THE BELL SYSTEM TECHNICAL JOURNAL
Vol. 57, No. 2, February 1978
Printed in U.S.A.

Common Channel Interoffice Signaling:

Field Implementation

By R. S. LITTLE

(Manuscript received May 7, 1977)

This article reviews the Bell System domestic toll CCIS introduction plan and summarizes the early stages of this field implementation. Establishment of the first two signaling regions, installation and cutover of the first two new CCIS toll switching offices, and the first retrofit of CCIS to an existing office are each described. Emphasis is placed on discussion of the installation sequence and special test methods developed for adding the CCIS feature to in-service switching offices in an efficient and reliable manner.

I. INTRODUCTION

Domestic CCIS will extend eventually to most SPC-type switching offices in the DDD network. The implementation plan[1] concentrates first on the toll portion of the network in order to realize the benefits of CCIS as soon as possible. Quasi-associated signaling is being used to form the initial domestic CCIS network.[2] This is a simple dual-level signaling network with ten regions corresponding geographically to the ten regions of the DDD message network. Each region has a Signal Transfer Point (STP), duplicated for reliability, which has signaling links to every other STP and to every CCIS-equipped Switching Office (SO) in its region.

Since the basic topological element of this signaling network is a "quad" consisting of the two (mate) STPs in one region fully interconnected with the STP pair of another signaling region, and since construction of a full quad of laboratory STP entities would be impractical, the first two pairs of field STPs were scheduled to serve also as a test vehicle for system design verification. This initial quad consists of STPs at Indianapolis and Omaha for the Norway region and at Dallas and Oklahoma City for the Dallas region. As noted in Ref. 2, these STPs were derived from existing toll crossbar Electronic Translator System (ETS) offices which must remain in service switching conventional SF/MF traffic while the STP feature was being installed and tested. Therefore, this initial quad served also to verify the engineering, data compilation, installation and test methods developed jointly by AT&T, Bell Labs and Western Electric.

Whereas the signal transfer function of an STP is entirely unrelated to any trunk switching activity that the host SPC processor[3] may also be directing, the signal processing function in every CCIS SO is quite intimately related to its trunk switching function. For this reason the first two CCIS SO implementation sites were both new office installations where the basic system design could be verified without risk to other (nonexistent) service on the system. Both available major Bell System toll switching system types were represented: No. 4A toll crossbar (4A) ETS[4] at Madison, Wisconsin, and No. 4 ESS[5] at Chicago. These offices are in the Norway region, so each has signaling links to the Indianapolis and Omaha STPs.

While the Chicago entity was the first No. 4 ESS (4ESS) in service and all such new offices will have the CCIS feature, the Madison entity is likely to be the last new toll crossbar installation and all subsequent toll crossbar CCIS applications will consequently involve retrofit of the CCIS feature to live offices. Therefore it was necessary in the toll crossbar application to also verify proposed retrofit procedures at some existing ETS site. Waukesha, Wisconsin was that site, which is also in the Norway region.

Starting with inaugural CCIS service between Madison and Chicago on May 15, 1976, the CCIS network had grown in six months to include six STPs and six SOs shown in Fig. 1, and reached triple this size within the first full year of CCIS service.

The following sections of this article describe the initial STP quad and SO implementations, with emphasis on the installation sequence and special test methods developed to assure smooth introduction of CCIS service to the domestic toll network.

II. INITIAL STP QUAD IMPLEMENTATION

2.1 Overall description

Indianapolis was selected as the initial application site for STP implementation. The other three members of the initial quad were scheduled to follow the lead set at Indianapolis, but to lag by three weeks in order to facilitate incorporation of any minor procedural modifications deemed advisable from the Indianapolis experience. The major sequential steps in the modification of an ETS office to become an STP are summarized in Fig. 2. Unlike most commercial data processing systems which can be temporarily shut down for periodic maintenance and al-

