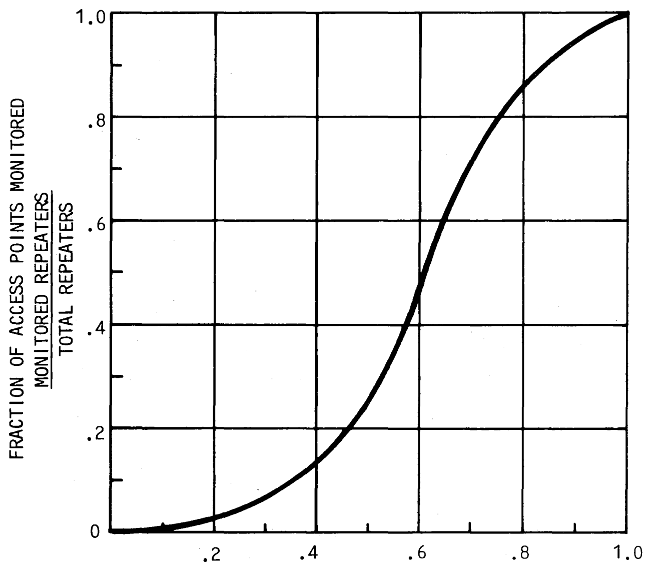


Fig. 12—Example of a Sectionalization Ratio Graph

6.10 The inventory of banks and repeaters listed in the Model of T-Carrier Network in a Metropolitan Area Table (Fig. 8) and the Selected Offices Ordered by Through Repeaters Table (Fig. 9) is the actual in-service equipment. However, since TCAS monitors all the banks in a terminal bay and all the repeaters in an office repeater bay including both those in service and those unassigned, the number of banks and repeaters in service must be expanded to include the unassigned banks and repeaters to arrive at the total to be monitored. One could determine the total by noting the number of bank and repeater bays in each office during the office inventory as presented in evaluation example paragraphs. If this is not available, one might safely assume for planning purposes a ratio of monitored banks (or repeaters) to in-service banks (or repeaters) of 1.2 (ie, 20 percent spare capacity). This example assumes a 20 percent installed and unassigned spare capacity. Additionally, the number of incoming maintenance or backbone lines must be noted. In the example, shown if Fig. 14, it is assumed that each office repeater bay has three incoming maintenance or backbone lines.

6.11 Use the following to arrive at the variables to be presented in the Variables For Selected Offices Table (Fig. 14):

(a) The following is the method to develop variables for the Ni column:

Let: N1 = total number of D1 and D2 banks

Let: N3 = total number of D3 banks

Note 1: N1 should be rounded up to the next higher integer.

Note 2: N1 + N2 must include the in-service and unassigned banks. Use actual count or assume 20 percent unassigned.

Calculate: Ni = (N1 + N3)/60

(b) The following is the method to develop variables for the Rn column:

Let: Rn = total office repeater bays in the office

Calculate: Rn = total number of office repeaters/75.

Note: Total repeaters includes both in-service and unassigned repeaters. Use actual count or assume 20 percent unassigned.

(c) The following is the method to determine the variables for the Sn column:

Let: Sn = number of MLSI shelves required

or

Let: Sn = (total maintenance lines)/32 rounded up

(d) The following is the method to determine the variables for the Pn column:

Let: Pn = number of MLSI detector cards required

or

Let: PN = (total maintenance lines)/2

(e) The following is the method to determine the variables for the Nb column:

Let: Nb = number of bank bays rounded up.

