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Automated Repair Service Bureau:

Evolution

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This paper describes the evolution of a family of integrated computer-based operations support systems, the Automated Repair Service Bureau (ARSB). The ARSB supports the maintenance of a telephone customer's service from the local switch to the subscriber's premises (i.e., the loop portion of the service). The automation of labor-intensive manual tasks has made it possible to provide better service at lower cost.

I. INTRODUCTION

Since 1971, Bell Telephone Laboratories has focused considerable attention on Repair Service Bureau (RSB) operations. Motivating factors for this effort included the increasing cost of trouble report processing, loop testing, and fault location; a decrease in the experience level of craft persons; increasing complexity of testing; and an increase in the number of customer trouble reports being processed. The result of this effort was the development of a family of integrated computer-based operations support systems, the Automated Repair Service Bureau (ARSB). The major reasons for automating repair service functions were to

(*i*) improve customer service by more rapid detection, location, and repair of troubles;

(*ii*) reduce the trouble report rate and outage time; and

(*iii*) improve the efficiency and reduce the cost of testing, dispatch and repair operations.

In addition, the system was designed to be compatible with existing and planned future Bell System standard equipment and, as far as possible, with equipment manufactured by outside suppliers for use on Bell System lines.

Customer service has been improved by simplifying the customer trouble report-taking procedure, providing more reliable identification of the type and location of troubles, keeping the customer better informed of the status of testing and repair work during the trouble handling process, increasing the reliability of appointment times for repair visits, and reducing the total out-of-service interval.

The customer trouble report, subsequent report,* and repeat report† rates have been reduced by improved testing and analysis techniques. Outage time has been reduced by improving the efficiency of the trouble handling process, and by dispatching the right repair person to the right place at the right time. Trouble reports (both on found troubles and other reports) have been closed out with greater confidence that the trouble no longer exists. The use of mechanized testing and repair force administration has resulted in faster, more efficient processing and clearing of troubles.

Repair Service Bureau operations have been improved by mechanizing many clerical and analytical tasks, by making more effective use of available employee resources (e.g., by allowing people to make more important decisions), and by better managerial control over RSB operations through the use of an automated information system. The ARSB concept described in this special issue of *The Bell System Technical Journal* represents, in many respects, a departure from previous RSB operational procedures. As a result, particular attention was paid during the design process to the problems associated with personnel subsystems, especially the human-machine interface. (Refer to the paper entitled "Automated Repair Service Bureau: Human Performance Design Techniques," appearing in this issue.)

A flexible, modular design of both the hardware and software was used to provide for compatibility with both existing and future equipment.

The ARSB system was designed to use existing standard interfaces, such as no-test trunk‡ interfaces for testing and line insulation testing teletype channels§ for predicting incipient cable troubles, and to share these interfaces with other systems when possible. In addition, it

* A subsequent report is a customer trouble report on a line for which there is already a pending report.

† A repeat report is a customer trouble report received within 30 days of a previously cleared customer trouble report on the same line.

‡ No-test trunks are four wire metallic trunks used to gain metallic access, through the switch serving the subscriber, for testing. The term "no-test" is used because the switch performs no test for a busy line to determine if access should be provided.

§ The LIT channels are teletype channels over which maintenance information, including an identification of those lines with low insulation resistance, is transmitted to the RSB.

included manual and machine interfaces with related Bell System standard testing and records systems.

The remainder of this paper describes the loop maintenance process before automation and the evolution of the ARSB from an experimental system in the New York Telephone Company to its present configuration.

1.1 Historical background

In the late sixties, it was apparent that the RSB, where customer trouble reports were being received and processed, offered opportunities for improvement in both the efficiency and quality of loop maintenance. Let's see how the RSB handled a typical report. For example, a customer may have tried to use the telephone and heard no dial tone, and no side tone,* i.e., the phone was dead. (Assume that the reason was a broken wire in a cross-connecting terminal halfway between the customer and the central office.) Consequently, the customer used a neighbor's telephone to report the trouble. At the bureau, the call was received by a clerk who filled out a form, called a trouble report, with all the pertinent information including telephone number, name, address, reach number (in this case, the neighbor's), a description of the trouble condition, and the commitment time (the time by when the phone was to be fixed). After the trouble report was taken, the line card was retrieved from a large tube file and the trouble report and line card were clipped together and passed to a screener. The line card contained pertinent information on the customer's service including:

(*i*) the portion of the central office equipment dedicated to the customer,

(*ii*) the location on the central office main frame where the cable pair is terminated,

(*iii*) the designation of the cable(s) and pair(s), or the Pair Gain System and channel, used to connect the customer premises to the central office,

(*iv*) a full description of the customer premises equipment (e.g., one main green 500-type set with *TOUCH-TONE*® service and one extension served by a blue *PRINCESS*® telephone), and

(*v*) the location of the serving terminal where the customer's drop wire is connected to the cable facility.