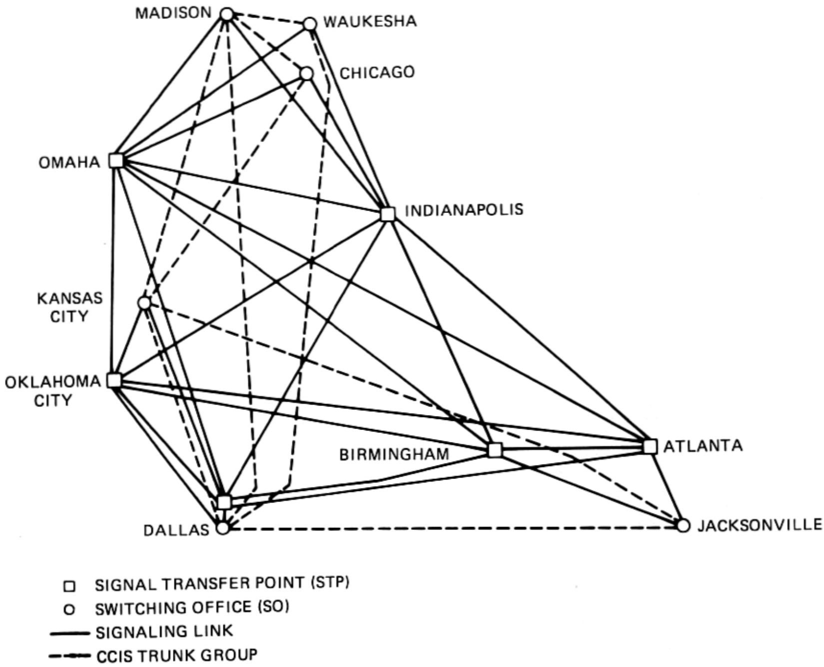

Fig. 1—CCIS network at year-end 1976.

teration, the toll switching systems of the DDD network are required to provide continuous real-time service. Therefore, special conversion and growth procedures are developed to facilitate system modification and to reduce the risk of service impairment to a practicable minimum.

2.1.1 STP candidate selection

An important consideration in STP selection is signaling network security. An STP candidate should be served by at least four physically independent transmission routes for most reliable interconnection of the signaling network, and an STP should be geographically remote enough from its mate that the likelihood of any single catastrophe affecting both STPs is very small.

Each of the ten regions has at least two ETS offices which meet these criteria. Each of the twenty initial STP sites is therefore already equipped with the necessary basic SPC processing system, specifically an ETS. To this nucleus must be added a number of significant features.

2.1.2 PBC retrofit

The first step beyond the basic ETS is addition of a feature known as Peripheral Bus Computer (PBC)[6] to enhance the plant and traffic

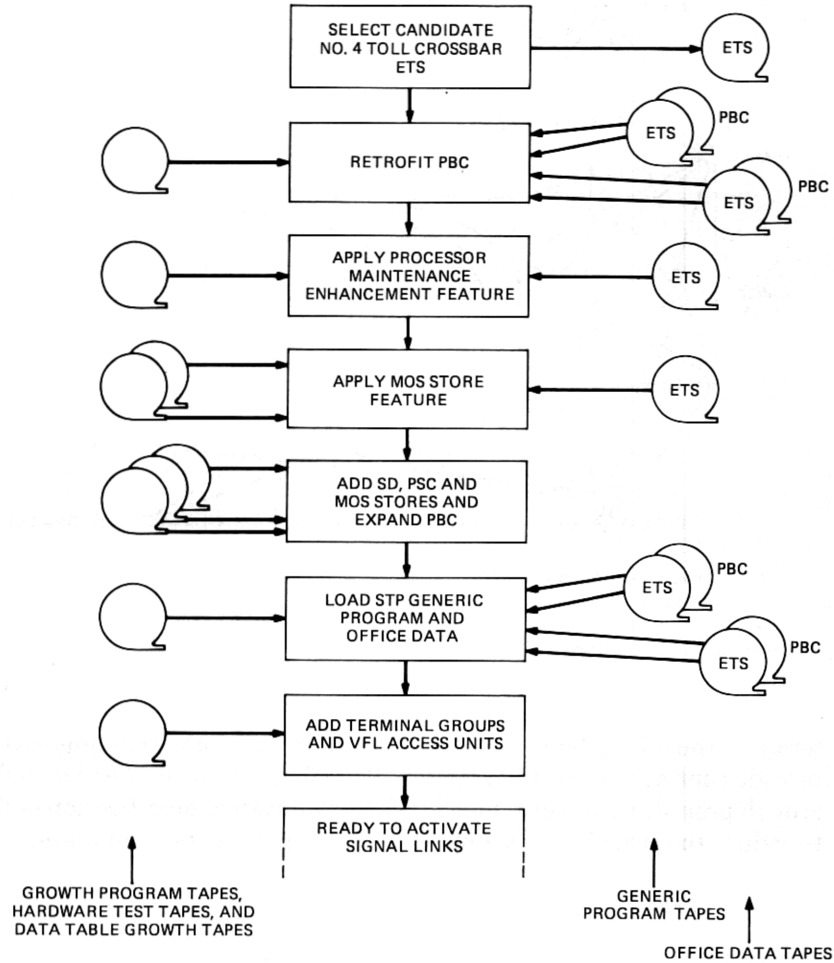

Fig. 2—STP implementation sequence.

measurement and administration functions of the office. This minicomputer adjunct communicates with the SPC processing system by means of an electronic interface known as the ac bus repeater, and obtains measurements from the toll crossbar equipment via two additional electromechanical interfaces called the traffic data converter and the traffic usage interface. Connections between the PBC and the electromechanical equipment of the toll crossbar system do not require any unusual installation treatment and will not be discussed further here. Two other aspects of the PBC retrofit operation are relevant and will be mentioned.