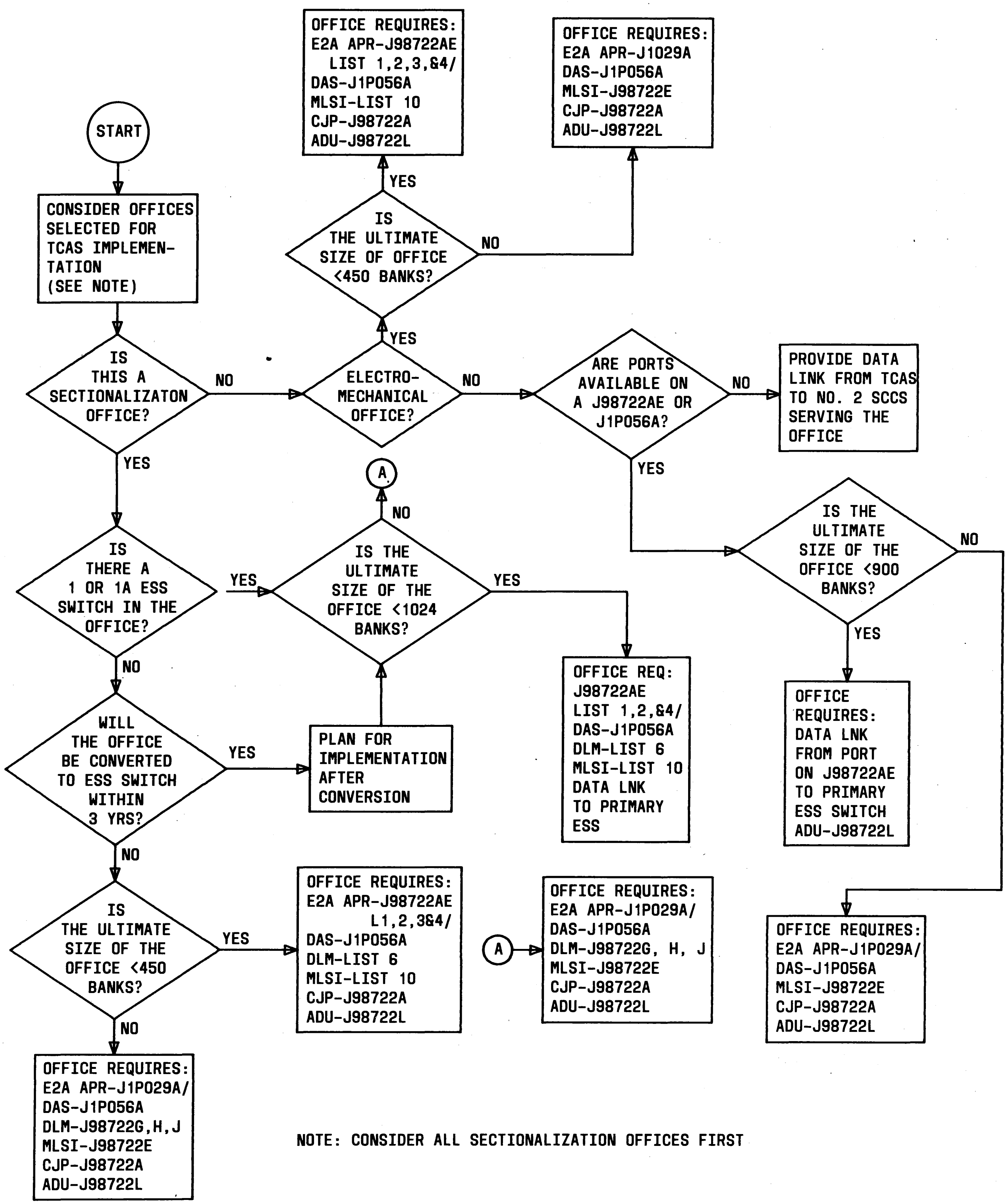


Fig. 13—▶Determining Method of Monitoring◀

OFFICE								
NAME	TYPE*	BANKS	REPEATERS	Ni	Rn	Sn	Pn	Nb
A	ESS	1000	2900	20	46	5	69	222
B	ESS	700	4200	14	67	7	101	156
C	ESS	650	5100	13	82	8	123	144
D	ESS	450	940	9	15	2	23	100
E	ESS	400	500	8	8	1	12	89
F	ESS	375	1000	8	16	2	24	83
G	ESS	350	800	7	13	2	20	78
H	5XB	350	2675	7	43	4	64	78
I	ESS	325	2600	7	42	4	63	72
J	ESS	310	1875	7	30	3	45	69
K	ESS	300	1375	6	22	2	32	67
L	ESS	275	1200	6	19	2	20	61
M	ESS	250	650	5	10	1	15	56
N	ESS	230	360	5	6	1	9	51
O	5XB	220	500	5	8	1	12	49
P	ESS	210	1800	5	29	3	44	47
Q	ESS	200	1200	4	19	2	20	44
R	ESS	200	1000	4	16	2	24	44
S	ESS	180	200	4	3	1	5	40
T	SXS	180	500	4	8	1	12	40
U	ESS	160	1200	4	19	2	29	36
V	ESS	150	220	3	3	1	5	33
W	ESS	150	650	3	10	1	15	33
X	ESS	150	650	3	10	1	15	33
Y	ESS	140	150	3	2	1	3	31
Z	ESS	140	720	3	12	2	18	31
A2	ESS	140	425	3	7	1	11	31
A3	ESS	120	575	3	9	1	14	27
A4	5XB	100	1225	2	20	2	30	22
B1	ESS	75	360	2	5	1	8	17
B2	ESS	75	360	2	5	1	8	18

* The ESS switching offices are assumed to be 1 or 1A ESS switching offices.

Fig. 14—Example of Variables for Selected Offices Table

6.12 Once data required for Variables for Selected Offices Table (Fig. 14) is obtained, determine (using Fig. 12) the equipment needed for each office. This information is used in developing the Cost of Implementing TCAS (K$) Full Line and Terminal Monitoring Table, example shown in Fig. 15, to determine the equipment costs for each individual office based on the type of monitoring. To generate the table, assume for the study example that implementation will be accomplished over a period of three years with the first ten offices implemented in 1983, the second ten in 1984, and the remainder of the offices implemented in 1985. The headings in the table are defined as follows:

(a) Ca = cost of terminal alarm monitoring

(b) Cm = cost of maintenance line monitoring

(c) Cte = installed cost of E2A telemetry with serial data port

(d) Ct = installed cost of E2A telemetry

(e) Cdb = installed cost of data bridge

(f) Cad = cost of alarm disable unit

(g) Cs = cost of sectionalization.

Cost in a Electromechanical Switching Office

6.13 The cost of the terminal monitoring arrangement in an electromechanical switching office is determined by the size of the office. If the ultimate size of the office will be less than 450 banks, the use of the E2A E-telemetry with SDP or E2A DAS is recommended. The cost formula for terminal monitoring an electromechanical switching office where there is over 450 banks is as follows:

(a) Determine the installed cost of E2A APR or E2A DAS (CT) equipment by the following example shown in Fig. 16.

(b) Determine the cost of equipment required for terminal alarm monitoring (CA) per the example shown in Fig. 17.

(c) Determine the installed cost of maintenance line monitoring in each office (CM) per the example shown in Fig. 18.

(d) Determine the installed cost of M1C monitoring in each office (CB) per the example shown in Fig. 19.

(e) Calulate the total cost using the following formula:

Total cost (CTM) = E2A cost (CT) + terminal alarm monitoring cost (CA) + maintenance line monitoring cost (CM) + M1C monitoring cost (CB)

Note: The example in Fig. 16 does not include monitoring of M1C muldems. Thus, the installed cost of M1C monitoring (Cb) is zero for each office.

Cost in a 1 or 1A ESS Switching Office With E2A Equipment

6.14 Terminal monitoring in 1 or 1A ESS switching offices can be provided using E2A APR with SDP or E2A DAS if the ultimate size of the office is less than 900 banks. Figure 3, Office A, shows the arrangement using a MLSI monitoring arrangement for M1C and E2A APR. A hardwired arrangement has to be used if the office size is greater than 900 banks. The cost of TCAS equipment in 1 or 1A ESS switching offices with arrangement shown in Fig. 3, Office A, is determined as follows:

(a) Determine the cost of E2A APR or E2A DAS equipment (CTE) per the example shown in Fig. 20.

(b) Determine the cost of maintenance line monitoring in each office (CM) per example shown in Fig. 18.

(c) Determine the cost of M1C monitoring in each office (CB) per example shown in Fig. 19.

(d) Calculate: Cost for terminal monitoring (CTM) = Cost of E2A APR equipment (CTE) + Cost of maintenance line monitoring (CM) + Cost of M1C monitoring (CB)

Cost in a 1 or 1A ESS Switching Office Without E2A Equipment

6.15 Monitoring a 1 or 1A ESS switch without an E2A APR or E2A DAS located in the office can be provided using a spare ESS switch port on a

YEAR	TERMINAL MONITORING						LINE MONITORING		TOTAL
	OFFICE	Ca	Cm	Cte	Ct	Cdb	Cad	Cs	
1983	A	–	29	12	–	–	5	91	137
	B	–	43	13	–	–	4	128	188
	C	–	51	13	–	–	4	154	222
	D	–	10	10	–	3	3	35	58
	E	–	5	10	–	3	3	–	41
	F	–	10	10	–	3	2	37	59
	G	–	9	10	–	3	2	31	52
	H	4	26	–	17	–	2	86	135
	I	–	26	11	–	–	2	84	123
	J	–	19	11	–	3	2	63	95
1984	K	–	13	10	–	3	2	47	72
	L	–	12	10	–	3	2	42	66
	M	–	6	10	–	3	1	26	43
	N	–	4	10	–	3	1	19	34
	O	3	5	–	13	–	1	23	45
	P	–	18	11	–	–	1	62	92
	Q	–	12	10	–	3	1	42	65
	R	–	11	10	–	3	1	38	59
	S	–	3	10	–	3	1	14	28
	T	3	5	–	12	–	1	23	44
1985	U	–	12	10	–	3	1	42	65
	V	–	3	–	–	3	1	–	–
	W	–	6	10	–	3	1	26	43
	X	–	6	10	–	3	1	26	43
	Y	–	2	–	–	3	1	–	–
	Z	–	9	10	–	–	1	29	49

Fig. 15—Example of a Cost of Implementing TCAS (K$) Full Line and Terminal Monitoring Table (Sheet 1 of 2)

YEAR	TERMINAL MONITORING						LINE MONITORING		TOTAL
	OFFICE	Ca	Cm	Cte	Ct	Cdb	Cad	Cs	
1985	A2	–	5	10	–	–	1	21	37
	A3	–	6	10	–	–	1	25	42
	A4	1	13	–	9	–	1	44	68
	B1	–	4	10	–	–	1	18	33
	B2	–	4	10	–	–	1	18	33

TCAS Central Cost

M = 31 monitored offices

N = 4800 systems

CC = Central Cost = $82,854 + 3 ($2537)

= $90,456

Fig. 15—Example of a Cost of Implementing TCAS (K$) Full line and Terminal Monitoring Table (Sheet 2 of 2)

remote E2A APR with SDP or E2A DAS. Figure 3, Office B, shows a dedicated data link between offices.

(a) Determine the cost of maintenance line monitoring in each office (CM) per example shown in Fig. 18.