This information was needed for testing and troubleshooting the fault. The screener then passed the trouble report and line card to a tester

* Side tone is the portion of the voice signal entering the transmitter of the telephone set that is coupled to the receiver of the same set. This allows the person speaking to hear both the transmitted and received signals.

who verified the trouble condition. The typical test position available was a test desk that consisted of a 100-volt, 1000-ohm/volt voltmeter and a talking set that could be bridged to the loop.

For the case being discussed, the 100-volt battery was applied to one side of the line, through the meter, and the other side of the line was grounded. The tester verified that the loop was open by observing the "capacitance kick" on the meter when the sides of the line to which the battery and ground were connected were reversed. The kick was lower in magnitude and shorter in time than would have been observed with a standard telephone set connected.* A more experienced tester might also have recognized that one side of the line was shorter than the other by measuring the capacitance kick from each side of the line to ground. This would have indicated that the open was not at the customer's premises but back towards the central office. However, since most opens were near the customer, a repair person responsible for station equipment and inside wiring up to the station protector (mounted on the side of the customer's premises) was dispatched. By testing from the protector, where the service entered the premises, and the serving terminal, the craft person concluded that the trouble was "in the cable plant" and turned the trouble over to "cable repair."

Cable repair† craft persons brought more sophisticated test equipment to bear and concluded that the open was halfway between the central office and the customer. Cable records were referred to and showed a cross-connecting terminal at the approximate fault location. Since most faults occurred where the cable was most easily accessible, such as in a cross-connecting terminal, the cable craft persons went to that location. An examination of the terminal and further testing revealed the trouble which was then repaired. The trouble found was reported by a call from the repair person to a tester at the RSB. The tester retested the line, found it normal, called the customer and "closed out" the trouble. Trouble time and disposition were added to both the trouble ticket, previously discussed, and to the cable trouble ticket. At still another position, various statistics were collected, summarized, and analyzed. Certain standard statistics were reported to AT&T and the state commissions.

Methods by which this approach could be improved are probably apparent to the reader, but the following will highlight the main ones:

(*i*) Mechanize the data on the line cards to

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* A typical station set, when on-hook, has a ringer circuit (LC ringer) consisting of an inductor and a capacitor in series across the line. This circuit looks basically like a tip to ring capacitor when a "ballistic kick" type of measurement is performed.

† Cable repair craft are responsible for all cable facilities from the protector on the mainframe at the central office up to the station protector.

(a) allow multiple users to access records at the same time, and

(b) reduce the manual updating required, and the inherent inaccuracies associated with it.

(*ii*) Mechanize trouble report tracking to

(a) provide a way of determining the status of a particular trouble without hunting through the bureau to find the trouble report,

(b) allow the clerks to talk more intelligently to customers who call again while their trouble report is still open, and

(c) allow bureau personnel to obtain information on groups of open troubles (for example, how many troubles have not yet been repaired).

(*iii*) Mechanize testing and analysis of test results to

(a) eliminate the need for asking the customer to stay at home on almost every trouble by making test result summaries available to the person receiving the trouble report (note: there is no need for the customer to stay home unless the trouble is on the premises), and

(b) decrease dependence on the experience level of the tester.

(*iv*) Mechanize the analysis of "closed" troubles to

(a) eliminate the need for extensive manual analysis,

(b) significantly reduce the time delay associated with manual analysis that detracts from the usefulness of the results, and

(c) allow previously rigid fixed format reports to be changed to meet each particular area's needs.

By the late sixties, it was technically feasible to use a computer for the line record information, and to track a trouble through the process. There was also no question about the technical feasibility of being able to measure the three terminal (tip, ring, and ground) characteristics of a faulted or unfaulted loop accurately from the central office end with the telephone on hook. The real issues were operations, human-machine interfaces, and economics. The following sections provide a more detailed discussion of these issues.