First, the connections between the PBC and the electronic nucleus of the ETS do require special care and are necessary to the STP and CCIS SO functions. These connections, consisting of insertion into the common duplicated peripheral unit address and answer busses and provision of certain dedicated control and status connections, are effected and verified with the aid of a peripheral unit growth program. This program is loaded as a temporary overlay during the PBC retrofit procedure and responds to input commands at the maintenance teletypewriter (TTY) to provide special time-shared test access to the new equipment while the original system continues to process calls in a simplex configuration. When the new connections and equipment have all been verified the growth program facilitates activation of this equipment by setting the appropriate system parameters and establishing the necessary software linkages. The growth program is removed by reloading the generic program.

The other significant aspect of PBC retrofit is the creation of the PBC data base and coordinated modification of the ETS data base to reflect the relocation of several plant and traffic functions from the ETS into the PBC. The normal "recent change" procedures for updating small amounts of ETS office data are not intended to handle such massive data reorganizations as are required during PBC retrofit. Instead an Office Data Recompile System (ODRS) is used to decompile the original ETS office data, merge this with new data owing to the PBC addition and recompile this in the new format appropriate to the ETS/PBC package. The ODRS operation is executed at a centralized data processing location on a general-purpose computer. The ODRS produces as output both printed documents for office record keeping purposes and magnetic tapes for conveying the recompiled data to the ETS/PBC site.

When the PBC equipment connections have been verified, the PBC is loaded with its program and data and the ETS is forced into simplex operation on the active store bus while the new ETS program and data are loaded into the standby store bus. After successfully comparing the newly loaded contents against a second magnetic tape copy, the ETS is forced into simplex operation on the new load and is subjected to a series of tests to verify basic system sanity. Upon satisfactory completion of these tests the ETS is returned to duplex operation on the new load.

2.1.3 Processor modifications

Processor modifications are required to improve system recovery capability and to permit addition of more economical Metal Oxide Semiconductor (MOS) program and data storage. After the processor modifications have been completed, actual store growth is possible. Since the system requires unique data tables for each store frame controller and for each store module, a special growth program is used to create these tables and to support the connection and verification of the new controllers to the existing store/processor subsystem.

Complete controller verification requires the presence of at least one memory module served by that controller, so growth of the first module on each frame is always part of the frame growth process. Up to five more modules can be added if more memory is required.

As with the peripheral unit address and answer busses, the store address and answer busses use parallel ac pulse communication over balanced and terminated pairs. A very important function of growth programs is the generation of bus pulse test patterns which facilitate oscilloscopic verification of bus connections since shorts, opens, misterminations, crosses, transpositions and reversals may occur during installation.

After all connections have been verified and the added store equipment has passed all diagnostic tests, the store growth program serves two additional functions. First, the contents of each store module are initialized to the values pertinent to spare memory. Up to this point all store growth activities have been performed on only one unit at a time. Final activation, however, is done on a duplex pair of modules by directing the growth program to set the equippage bits in active system memory for this new pair of stores.

2.1.4 Additional STP equipment

The STP also requires growth of another Signal Distributor (SD1) frame and another Peripheral Scanner (PSC4) frame to augment the distribute and scan capability of the basic ETS configuration. An extension of the same peripheral unit growth program that is used during the PBC retrofit is used to support SD1 and PSC4 connection, verification and activation.

Growth of the signaling terminal equipment is predicated upon first having loaded the STP generic program. Each group of signaling terminals is served by a pair of Terminal Access Circuits (TACs) which must be connected into the peripheral address and answer busses. A further extension of the peripheral unit growth program supports TAC growth and provides a means to check installation of each terminal unit and each associated Voice Frequency Link (VFL) access circuit. Equipped signaling terminals are left in the diagnostic state for future activation under the STP generic program whenever a signaling link is to be placed into service.

2.1.5 STP generic program activation

Upon completion of store, PSC4 and SD1 growth, the system is ready to receive the STP generic program and office data. The STP program supercedes the ETS program and the STP office data tape is loaded to augment existing office data. Since the STP function is an addition to the regular ETS trunk switching function, rather than an integral part of it, the STP software is designed to permit retention of the existing ETS office data intact, thereby avoiding a decompile/recompile operation.

Introduction of the STP function also entails a coordinated load of a new generic program and additional data into the PBC; however, no extraordinary procedures are necessary.

2.2 VFL layout and characterization

Careful selection of transmission facilities for VFLs is essential to the reliability of the signaling network. Circuit layouts for the initial signaling links were provided by the CCIS Network Administration Center (CNAC) several months earlier than normal so that these VFLs could be characterized prior to signaling link activation. Normal analog measurements of loss and noise parameters were recorded periodically for possible future correlation with signaling link performance. Experience shows the circuit layout procedures are effective in securing diverse routes, and that the transmission characteristics are comfortably within the system design objectives.