(b) Determine the cost of M1C monitoring in each office (CB) per example shown in Fig. 19.

(c) Determine the cost of equipment associated with 1 or 1A ESS switching machine without an E2A APR or E2A DAS per example shown in Fig. 21.

(d) Calculate: Total monitoring cost (CTM) = Cost maintenance line monitoring (CM) + Cost of M1C monitoring (CB) + Cost of E2A equipment (CTE).

Sectionalization Requirements

6.16 The following are the methods to determine the cost of sectionalization:

(a) ***Repeater monitoring:*** The J98722F repeater access unit (RAU), in conjunction with an appropriate bridging resistor arrangement, provides the ability to access, on a bridged basis, each repeater in an office repeater bay. The RAU is available in two size configurations; a 75 repeater unit and a 100 repeater unit. The method of determining the cost of equipment required for sectionalization in each office is shown per example in Fig. 22. The cost estimates in Fig. 22 are based upon the 75 repeater arrangement.

> ***Note:*** Bridging resistor panels ED-1P288 and ED-1P289 are required for 206- and 201-type office repeater bays, respectively. The J98722F L4, 5, or 6 are required for T1C repeater bays.

(b) ***Sectionalization measurements:*** The J98722G, H, and J directed line monitor (DLM) provides the ability to select and measure bipolar violation performance of each T1 line accessed through an RAU. Since each DLM can accommodate up to 79 RAUs, one DLM per sectionalization office is sufficient for planning purposes. In addition, one E2A hardwired display (1-J1P029A L8) is required for status information from the DLM. A dedicated switch expander panel (J1P029A L13) is required for DLM control and

ITEM	MATERIAL PRICE	AT&T TECH. ENG.	AT&T TECH. INST.	USER ENG. & INST.
J1P029A L5,6,19,22	$3980	$570	$900	$370
J1P029A L7 GSU	1258	–	–	–
J1P029A L8 Displ. (CGA)	238	200	340	140
J1P029A L8 Displ. (MLSI)	238	60	115	25
Connectorized Cables for CGAs	56	–	20	–
Connectorized Cables for MLSI	28	–	10	–

Ct = $5820 Basic remote

+1308 (Ni+Nj) GSU and displays for CGA (includes cables)

+790 (Sn/2) RU P/O GSU and display for MLSI (display 5)

where:

Ni = (Total D-banks in office ÷ 60) rounded to next higher integer.

Nj = (Total M1C muldems in office ÷ 60) rounded to next higher integer.

Sn = (Total maintenance lines ÷ 32) rounded up.

()RU = indicates rounding up to the next higher integer.

Fig. 16—Example of Method to Determine Installed Cost of E2A APR or DAS Equipment

selection of the first 23 RAUs. An additional L14 is required for an office with more than 23 RAUs.

(c) ***Alarm disable:*** A number of arrangements are possible depending upon the office alarm wiring. The minimum arrangement is to provide one audible and one visual inhibit pair per D-bank bay lineup. Thus, one alarm disable unit (J98722L) can accommodate 36 bay lineups. The maximum arrangement is to provide one audible and one visual inhibit pair per D-bank bay. In this arrangement, one alarm disable unit can accommodate 36 bays. The method for determining the cost of equipment required for alarm disable in each office is shown per the example in Fig. 23. The example (Fig. 23) uses the basis of one alarm disable unit for 36 bays.

Cost in a 4 ESS Switching Office - Terminal Monitoring

6.17 Office B of Fig. 5 shows a 4 ESS switching office selected for terminal monitoring. The fol-

ITEM	MATERIAL PRICE	AT&T TECH. ENG.	AT&T TECH. INST.	USER ENG. & INST.
J98722A L4	$177	$115	$170	$45
Cables (300' conn 100' SB)	100	–	90	–
Ni = (Total D-banks in office ÷ 60) rounded to next higher integer				
CA = $507 (Ni)		CJP		
+190 (Ni)		Cables		
CA = $697 (Ni)		TCAS Alarm Access		

Fig. 17—Example of Method to Determine Cost of Equipment Required for Terminal Alarm Monitoring

lowing is methods of determining the cost of the required equipment:

(a) The cost of MLSIs and associated cabling and bridging resistor panels required to monitor maintenance and backbone lines is shown in the example of Fig. 18.

(b) The cost of arrangements for monitoring M1Cs is shown in the example of Fig. 19.

(c) The cost of reporting MLSI and M1C indications is shown in the example of Fig. 23.

(d) The CMS to TCAS data link must be a dedicated 1200 baud 4-wire private line data channel for each 4 ESS switching machine. The data channel port at the CMS already exists in CMS so no cost for that arrangement is included herein. The data facility should be provided on a customer services basis and represents a small annual expense compared to other expenses, so it has been ignored. Finally, the cost of the CMS interface at the TCAS central has been included in the TCAS central costs, so it is not included here.

Cost in a 4 ESS Switching Office - Line Sectionalization

6.18 Office A of Fig. 5 gives an example of a 4 ESS switching office selected for line sectionalization. The cost and equipment required is as follows:

(a) The method to determine MLSI cost is shown in example of Fig. 18.

(b) The method to determine cost of arrangements for monitoring M1Cs is shown in example of Fig. 19.

(c) The method to determine cost of sectionalization cost is shown in example of Fig. 22.

(d) The method to determine the cost of E2A remote is shown in example of Fig. 20. The example is less the cost of the SD-1A147-02 data bridge.

(e) CMS to TCAS data link (ignore cost).

Total TCAS Investment and Annual Charges

6.19 For purposes of this study, it is assumed that the user wants to compute the total TCAS investment and annual charges for a 10-year study period. A 10-year period was chosen to avoid the need to consider the impact of higher level digital systems and advancements in technology.

ITEM	MATERIAL PRICE	AT&T TECH. ENG.	AT&T TECH. INST.	USER ENG. & INST.
J98722E L1	$1196	$285	$115	$105
J98722E L3	217	–	–	–
J987223 L4	384	–	–	–
ED-1P267-30	72	–	12	–
100' ABAM	23	–	60	–

CM = $1701 Sn	Shelves
+217 Pn	Plug-ins
+384 [(Pn/8)-Sn]	Power supplies
+84 RN	Bridging resistor panels
+83 Pn/8	Cabling

CM = $1317 Sn + $275 Pn + $84 Rn

where:

Sn = (total maintenance lines ÷ 32) rounded up

Pn = (total maintenance lines ÷ 2) rounded up

Rn = total office repeater bays in the office

Fig. 18—Example of Method to Determine the Installed Cost of Maintenance Line Monitoring in Each Office

6.20 The information obtained as a result of the calculations performed to complete the Cost of Implementing TCAS (K$) Table (Fig. 15) is then used to determine the total investment and annual charges for the remote office equipment.

6.21 The calculations used in determining the monitored systems and total investment shown in the example of Fig. 24 was developed from the following data:

(a) ***Monitored systems:*** The model network contains 4800 systems. In the example of Fig. 25, the number of monitored systems at the end of 1983 is given as 77 percent. Therefore, the monitored systems at this point in time are 77 percent of 4800 or approximately 3700. For the year 1984, The example of Fig. 26 indicates that 91 percent system coverage is obtained and at the end of 1985, 95 percent coverage is achieved. Growth is assumed to be 10 percent annually after 1983. Therefore, in 1984 the expected growth of the network will be to 5280 systems. At the end of 1984 as shown in example of Fig. 26, about 91 percent of the systems will be monitored or approximately 4790 of the total systems. In 1985, the network will grow to 5800 systems of which 95 percent (or about 5510) will be monitored.