2.3 Signaling link activation

A signaling link consists of a VFL and terminal equipment at each end of the VFL. This terminal equipment can, under program control, be operated in a self-looped mode which does not include the VFL, a remote-looped mode which does not include the distant terminal, or a fully duplex synchronized mode which is the normal service configuration. The signaling link activation procedure requires that each end of the link pass a series of local tests in the self-looped mode. The office which has been assigned maintenance control of the link advances the link through the remote-looped mode into the normal duplex signaling configuration, whereupon the two terminals automatically achieve synchronization and the signaling link activation is complete.

2.4 Quad security verification

The first signaling links activated at the Indianapolis STP were temporarily connected to the development laboratory equipment[7] in Columbus, Ohio. During this phase of CCIS implementation the laboratory served many roles, simulating the remainder of the CCIS network in support of basic tests at Indianapolis. As the Omaha, Dallas, and Oklahoma City STPs became available the temporary VFLs from Indianapolis to Columbus were replaced by the standard VFLs from Indianapolis to those other STPs.

Prior to activating any links to the first CCIS switching offices this signaling quad was deliberately faulted to verify signaling security. Link failures as well as complete STP failures were simulated and signaling integrity was continuously maintained by virtue of network redundancy. Access links to the Chicago and Madison CCIS switching offices from the Indianapolis and Omaha STPs were then activated and proper responses to access link troubles and to simulated switching office failures were verified.

2.5 Signaling network growth

Signaling link activation for any new CCIS SO should precede CCIS service to permit pre-cutover interoffice testing of CCIS trunks. When a CCIS SO is the first in its region, as is the Jacksonville 4ESS, the pair of STPs for that region must first be added to the signaling network. This in turn means activating a new quad of signaling links from the new STP pair to every existing STP pair. The installation and activation methods are the same as proven during implementation of the initial signaling quad.

When the tenth and final pair of STPs are activated in late 1977, each STP will require at least twenty CCIS terminals to establish the basic interregional signaling network. When the signaling capacity of one signaling link quad is reached, corresponding roughly to six thousand CCIS trunks between the switching offices in those two regions, it becomes necessary to activate another quad of signaling links between the associated STPs.

III. INITIAL SWITCHING OFFICE IMPLEMENTATION

3.1 "Chicago 7" first 4ESS installation

The first 4ESS installation, known as Chicago 7, entered regular service on January 17, 1976. As discussed in Ref. 5, the CCIS SO feature is an inherent part of every 4ESS, so no retrofit procedure is required.

The initial STP network was not available in January, so Chicago 7 cut over with its signaling terminals in the self-looped mode. During the next three months the VFLs to Indianapolis and Omaha and the CCIS trunk facilities to Madison were aligned and tested. In March, when the STPs were ready to begin access link tests, the VFL-to-terminal connections were completed and these signaling links were activated. In April, when the Madison CCIS SO was ready to begin interoffice CCIS trunk tests, the trunk facility-to-trunk unit connections were completed and preservice tests were performed.

3.2 "Madison 2" 4A installation

As mentioned in the introduction and further discussed in Ref. 4, the installation of the new 4A toll crossbar office, known as Madison 2, provided the last "nonpenalty" environment in which to prove the integrity of the 4A CCIS SO design.

Although many new 4A/ETS installations have been initially equipped with the PBC, none other than Madison had the prerequisite processor maintenance improvements included in the equipment as shipped from the factory. With the prerequisite generic program in the system, the MOS memory feature was introduced and the transition generic program was loaded to support store growth.

Actual store growth at Madison 2 was completed without the security and assistance of formal store growth procedures. This successful departure from standard practice permitted an early version of the 4A CCIS SO generic program and preliminary office data to be loaded into Madison 2. As the SO generic program development progressed, successively more complete versions were loaded and verified.

Since new peripheral equipment, consisting of a Terminal Group (TG) and a pair of Distributor and Scanner (DAS)[8] frames, must be added to the peripheral address and answer busses of each 4A CCIS SO, and since standard growth procedures were not available in time to meet the Madison 2 schedule, special arrangements were made to pretest this equipment extensively prior to its connection into the peripheral busses. The existing PBC system was used to exercise the DAS and TG frames for off-system verification of these frames at Madison 2.

With the DAS frames on line, CCIS feature tests can get into full swing. At Madison 2 this phase of the installation allowed discovery of latent problems and permitted early determination of the root cause of these problems.

3.3 "Waukesha 2" 4A retrofit

The Waukesha 2 4A/ETS entered regular service in 1973. It is therefore a relatively new office with recent vintages of equipment. Its PBC has been in service since early 1975. These factors, plus its position as a sectional center in the Norway region, made it an excellent candidate as the initial 4A CCIS SO retrofit site. However, unlike Madison 2, the existing equipment did not already contain apparatus and wiring for the CCIS feature, nor did the basic SPC contain the improved maintenance feature. The most significant difference is that Waukesha 2 was in service. Therefore, whereas the Madison 2 experience had proven in most of the 4A CCIS SO design and manufacture, the role of Waukesha 2 was to prove in the retrofit procedures.

3.3.1 PBC retrofit and 4A CCIS modifications

The major sequential steps in the modification of an ETS machine to become a CCIS SO are summarized in Fig. 3. Most 4A/ETS offices which

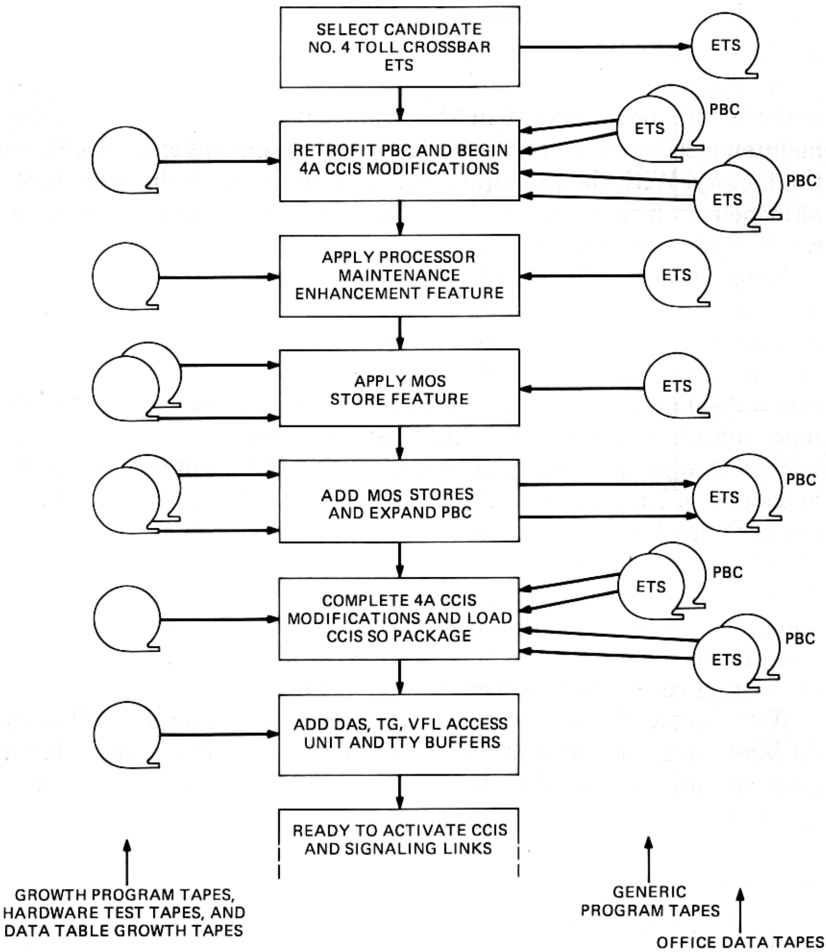

Fig. 3—No. 4A CCIS SO implementation sequence.

are candidates for the CCIS SO feature are also independently candidates for the PBC and maintenance enhancement features by virtue of their expected service longevity. Several of these offices have already been retrofitted with the PBC. Many of the same 4A equipment frames which must be modified for the PBC feature will receive additional modification for the CCIS SO feature. Therefore, recent and future PBC retrofit jobs at CCIS SO sites include many of the 4A CCIS modifications in the same operation, which reduces the overall time required to implement the two features. In either case it is not feasible to verify the CCIS capability of the modified 4A equipment until later in the retrofit sequence. Instead it is only practical to verify that the CCIS modifications do not interfere with conventional 4A/ETS operation before returning each modified equipment unit to service.

Of all the equipment requiring modification during retrofit of the CCIS feature, the quantity and vintage of senders is most critical in determining the overall time required for a given CCIS SO retrofit job, and the moderate number and recent manufacture of senders in the Waukesha 2 office served to minimize the modification interval.

3.3.2 Maintenance enhancement and MOS store features

Application of the processor modifications, growth of the stores and expansion of the PBC configuration in each CCIS SO retrofit situation are nearly identical to those steps of the STP retrofit operation (see Section 2.1.3). The only difference is in the greater number of store modules and the greater amount of PBC core storage added for the CCIS SO application.