ITEM	MATERIAL PRICE	AT&T TECH. ENG.	AT&T TECH. INST.	USER ENG. & INST.
J98722A L4	$177	$115	$170	$45
Cable (300' conn 100' SB)	100	–	90	–

Cb = $507 Nj CJP
+190 Nj Cables
= $697 Nj TCAS Alarm Access

where:

Nj = (Total M1C muldems in office ÷ 60) rounded to next highest integer.

Fig. 19—Example of Method to Determine Installed Cost of M1C Monitoring in Each Office

(b) The total investment for the three implementation plan years is obtained from the Cost of Implementing TCAS (K$) Table. The cumulative investment in the example shown in Fig. 25 represents the total investment for the offices for each year and include the inflation rate for central office equipment. The annual charges represent the 30 percent charge factor and are totaled separately. The example of Fig. 25 expands the Cost of Implementing TCAS (K$) Table data to include all years in the 10-year study period to obtain the total investment and annual charges. To complete the example of Fig. 25, the following calculations were performed:

1983 through 1985

Cumulative total investment = [(inflation factor) (new investment per year)] + (previous year cumulative investment).

1986 and on

The average cost per system at this point in time was computed.

Cost per system = 2143K/5510 = $388

Then:

Cumulative total investment = [(10% of previous year-end monitored systems ($388) (inflation factor)] + (previous year cumulative investment).

6.22 The next cost item represents the investment required in the TCAS central equipment. The example shown in Fig. 26 illustrates the initial 1983 TCAS central investment and new investment required during the 10-year study period. The new investment is primarily additional TCT and CDTs required to keep up with system growth.

6.23 The initial TCAS central cost is based on the hardware required to monitor 31 offices comprising approximately 4800 systems. The cost estimate assumes a dedicated data base CDT and supervisory CDT, both equipped with printers. The cost estimate was computed as follows:

(a) Let N4E = number of 4 ESS switching offices monitored

M = number of E2A remotes

R = rounded to nearest integer.

Central cost = $82,854 + $2,537 (M/10)R +$550 N4E

ITEM	MATERIAL PRICE	AT&T TECH. ENG.	AT&T TECH. INST.	USER ENG. & INST.
J1P029D L1,3, and 9	$4980	$570	$900	$370
J1P029DL8 Data Set Interface	200	–	–	–
SD-1A147-02 Data Bridge	1200	200	600	400
J1P029D L6 GSU	1258	–	–	–
J1P029D L7 Displ. (MLSI)	238	60	115	25
J1P029D L7 Displ. (M1C)	238	200	340	140
Connectorized Cables for MLSI	28	–	10	–
Connectorized Cables for M1C	56	–	20	–

Cte = $6820 basic remote (no hard wired displays)

+400 data set interfaces for links to 1 ESS Switching offices

+2400 data bridge on primary maintenance channel

+790 (Sn/2)RU P/O GSU and display for MLSI

+1308 Nj GSU and displays for M1C

Cte = $9620 +790 (Sn/2) RU + 1308 Nj

where:

Nj = (total M1C muldems in office ÷ 60) rounded up.

Sn = (total maintenance lines ÷ 32) rounded up.

()RU = indicates rounding up to the next higher integer.

Fig. 20—Example of Method to Determine Installed Cost of E2A APR or DAS Equipment With ESS Switching Monitoring Capability

ITEM	MATERIAL PRICE	AT&T TECH. ENG.	AT&T TECH. INST.	USER ENG. & INST.
SD-1A147-02 Data Bridge	$1200	$200	$600	$400
32 Scan Point Terminations	160	35	85	40

Cdb = $2400 data bridge
+320 SN MLSI monitoring
+640 Nj M1C monitoring

where:

Sn = (total maintenance lines ÷ 32) rounded up.

Nj = (total M1C muldems in office ÷ 60) rounded up.

Fig. 21—Example of Method to Determine Installed Cost of Equipment Associated With the 1 or 1A ESS Switching Machine in Each ESS Switch Office Without an E2A Remote

Note: There are not any 4 ESS switching offices in this example. Thus, the central cost = $90,465.

(b) The new investment required in 1985 represents an additional CDT being added as the number of monitored systems increase. The CDTs are added on the basis of one per 1500 systems monitored.

(c) Optional central equipment, such as pedestals for the CDTs or optional printers, is not included in the basic cost. These additional items must be added as required.

6.24 The final cost item to consider is the software and data base charges. Since the right-to-use fee for TCAS software must be treated as an expense item and the data base upkeep charges are recurring, these costs are added to the annual charges for the equipment. The total annual charges are then accumulated in a Total Annual Charges Table as shown in the example of Fig. 27.

6.25 As a result of experience gained in the preparation of the data base for the initial installation, the cost of generating a TCAS data base is estimated to be about $10 per system. Because of system rearrangements, an upkeep cost of about $5 per system per year is expected. The calculations used to determine the total annual charges are as follows:

(a) To determine the data base cost, the following calculations would be made:

Let: N = total monitored systems

Let: NG = growth systems during the year

Data base cost = $10 NG + 5(N-NG)

Annual charges for the data base can then be obtained from:

Annual charges = [$10 Ng+5(N-Ng)] [inflation factor]

(b) The total annual charges, including the right-to-use fees, are then added as shown. These charges are the percent worth as shown in the example of Fig. 28 using the 12 percent cost of capital factors.

6.26 To determine the potential annual savings, or value, realized from the implementation of TCAS would require an in-depth analysis of many factors. These factors have been analyzed and are presented in detail in Part 6, Value Analysis of Im-

ITEM	MATERIAL PRICE	AT&T TECH. ENG.	AT&T TECH. INST.	USER ENG. & INST.
J98722F L1	$ 898	$ 80	$ 575	$160
ED-1P288-30	150	–	–	–
J98722G&H	4410	115	115	60
J98722G L5	200	–	–	–
J98722J&G L2	382	–	35	–
J1P029A L8	238	60	115	30
J1P029A L7	1258	–	–	–
J1P029A L13	823	255	1110	340
J1P029A L14	611	255	1110	340
Cables	50	–	40	–

Cs = $4990	DLM basic unit (includes cables)
+758	DLM reporting (E2A)
+417 (Rn/16) RU-1	RAU selection (DLM cost)
+2528	DLM control and RAU selection (E2A cost)
$+2316\left[\left(\frac{Rn}{56}\right)RU-1\right]$	RAU selection (Rn > 23) (E2A cost)
+758 (Rn/56) RU	Shelf fuse (E2A cost)
+1713 Rn	RAU

$$Cs = \$8681 + 417 \left(\frac{Rn}{16}\right) Ru + 1713\ Rn \quad Rn \le 23$$

$$CS = \$10,917 + 417 \left(\frac{Rn}{16}\right) Ru + 1713\ Rn \quad Rn > 23$$

where:

Rn = total office repeater bays in the office

()RU = indicates rounding up to the next higher integer

Fig. 22—Example of Method to Determine Installed Cost of Equipment Required for Sectionalization in Each Office

ITEM	MATERIAL PRICE	AT&T TECH. ENG.	AT&T TECH. INST.	USER ENG. & INST.
Alarm Disable Unit	$300	$100	$150	$40
Cables	100	–	80	–

CAD = $770 for 36 terminal bays

= $21 Nb

where:

Nb = number of terminal bays

Fig. 23—Example of Method to Determine Installed Cost of Equipment Required for Alarm Disable in Each Office With an E2A APR or DAS Remote Unit

ITEM	MATERIAL PRICE	AT&T TECH. ENG.	AT&T TECH. INST.	USER ENG. & INST.
32 Scan Point Terminations	$160	$35	$85	$40

Cmr = 320 Sn + 640 Nj

where:

Sn = (total maintenance lines ÷ 32) rounded up.