3.3.3 CCIS SO data compilation

Once the store modules are activated, a substantial divergence occurs between the SO and STP retrofit sequences. The 4A/ETS office data additions and modifications needed to support the CCIS SO feature are so extensive as to require a decompile/recompile operation analogous to that provided by ODRS for PBC retrofit (see Section 2.1.2). An entirely new and more powerful Integrated Data Management System (IDMS) has been developed to provide this function. IDMS is able to decompile existing office data, merge these data with new CCIS SO information and create a recompiled set of data pertinent to the ultimate retrofitted configuration of the office equipment and traffic routing. Since Madison 2 was an entirely new office with no existing data to decompile, Waukesha 2 was the first IDMS application.

New information is provided to IDMS via a questionnaire containing a series of formcodes which are filled out by the telephone company planners in conjunction with the Western Electric line engineers. These formcodes are similar to, but much more extensive than, the formcodes which are filled out to specify the additional CCIS data required for an STP office. Preplanning is an important aspect of any office data compilation, to reduce or preclude the need for recent change activity as trunking to other switching offices is added or reassigned during the foreseeable future. Therefore, formcodes are filled out to include data for at least two years, as an objective, of preplanned trunk additions and rearrangements.

Existing office data are provided to IDMS via a magnetic tape copy of those areas of system memory containing office data. A preliminary audit dump of existing office data is submitted to IDMS in order to obtain an indication of any incompatibilities between the formcode entries and the existing office data. Any such problems are resolved while the store modifications are being made. As soon as the new stores are activated, the final dump is made and final IDMS processing is performed. This final processing typically requires several iterations to resolve data errors, many of which are detected by IDMS itself through a series of reasonableness tests. The new office data tapes and documentation are delivered to the CCIS SO job site for further checking. This final checking is the opportunity to prepare recent changes to correct minor errors in the recompiled data, and to reprepare any recent changes which have been entered into the existing office data base after the final dump was taken. These recent changes are arranged for entry into the machine in decreasing order of importance to proper service.

3.3.4 CCIS SO software load

With all of the 4A common control modifications completed, the recompiled "ETS" and PBC data tapes ready to load and the most critical recent changes ready to be entered upon this new load, consider for a moment the matter of program compatibility. Whereas ETS call progress is controlled mainly in hardware, CCIS SO call progress is controlled largely in software, even for calls not involving CCIS trunks. The DAS equipment (mentioned in Section 3.2 and described more completely in Refs. 4 and 8), which provides the interface necessary to obtain software control of the 4A call processing hardware, is as alien to the pre-CCIS generic programs as it is vital to the CCIS SO generic program. This apparent dilemma is solved by transcending through a series of four intermediate program versions which support gradual metamorphosis of the critical hardware from ETS operation to CCIS operation.

The first intermediate program introduced at Waukesha allowed call processing to continue in the hardware-controlled ETS manner, but using the CCIS SO data base. The main function of this program version was to maintain the integrity of switching service while the new "ETS" and PBC data bases were brought up to date and verified. It also allowed, via a compatible growth overlay program, controlled connection, verification and activation of the new CCIS SO peripheral units. These are the DAS frames, the TG with typically two terminal units and one VFL access unit, and an additional TTY buffer frame or two for I/O channels associated with CCIS-equipped Integrated Manual Test Frames (IMTFs) for interoffice CCIS trunk testing and status reporting.

Upon activation of DAS frames 0 and 1, which terminate the scan and distribute leads for all common control equipment, the second intermediate program was loaded. This version allowed 4A senders to be tested on a demand basis to verify their ability to properly report seizure and release to the processor via the DAS. These were the first of many tests to verify that the CCIS modifications previously installed in the 4A hardware actually provided the CCIS function. This step afforded an important opportunity not only to correct any problems affecting DAS scanning of senders prior to committing service calls to such control, but also a further chance for office personnel to become accustomed to operation and maintenance of this new DAS equipment.

Successful completion of the above tests allowed advancement to the third intermediate program, which expected sender DAS reports for all calls, not just test calls. Thereafter, DAS frames 0 and 1 were an integral and vital part of the system for all call processing. Their activation also allowed subsequent activation of the TG equipment and of any additional DAS frames which might have been needed to serve CCIS trunks beyond the capacity of the first two frames. The modest size, recent vintage and careful installation of the Waukesha 2 system permitted rapid progress to be made through the first three versions of intermediate program. Activation of the TG equipment was deferred until closer to the time that signaling links to the home STPs were due for service in support of interoffice CCIS trunk testing.