Nj = (total M1C muldems in office ÷ 60) rounded up.

Fig. 24—Example of Method to Determine Installed Cost of Reporting MLSI and M1C Indications in a 4 ESS Switching Office

plementing TCAS. However, for the purposes of this study, the results of the detailed analysis have been summarized and conservatively applied to the model.

6.27 Assumptions used in the preparation of the Annual Savings Table (Fig. 29) to obtain the estimated savings are stated so that they can be evaluated and modified if appropriate. Using the assumption of an hourly labor rate of $16 and an annual CGA rate of 60 CGAs per system per year, the annual savings per system per year for TCAS can be expressed as:

Full annual savings = $222 + 130SR

Where: SR = sectionalization ratio.

6.28 To maintain a conservative approach to computing annual savings, assume that 80 percent

YEAR END	MONITORED SYSTEMS	INFLATION FACTOR	CUMULATIVE INVESTMENT ($K)	ANNUAL CHARGES ($K)
1983	3700	1.00	1291	387
1984	4790	1.052	1907	572
1985	5510	1.104	2300	690
1986	6060	1.156	2565	769
1987	6660	1.208	2870	861
1988	7330	1.260	3220	966
1989	8060	1.312	3621	1086
1990	8870	1.364	4079	1224
1991	9750	1.416	4603	1381
1992	10730	1.468	5200	1560

ASSUMPTIONS:
10 Percent annual growth of T-systems
Inflation rate for CO equipment = 5.2 percent
Annual charge factor = 30 percent

Fig. 25—Example of Calculations Used in Determining the Monitored Systems and Total Investment

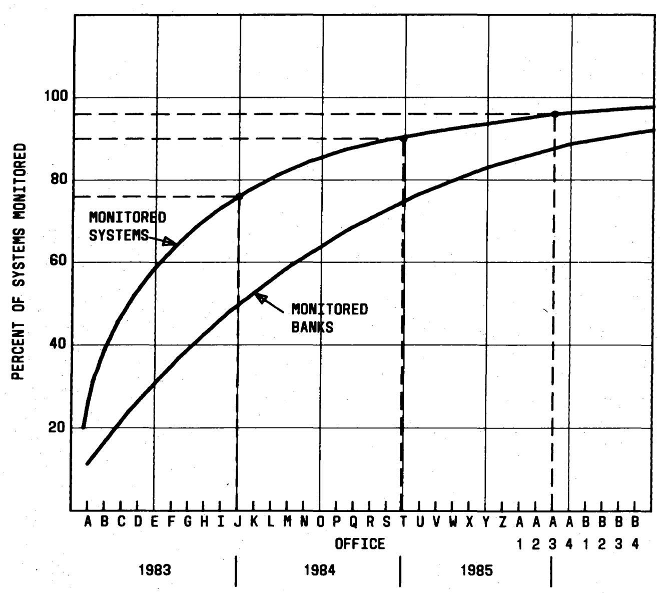


Fig. 26—Example of a Percent of Systems Monitored Graph

of these savings can actually be realized. The average annual savings per system per year then becomes:

Average annual savings = ($178 + $104SR)

6.29 The Annual Savings Table shown in example (Fig. 30) shows the expected annual savings for each year of the study. Since the growth throughout the year is not uniform, the calculation for the savings assumes that the savings actually realized on the growth systems (increase from previous year) is 25 percent of that computed for the total systems monitored. This has the effect of delaying realization of full savings for a period of 6 months. The following is the method to complete the Annual Savings Table (Fig. 30):

Let NT = total monitored systems at the end of current year

Let N = previous year's systems

Annual savings = (NT - N/4 + N)(178 + 104SR)

YEAR END	MONITORED SYSTEMS	INFLATION FACTOR	CUMULATIVE INVESTMENT ($K)	ANNUAL CHARGES ($K)
1983	94,644	1.00	94	47
1984	4,337	1.043	98	40
1985	2,383	1.086	100	50
1986	–	1.129	100	50
1987	4,337	1.172	105	52
1988	–	1.215	105	52
1989	4,337	1.258	110	55
1990	–	1.301	110	55
1991	4,337	1.344	115	58
1992	–	1.387	115	58

ASSUMPTIONS:
Inflation rate = 4.3 percent
Annual charge factor = 50 percent

Fig. 27—Example of Determining the Initial TCAS Investment and Investment Required over a 10-Year Period

D. Value Analysis of Implementing TCAS

General

6.30 This part elaborates on the analysis of factors used to determine the value realized from the implementation of TCAS.

6.31 The benefits to be derived from TCAS may be grouped into four categories:

(a) Manpower savings

(b) Facility utilization

(c) Service cost savings

(d) Improved transmission performance.

6.32 Manpower savings results from a more effective direction of the restoration effort and by eliminating unnecessary response to T-carrier alarms. Elimination of CGA register readings, false dispatches, and some maintenance routines can also be achieved.

6.33 By reducing the outage time on T-Carrier Systems, the required number of facilities can be made available for service without engineering new facilities. Similarly, by properly administering the maintenance and backbone lines, fewer lines are required and existing maintenance lines can be used for service.

6.34 T-carrier failures tend to generate many short outages which disconnect all calls in progress on the facility. In addition to being very annoying to the customer, a percentage of these cutoffs result in credit requests on the disconnected calls. The cost of handling these complaints as well as the credit granted are referred to as service costs.

6.35 Finally, errors on the T-carrier facility can have a devastating effect upon voice and data transmission without generating carrier group alarms. Maintenance forces only become aware of these problems while investigating customer complaints or performing time consuming routine tests. The TCAS can conduct performance measurements on a routine basis to identify those systems with substandard performance.

YEAR END	MONITORED SYSTEM	R-U FEES ($K)	INFLATION FACTOR	ANNUAL CHARGES ($K)*			
				DATA BASE	CENTRAL	REMOTE OFFICE	TOTAL
1983	3700	117.5	1.00	37	47	387	588
1984	4790	40	1.07	31	49	572	692
1985	5510	–	1.14	36	50	690	776
1986	6060	–	1.21	40	50	769	859
1987	6660	–	1.28	47	52	861	960
1988	7330	–	1.35	54	52	966	1072
1989	8060	–	1.42	62	55	1086	1203
1990	8070	–	1.49	72	55	1224	1351
1991	9750	–	1.56	83	58	1381	1522
1992	10730	–	1.63	95	58	1560	1713

*Rounded off

ASSUMPTIONS:
Right-to-use (RU) fees Terminal Monitoring = $117,500
Line Monitoring = $ 40,000
Labor inflation factor = 7 percent

Fig. 28—Example of a Total Annual Charges Table

6.36 The remainder of this part addresses the economic value of TCAS in the first three areas. No attempt has been made to quantify the value of the expected service improvements achieved by TCAS. The following paragraphs describe the areas of potential savings due to an implementation of TCAS and the information required to compute these savings. It should be noted that all potential savings may not be applicable to each operating company. The objective of this part is to identify the areas of possible savings in such a way that they can be tailored to each metropolitan area that might implement TCAS.

Special Service Testing

6.37 Each hard outage on a T-Carrier System which carries special services will result in customer complaints, especially during the business day. In addition, frequent hits on the system results in a disruption in the customer's data services and may also lead to customer complaints. Each such complaint results in the expenditure of test and analysis time by the serving test center. A reduction in the number of hard outages and CGAs will result in a corresponding reduction in customer complaints and the associated testing costs.

6.38 To estimate this savings, the following information is required:

TS = testing time

H = hourly labor rate

FH = hard failure rate

R = expected reduction in hard outages

S = number of special service circuits per system

YEAR END	ANNUAL CHARGES ($K)	PRESENT WORTH FACTOR	PWAC $K
1983	588	.893	525
1984	692	.797	552
1985	776	.712	553
1986	859	.636	546
1987	960	.567	544
1988	1072	.507	544
1989	1203	.452	544
1990	1351	.404	546
1991	1522	.361	549
1992	1713	.322	552

Total annual charges = $10.736M
Average annual charges = $ 1.07M
Total PWAC = $ 5.455M

Fig. 29—Example of a Percent Worth of Annual Charges Table

The annual savings is given by:

SS = FH x R x S x TS x H

Data from the TCAS trials indicate that typical values are FH = 3, R = 20%, S = 5, and TS = 0.5 man-hours

SS = 1.5H

This savings is applicable in terminal monitoring.

Trouble Sectionalization

6.39 Each hard outage requires the expenditure of sectionalization effort in a number of offices to reach th point where a maintenance line patch can be established and fault location can begin. Sectionalization using the DLM and alarm cutoff can minimize the effort required.

6.40 Appendix A of EL 2672 provides an analysis of the manpower savings expected from the provision of automatic sectionalization in each office of a four span system. This estimate of 0.75 man-hours per span is considered conservative. However, a typical TCAS installation may provide only partial sectionalization capability, especially during the implementation phase. As a result, a sectionalization ratio (SR) must be used to adjust the savings.

6.41 Other information required is:

Let: FH = hard failure rate

Let: H = hourly labor rate

Let: SR = sectionalization ratio

Let: TS = trouble sectionalization

The annual savings due to trouble sectionalization is:

TS = FH x H x 0.75 man hrs/span x span/sys x 0.9 x SR

TS = 2.7FH x H x SR

TS = 8.1H x SR

This savings is applicable to sectionalization only.

Report Preparation

6.42 Normal T-carrier central office and FMAC-M operation requires the preparation of numerous reports. The TCAS can automatically prepare these as well as many other desirable reports. These reports can improve T-carrier performance by providing management with timely information concerning the status of the network. It should be emphasized that even though these reports may not be currently prepared, their intrinsic value can be estimated by the effort that would be required for their preparation.

6.43 It is estimated that at least one man, full time, is required to prepare the reports necessary for a good FMAC-M operation in a network with 5000 T-Carrier Systems. On a per system basis:

RP = 2000 hrs/yr x H/5000 Systems

RP = 0.4H

YEAR END	MONITORED SYSTEM	m	SR	INFLATION FACTOR	ANNUAL SAVINGS
1983	3700	.50	.63	1.00	228
1984	4790	.75	.73	1.07	1106
1985	5510	.87	.90	1.14	1575
1986	6060	.87	.90	1.21	1900
1987	6660	.87	.90	1.28	2210
1988	7330	.87	.90	1.35	2564
1989	8060	.87	.90	1.42	2967
1990	8070	.87	.90	1.49	3421
1991	9750	.87	.90	1.56	3945
1992	10730	.87	.90	1.63	4528

10 year total savings = $24.44M

Average annual savings = $ 2.44M

ASSUMPTIONS:
Labor Inflation Factor = 7 Percent

Fig. 30—Example of an Annual Savings Table

This savings will be primarily applicable to terminal monitoring.

6.44 Most FMAC-Ms rely upon reports of outages from the field before restoration action can be initiated. Thus, the work load to the FMAC-M is filtered by the response of the office personnel. The FMAC-M subcommittee of the AT&T T-carrier maintenance task force has estimated that one FMAC-M MC can handle 500 T-Carrier Systems. With the automated capabilities provided by TCAS it is expected that one MC can handle at least 1500 systems. Also, with the ability to remote MC positions to a manned location, 24-hour coverage can be achieved without full-time manning of the center. The savings from this reduction in required personnel becomes:

OP = 2000 hrs/y (2 man saved/1500 Sys)H

OP = 2.67H

This savings may be divided equally between terminal monitoring and sectionalization.

False Dispatch of Repair Crews

6.45 About two-thirds of the hard outages on T-carrier require the dispatch of a repair crew. A recent survey of fault locating accuracy in a number of companies revealed that 16 percent of these dispatches result in a no trouble found report. This is believed to be due to the time lag between the dispatch request and the actual dispatch. With TCAS, the condition of the defective span can be rechecked immediately prior to the actual dispatch, thereby eliminating these false dispatches. Since a 2-man crew is required for each dispatch, remote controlled testing would result in savings of:

FD = FH x 0.67 x 0.16 false dispatches x 3-hr/visit

x 2-man/crew x $H/hr

FD = 0.64 FH x H

FD = 1.92 x H

for

FH = 3 failures/sys/yr

This savings is for sectionalization only.

Elimination of CGA Register Readings

6.46 Some users utilize a weekly CGA register reading program as a means of evaluating the performance of the network and to detect intermittent systems. Since TCAS automatically records and analyzes each CGA, register reading programs can be eliminated on each controlled monitored system. To estimate these savings, it is assumed that registered readings require 5 minutes per CGA bay plus 15 minutes per office for recording and analyzing the results. To calculate these savings, the following information is required:

NW = number of working banks in the office

R = number of readings per year

K = monitored banks/monitored systems (see Fig. 7)

RR = 15 min. - 5 min. x N/12 CGA bays

divided by 60 min./hr.

times H x k x R

divided by Nw

RR = 0.25 + 0.00694Nw times

H x k x R

divided by Nw

For an office with 250 banks:

k = 1.67

and

R = 52

RR = .69H

This savings is a terminal monitoring savings.

Maintenance Line Testing

6.47 As an alternative to using excess maintenance lines for service, daily testing and tight administration could reduce the overall number of maintenance lines provided under FMAC-M operation. With TCAS, daily testing would not be required. Data from field trials indicate a 42 percent reduction in the number of maintenance and backbone lines can be achieved by administration via TCAS. Assuming this reduction is valid for a FMAC-M operation and daily testing of maintenance lines, the Equipment Required for Terminal Monitoring Table (Fig. 17) provides a guide as to the minimum number of maintenance lines required versus span cross section.

6.48 Assuming a 42 percent reduction and four spans per system, the number of remaining maintenance lines which would have to be tested daily is:

m = N systems x 4 span lines/system

divided by 25 span lines/maint. lines

times 0.58

x 2 directions

m = 0.19N

Assuming an average of 3 minutes per maintenance line test including overhead, daily testing would cost:

MT = 0.19N lines/N systems

times 3 min./test/60 min./hr.

times $H/hr x 250 days/hr

MT = 2.375H

Time Hunting Alarms

6.49 One of the functions of the LMCD is to minimize the time spent by central office craft responding to alarms. Often the alarm clears by itself before the craftsman is able to locate the failed bank. Several minutes are often spent searching an aisle for the specific system that has failed. When properly used, the LMCD can immediately identify the failed system and provides a locked indication of the failure to aid in identifying intermittent systems.