The Decoder-Marker Test (DMT) frame and associated trouble recorder were retrofitted with the CCIS feature. At this point the fourth intermediate program was loaded; then it was only necessary to rearrange a few cross-connections in order to activate the CCIS mode of testing. This rearrangement then permitted verification of CCIS capability previously installed in the decoder channels. These manual tests performed at the DMT frame paved the way for activation of the CCIS feature in the markers. The first intertoll marker was removed from service, its cross-connections were rearranged for CCIS operation, it was subjected to a series of tests from the DMT frame and it was returned to service. Upon similar conversion of the remaining intertoll and toll completing markers, the transformation of an ETS office into a CCIS SO is virtually complete as far as conventional trunk call processing is concerned. What remains to be proven before any CCIS trunks may be activated is that all senders, transceivers and outpulsers or modified sender/outpulsers are capable of serving CCIS trunks.

3.3.5 Sender test automation

Key to CCIS testing of senders, outpulsers, sender/outpulsers and transceivers is automation of the Incoming Sender and Register Test (ISRT) frame. With the automated ISRT frame, referred to as the ASRT frame, under program control it becomes possible to finish the verification of sender CCIS modifications and to begin the outpulser and transceiver tests. Completion of these tests is necessary prior to allowing any CCIS traffic into the office, although pre-cutover CCIS trunk tests can be performed as soon as a few of the outpulsers and transceivers have been verified.

3.3.6 CCIS trunk testing

All CCIS trunks terminating on the Waukesha 2 system are new plug-in trunk relay units served by a new outpulser group. Access to these outpulsers is provided by the outpulser link and outpulser link controller. The link controllers are tested with the new Outpulser Link Controller Test (OLCT) frame. These tests are performed soon after marker tests are completed. Thus, when the ASRT frame is ready for CCIS testing and a few outpulsers and transceivers have been verified, the CCIS Intraoffice Trunk Test (CIOT) frame can be verified and used to exercise the CCIS trunk equipment. CIOT tests can be performed on the entire "drop" if the trunk relay unit is actually equipped, or simply on the cabling to the empty socket and associated outpulser link termination on the trunk frame if plug-in equippage has been deferred. These CIOT tests can verify the incoming and outgoing modes of trunk seizure, including both hardware and software in the process.

When circuit orders for the CCIS trunk circuits have been worked, the IMTF is utilized to complete the interoffice trunk lineup, verification and activation. An initial trunk query entered at the IMTF will verify compatibility of assignment data at both CCIS SOs interconnected by a given trunk. Transmission characteristics are measured and final adjustments are made to assure standard levels throughout each trunk circuit. The office which has maintenance control of a given trunk group has the final pleasure of activating each trunk via an IMTF keyboard message. Periodically thereafter these trunks are routinely tested for proper operational and transmission characteristics by either the new Outgoing Trunk Testing System (OTTS) as at Madison 2 or the CCIS-modified Automatic Directed Outgoing Intertoll Trunk Test (ADOIT) frame as at Waukesha 2. Additionally the CIOT is scheduled under system program control to perform a quick continuity check on CCIS trunks immediately prior to periods of expected heavy traffic and to check the operational features of CCIS trunks during light traffic periods.

Thus has the Waukesha 2 4A/ETS office been retrofitted with the CCIS SO feature. Not only was this accomplished without disruption to its continuous message switching service, but also it was done concurrently with the completion of design development of such major items as IDMS and ASRT. Most importantly the procedures for applying CCIS to a working 4A/ETS have been demonstrated and refined into standards which will permit rapid deployment of CCIS into the DDD toll network.

3.4 Other early CCIS sites

Beyond the initial STP quad and the three CCIS offices which have just been discussed, Fig. 1 shows another pair of STPs and three more switching offices entering CCIS service in 1976. The three SOs are each new 4ESS installations in Kansas City, Jacksonville, and Dallas. Each of these new entities is capable of CCIS operation, but only Dallas lies in a region with STPs already available. The Rockdale region STPs at Atlanta and Birmingham were added to the signaling network to serve the Jacksonville CCIS SO in 1976 and several more new 4ESS and retrofit 4A/ETS offices in 1977 and following years. However, the St. Louis region STPs would have only the Kansas City 4ESS to serve until 1978, so signaling for the Kansas City SO is being temporarily handled by the Dallas region STPs. When the St. Louis region STPs at St. Louis and Kansas City are placed in service and connected to a new pair of terminals in the Kansas City SO, translation instructions at all other STPs will be changed to direct Kansas City SO signals to the St. Louis region STPs in normal fashion. The existing signaling links between the Kansas City SO and the Dallas region STPs will then be deactivated and the associated terminals held for future reassignment.

In Section 3.3.4 it was noted that the 4A/ETS CCIS retrofit at Waukesha utilized a series of four program load steps to achieve the transition from non-CCIS to CCIS operation, and that automation of the ISRT was perhaps the fifth step of this process. It is desirable to have ASRT available much earlier in the retrofit sequence in order to expedite pre- and post-modification testing of senders. A non-CCIS software package capable of driving the ASRT frame is being developed. Later CCIS SO retrofit jobs will utilize this approach to support ISRT automation prior to application of the MOS store feature.