6.50 Data from the TCAS trials indicate that about 70 percent of CGAs clear within the first minute. Assuming that an average of 2 minutes can be saved in responding to each of the remaining alarms, the value of the LMCD is given by:

HA = Nibanks x (2/60 hr/alarm) x RG x 0.3 x $H/hr

HA = 0.01NiRGH per office

HA = 0.01RGH per bank

Where: RG is the annual CGA rate.

Reduction in Outage Time

6.51 By reducing the outage time for hard failures, the time that a system is available for handling traffic is increased. As a result, fewer systems are required to handle a given daily volume of traffic. Since virtually all message traffic on T-Carrier Systems occurs during the business day, only decreases in business day outage time should be considered. The value of reducing outage time depends upon the following:

CF = installed cost of a T1-Carrier System including trunk circuits

r = annual charge factor for central office equipment

TA = average outage time without FMAC-M or TCAS

TB = average outage time with FMAC-M

TC = average outage time with TCAS

TH = annual hard failure rate

R = expected reduction in hard outages

FU1 = CF x r x FH/2000 hrs./yr.

times TA - TC + RTA no FMAC to TCAS

FU2 = CF x r/2000 hrs./yr.

times TB - TC + RTB FMAC to TCAS

It should be noted that the average outage time with a FMAC-M, TB, is the total outage time and not the FMAC-M restoration time.

6.52 The first cost of a T1-Carrier System including trunk circuits is about $30,000. Current annual charge factors run about 30 percent. A recent study of several metropolitan areas indicates that the outage time without FMAC-M is about 2 hours, while that with FMAC-M is 1 hour. The TCAS outage objective is 15 minutes. As indicated previously, the expected reduction in hard outages is 20 percent. Thus, the savings become:

FU1 = 30,000 x 0.3/2000

times 3[(2 - 0.25) + 0.2 x 2]

FU1 = $29 no FMAC-M or TCAS

FU2 = 30,000 x 0.3/2000

times 3[(1-0.25) + 0.2 x 1]

FU2 = $13 FMAC-M to TCAS.

Maintenance Line Utilization

6.53 Better administration of maintenance lines will result in returning excess maintenance lines to service. Assume a 42 percent reduction in the required maintenance lines is realistic, the annual savings becomes:

MU = 1 maint. line/24 span lines

times 4 span lines/sys

times 0.42 x CM x r

x 0.42 x CM x r

MU = 0.07CMr

Where: Cm = installed cost of maintenance line

Assuming an installed cost of $1000 and a 30 percent annual charge factor.

MU = $21

Service Cost Reductions

6.54 Each CGA on a T1-Carrier System causes all calls on switched message trunks to be disconnected and charging on the calls to be terminated. If a customer is disconnected and reestablishes the call, the customer will be billed for a second call setup. This billing is valid since the equipment was actually used a second time. However, from the customer's viewpoint, an overcharge has occurred since the customer did not voluntarily initiate the disconnect. The policy of users is to refund a portion of the disconnected call to each such customer who initiates a rebate request. The actual rebate plus the cost of handling the credit request represent real expenses to the user and are referred to as service costs.

6.55 A reduction in the number of T-carrier CGAs will reduce these service costs. Computation of this cost savings requires the following information:

RG = annual CGA rate

D = expected CGA reduction in percent with TCAS

TK = message trunks per system

TO = business day trunk occupancy

CR = credit request rate

FB = fraction of CGAs during the business day

TK1 = percent trunks used for interstate toll

TK2 = percent trunks used for interstae calls

TK3 = percent trunks used for multimessage unit service

C1 = initial charge for interstate calls

C2 = initial charge for interstate calls

C3 = initial charge for multimessage unit calls

RB1 = credit request handling charge - prebilling

RB2 = credit request handling charge - postbilling

CR1 = credit request handling charge - prebilling

CR2 = credit request handling charge - postbilling.

6.56 The actual computation of the savings can best be developed in a step-by-step fashion. A composite credit request handling charge must be determined. It is assumed here that only toll calls will involve postbilling charges.

CH = CR1 x RB1 + CR2 x RB2

divided by CR1 + CR2

The handling charges are then determined based upon the portion of calls of each type as given by the trunk usage.

CH = CH(TK1+ TK2) + RB1XTK3

Similarily, the rebate is given by:

CR = C1TK1 + C2TK2 + C3TK3

Finally, the composite credit request rate is:

CR = CR1 + CR2.

6.57 The service cost savings is given by:

SC = (handling cost + rebate)

x total CGAs x CGA reduction

x trunks/system x trunk occupancy

x credit request rate

x fraction of CGAs during business day

SC = (CH + CR)RB x D x TK x TO x CR x FB.

6.58 From data collected during an economic study at a field trial site, the following values were determined:

D = 30 percent for terminal monitoring - 20 percent for sectionalization

FB = 67 percent from TCAS field trial

TO = 50 percent

CR1 = 20 percent from a TELSAM questionaire

CR2 = 5 percent estimate by AT&T Bell Laboratories (BL)

TK1 = 27 percent; TK2 = 23 percent; TK3 = 50 percent

C1 = \$.91; C2 = \$.73; C3 = \$.10

RB1 = \$.60 field trial study

RB2 = \$3.60 field trial study of a business office

TK = 14

SC2 =0.48RG terminal monitoring

SC3 = 0.32RG sectionalization.

Another value of the LMCD is the detection of intermittent systems and the resultant reduction in CGAs. Assuming a 5 percent reduction, the value would be: SC1 = 0.08RG

Summary of TCAS Savings

6.59 The cost savings developed in the preceding sections are summarized as follows:

Remote office maintenance aids:

(Phase I) annual savings = HA + SC1 + MT + MU

(Phase I) annual savings = 0.01RGH LMCD + 0.08G + 2.35H + \$21 MLSI.

E. CUCRIT 3 Analysis Data

6.60 A CUCRIT 3 analysis performs a financial evaluation based upon the capital, expense, and revenue differences between the present method of T-carrier operation and the TCAS data under study. Figure 30 shows an example of the output from the CUCRIT 3 program.

7. OTHER PLANNING CONSIDERATIONS

A. General

7.01 The detailed office selection procedure and economic evaluation presented in Part 6 allows the users to select the set of offices which maximizes the utility of TCAS. Various implementation options were presented to allow tradeoffs to be evaluated.

7.02 This model study assumes that the full cost of TCAS growth is part of the project expense. In practice, much of the TCAS equipment and wiring will actually be part of T-carrier additions in the form of shop-wired bays. These TCAS costs would then be included in the cost of T-carrier equipment and would not be part of the TCAS project expense.

7.03 Various optional hardware arrangements, such as optional printers, fuse, alarm or position alarm panels, were not considered as part of the economic evaluation. Additionally, the telemetry data network, as well as the data sets, were not included. Since these costs are relatively minor compared to the other TCAS costs, they were ignored for the purpose of determining an installed cost estimate.

B. Standalone Maintenance Aids

7.04 The local office maintenance aids consist of the local maintenance center display (LMCD) and the maintenance line status indicator (MLSI). These units can be used on a standalone basis and provided as part of a T1 maintenance center. In this application, the cost of these arrangements would not be allocated to TCAS. However, since TCAS requires the use of the MLSI as well as terminal alarm access, the TCAS costs as derived earlier include this arrangement. Since TCAS does not require that local display of terminal alarms be provided, the cost of providing the optional LMCD is not included.