The other significant difference in procedure at later 4A/ETS CCIS SO retrofit jobs is in the transition software. The Anaheim and Gardena offices in California (which provided initial CCIS service in February, 1977) have superimposed a transition overlay program upon the CCIS SO generic program at the time of initial load. This overlay program causes the main program to function as the first version in the Waukesha sequence. It also contains a small control routine which responds to TTY commands to advance the mode of operation to the next version, and so forth, without requiring a reload at each step. This procedural improvement not only speeds the transition and lessens the risk of trouble, but also materially reduces the number of magnetic tapes that must be delivered to the job, kept properly in sequence during the transition, and maintained as future issues of the system are developed.

IV. INITIAL CCIS SERVICE

4.1 Chicago 7—Madison 2 trunk service

On May 15, 1976, the traffic routing instructions at Chicago 7 and Madison 2 were altered to offer regular traffic to the CCIS trunks between these offices. Overflow traffic would be offered to the regular existing routes for calls between these two areas. Since Chicago 7 is a high volume tandem switching office not normally involved in traffic with the Madison area, these conditions were artificially induced for test purposes.

Throughout the initial months of CCIS service the signaling network performance has been excellent. No CCIS traffic has been affected by any signaling link outages, nor by an entire STP outage which occurred when the host Indianapolis switching office failed, leaving the mate STP at Omaha to carry the full signaling load. Moreover, the rate and extent of signaling link interruptions due to all causes is comfortably below the level for which the signaling network has been designed.

4.2 Expansion to other switching offices

At least two aspects of extending CCIS to other switching offices which should be mentioned are signaling and trunking. Since CNAC has been able to preplan the assignment of terminals and bands for two years from the date of service, the STPs already contain the data and most of the terminal hardware necessary to serve all needs into 1978. In such cases it is merely necessary to work the circuit orders for the new VFLs and activate the terminals associated with signaling links for each new switching office as that office prepares for CCIS service.

Provision of CCIS trunks for expansion of the CCIS network has more alternatives. The simplest of these, conceptually, is through completely new "drops" at each switching office and new voice transmission channels to interconnect them. This approach is most likely to be used in growth situations. At the opposite extreme, existing SF/MF trunks may be modified for CCIS operation in place while the traffic group remains in service. Various combinations of these approaches are most likely to be used in nongrowth situations. A special routing change technique has been developed to permit concurrent access to both the "old" SF/MF route and the "new" CCIS route during conversion. Upon completion of the conversion, only the CCIS route remains linked into the routing patterns, and the memory space previously occupied by SF/MF trunk data may be reused.

V. CONCLUSION

The initial CCIS network is successfully in service. The basic CCIS system design and new office installation methods have been verified. Retrofit procedures for STPs and 4A CCIS switching offices are practicable. The domestic CCIS design meets its objectives and additional installations of 4ESS and retrofits of 4A offices are in progress. The rapid deployment necessary for effectively realizing the potential of CCIS presents a real logistics challenge. At the same time, CCIS implementation opens vast new horizons which help assure a healthy entry into the second century of telecommunications service.

VI. ACKNOWLEDGMENTS

The design and development reported in this article are a result of combined effort by many people of the Bell System working toward a joint goal of introducing and deploying CCIS in the DDD network at the earliest practical time. To single out individuals would unintentionally lessen the contributions of others; to omit recognition of the teamwork would be to deny the achievement of CCIS.

REFERENCES

1. P. K. Bohacek, A. Kalro, and L. A. Tomko, "Implementation Planning," B.S.T.J., this issue.
2. P. R. Miller and R. E. Wallace, "Signaling Network," B.S.T.J., this issue.
3. G. R. Durney and R. S. Little, "The Stored Program Control No. 1A," Proc. of Nat. Elec. Conf., Chicago, Illinois, *25* (December 1969), pp. 382–387.
4. K. E. Crawford, C. J. Funk, P. R. Miller, and J. D. Sipes, "4A Toll Crossbar Application," B.S.T.J., this issue.
5. L. M. Croxall and R. E. Stone, "No. 4 ESS Application," B.S.T.J., this issue.
6. K. E. Crawford, C. J. Funk, and R. C. Snare, "A Peripheral Computer System for Maintenance and Administration of No. 4 Crossbar Toll Offices," Proc. of Nat. Elec. Conf., Chicago, Illinois, *30* (October 1975), pp. 301–306.
7. J. S. Colson, J. E. Massery, and G. A. Raack, "Development Tools," B.S.T.J., this issue.
8. B. Kaskey, J. S. Colson, R. F. Mills, F. H. Myers, J. T. Raleigh, A. F. Schweizer, and R. A. Tauson, "Technology and Hardware," B.S.T.J., this issue.