7.05 The LMCD may be selected for inclusion in an office, either as a standalone display, or as part of a TCAS. In either case, the costs associated with its implementation can be estimated. The cost of standalone aids is comprised of local monitoring and alarm access. This is expressed as:

Ca = alarm access Cd = alarm display

Ca + Cd = \$1830 + \$1870 (Ni) + \$803 (Ki-1)

Where: Ki = (Ni)/8 rounded up.

7.06 When an LMCD is included as part of a terminal monitoring, the additional cost is determined by:

Cd = \$1830 + \$1203 (Ni) + \$803 (Ki-1) rounded up.

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            CAPITAL UTILIZATION CRITERIA EXECUTIVE SUMMARY
            ------- ----------- -------- --------- -------
                  (ASSUMES FIXED BOOK AND TAX LIVES)

                      FULL PHASE 3 VERSUS STATUS QUO

FULL PHASE 3 FULL PHASE 2 AND FULL PHASE 3
STATUS QUO   T-CXR PRESENT METHOD OF OPERATION
```

	NON-TRENDED($000)		TRENDED($000)	
. NON-DISCOUNTED INPUT SUMMARY	FULL PHASE 3	STATUS QUO	FULL PHASE 3	STATUS QUO
CAPITAL REQTS.	3850.0	0.0	4399.1	0.0
EXPENSE REQTS.	1918.8	17140.0	3003.2	27866.9
CO. REVENUES	0.0	0.0	0.0	0.0
♦ PRESENT WORTH EXPEND	4873.8	8982.7	5836.2	13884.3

CUCRIT PERFORMS A FINANCIAL EVALUATION BASED UPON THE CAPITAL, EXPENSE, AND REVENUE DIFFERENCES BETWEEN TWO PLANS. THE EVALUATORS WHICH THE PROGRAM GENERATES ONLY DESCRIBE THE ECONOMIC WORTH OF THE DIFFERENCES IN CAPITAL, EXPENSE AND/OR REVENUES BETWEEN THE PLANS, AND ARE NOT ATTRIBUTABLE TO EITHER PLAN INDIVIDUALLY.

INCREMENTAL INCOME AND CAPITAL SHORT TERM EVALUATORS

	NON-TRENDED($000)			TRENDED($000)		
YEAR	NET INCOME	NET AVG. INVEST.	RETURN ON CAPITAL INVEST.(%)	NET INCOME	NET AVG. INVEST.	RETURN ON CAPITAL INVEST.(%)
1979	-19.3	1123.1	1.9	-18.3	1153.8	2.0
1980	402.9	1512.2	30.2	477.6	1570.7	34.0
1981	553.9	1757.2	35.1	706.1	1847.0	41.8
1982	637.2	1763.6	39.7	874.3	1866.8	50.4
1983	706.3	1788.0	43.1	1041.1	1912.5	58.0

INCREMENTAL CASH FLOW LONG TERM & RISK EVALUATORS

	NON-TRENDED	TRENDED
LONG TERM RATE OF RETURN (10 YR. STUDY) EARNED:	29.7%	38.2%
♦ NET PRESENT VALUE($000)	2006.3	3929.8
♦ PRES. WORTH EXPEND.($000)	-4108.8	-8048.2
♦ DISCOUNTED PAYBACK (YRS.)	6	5

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♦ AT 12.0% COST OF MONEY.

Fig. 31—Example of a CUCRIT 3 Analysis Data Output

7.07 When the MLSI is added as a standalone maintenance aid, the cost is determined from the formula for CM given in Fig. 18.

C. Data Base

7.08 In general, the data base is the specific information needed by the TCAS central to define the monitored network. This information is required in addition to the Hewlett-Packard RTE program and the TCAS software. Data base requirements are described here to allow for planning effort in this area. For additional details refer to Document 865-201-102.

7.09 Basically, the types of information required for the TCAS data base can be separated into the following general categories:

(a) T-Carrier System layout data which includes the following information:

(1) Span line information

(2) Cable designations

(3) Terminal information

(4) System identification.

(b) E-telemetry remote data which pertains to the assignment of each T-carrier status point to be monitored to an individual status bit in the remote.

(c) The DLM assignment information which includes relay rack number and shelf number of each repeater bay in each office equipped with a DLM.

(d) The TCAS area descriptive data which includes the corporate organizational structure, data facility structure, and office names.

7.10 Briefly, the system layout data includes span line information, cable designations, terminal information, and system identification. Similar information is required for maintenance lines and backbone lines. The second category of data base information is that pertaining to the assignment of each T-carrier status point to be monitored to an individual status bit in the E-telemetry remote. The DLM assignment information required is the relay rack bay number and shelf of each repeater bay in each office equipped with DLMs. The third category, TCAS area descriptive data, consists of the corporate organizational structure, data facility structure, and office names.

D. Data Facility—Telemetry Network

7.11 The data facilities required for E-telemetry are 4-wire facilities using 2-wire, 4-way split bridges meeting 3002 channel requirements. Practice 865-100-101 provides engineering rules for the design of the data network. The interface between the computer and a data network is provided by the TCT. The TCAS central can be equipped to handle up to 10 separate multipoint data networks and an individual data network may contain up to 16 E-telemetry remote terminals. Due to addressing restrictions, the maximum capacity of the central is 128 remotes and not 10 TCTs 16 remotes.

7.12 It is also recommended that hubbing arrangements be used wherever possible to minimize the disabling effect of a single facility failure. In addition, care should be taken to distribute major offices across the required data networks so as to minimize the impact of a data facility failure on the TCAS operations. The network designs should be provided by the user in a manner consistent with that used for standard customer applications. This includes the provision of proper administrative and maintenance criteria such as the use of serving test centers (STCs).

7.13 The cost of the data facility may be estimated based on the following assumptions. In a typical metropolitan area, the offices on a data facility may be separated by about 5 miles. Since each office may not be a data bridge location, an average leg length of 8 miles may be assumed. Using private line revenue requirements, the first cost of each data leg will be about $700. The data facility cost for a TCAS network will then be:

Cf = $700 M

Where: M = number of E-telemetry remotes.

> ***Note:*** If E-telemetry remotes in a satellite metropolitan area are included in a TCAS implementation, the data facility costs may differ substantially from those previously derived.

E. Telemetry, DLM, and MLSI Assignments

7.14 The E-telemetry assignments are made by the AT&T Technologies line engineer, or optionally by the user's engineer, on a per office basis as part of the job engineering when individual offices are equipped with TCAS E-telemetry equipment. The status assignment process consists of assigning each T-carrier status to be monitored in an office to an individual status bit in the E-telemetry remote. The overall assignments for any particular office can be thought of as being made on a semicustomized basis. They are customized in that each office will be equipped differently with regard to the complement of T-carrier equipment present. However, considerable standardization is applied in that a related group of up to 64 statuses is assigned in a standardized manner within a particular display.

7.15 The specific assignment process is not discussed in detail here. Details are presented in Practice 865-201-111. The important aspect to note is that the appropriate engineer will use special assignment forms in making and recording the telemetry assignments for each office.

7.16 Assignment of the MLSI to the maintenance lines to be monitored requires the identification of the type of line, its designation, from-to points, and block diagram number on SD-1P090-01. Additionally, the repeater identification as well as the MLSI identification data are required. The MLSI assignments are provided by the user.

7.17 The DLM assignment information originates as part of the AT&T Technologies job engineering associated with the installation of TCAS equipment in remote offices. This information must contain the relay rack bay number and shelf of each repeater bay in each office equipped with DLMs.