1.1.1 Operations

The RSB is the nerve center for all loop maintenance and is busiest during a crisis (e.g., flood, fire, hurricane damage). A mechanized system must be sized for the so-called peak busy hour, but seldom can we afford to size it for the "once-every-few-years" crisis. However, the design of the total system must be such that it does not "choke" at some point causing processing capability to decrease beyond some load point. There also has to be some backup procedure when computers or data lines fail. The mechanization should make the average position or work station more efficient without making it boring. Care should be taken not to mechanize that which can be done better manually. For example, a decision was made with respect to the Basic Output

Report (BOR) (a computer printout to be described later) to pass it manually from work-station-to-work-station rather than retrieve it from a computer terminal each time.

1.1.2 Human-Machine Interface

In addition to the obvious human factors problems related to screen content, mask design I/O transactions, etc., there was the retraining problem for the people who had operated in the manual environment. The human mind allows tremendous flexibility. It enables us to change jobs in midstream and to be amazingly tolerant of errors because of our ability to grasp context and also remember valid sets of information. For a system to be accepted, it should not accept "foolish" data, provide impossible outputs, or take too long between input and output.

1.1.3 Economics

The only way computers can lead to net savings in the repair process is to reduce the size of the work force. Reducing, even by 80 percent, the load on a one-person work force is meaningless if that one person must remain to perform 20 percent of the original task.

Therefore, economics studies were aimed at identifying areas where mechanization would reduce the number of people in a particular work force. Specifically, it was anticipated that a work force of, for example, 7 testers could be reduced by 2 or more, and a work force of 8 repair answering clerks could be reduced by 4. The savings in labor associated with repair answering clerks results from the consolidation of many small work forces into a larger centralized one and the elimination of the manual line record file.

1.2 Opportunities for upkeep expense savings

To quantify the potential opportunity for ARSB benefits, certain expenses were identified as being prime candidates for significant reductions. Included were the RSB testing and clerical expenses, plus potentially unnecessary dispatch expenses. The RSB clerical expenses included taking trouble reports, maintaining the manual line record card file, and dispatching repair craft. It appeared that the RSB expenses could be significantly reduced by mechanizing the line record files, automating much of the testing function, and streamlining the trouble report flow in the RSB.

Although some repeat reports are unavoidable, it was felt that many repeat reports are a result of not properly repairing the first trouble. A test to quickly verify that a trouble had been repaired before the repair craft left the area was needed to help reduce repeat reports.

Work discontinued is due, in part, to the outside plant repair craft being unable to locate a trouble within a reasonable amount of time and having to redispatch on the same trouble the following day. "Found OK" dispatches are those on which no trouble is found and the dispatch is terminated, resulting in a repeat report and/or wasted repair craft time. To reduce both the work discontinued and found OK dispatches, improved testing was required. Outside plant troubles were frequently dispatched first to station repair craft and then redispatched to cable repair craft because the manual testing methods could not identify the trouble as being in the outside plant. Again, it was felt that improved testing methods, by identifying the approximate location of the trouble, could avoid sending many of these dispatches to the wrong craft.

In summary, almost 20 percent of the total upkeep budget was a prime target for significant reductions because of an RSB mechanization system like ARSB.

II. THE EARLY DAYS—FIRST GENERATION

The manual RSB has just been described. We now focus on the early days of defining requirements for the new mechanized system and the need to understand the manual environment thoroughly; this is the reason for the extensive involvement of systems engineering personnel in RSB operations. This effort, which continues even today, was facilitated by New York Telephone Company's development of an experimental system covering ten thousand lines in its West 73rd Street RSB in 1970–1971. Careful observation of this experiment, as well as long hours within RSBs interviewing and observing personnel at work, led to the early definition of requirements for a system. The principal focus of this work was on the tracking of trouble reports and the mechanization of the customer line card, resulting in the development of a Mechanized Line Records (MLR) system at Bell Laboratories. Also, during this stage of definition and development, it was recognized that much of the environment would be changed significantly by the advent of a mechanized system and that it was difficult, if not impossible, to predict the RSB environment after the change. This realization dictated that a system be deployed as quickly as possible to discover operationally how the people and machines interacted. Thus, MLR was deployed quickly on a centralized processor for New York Telephone to better understand the needs of the bureau and to provide data for planning future development.

In addition to MLR, substantial development effort by Bell Laboratories resulted in the Line Status Verifier (LSV), designed jointly with Western Electric Company. The LSV, which was field-trialed in 1972, was an automatic line verification device applicable to one class of RSB testing problems. The system was especially useful when applied to trouble reports which, when tested shortly after the trouble report was received, gave no indication of trouble (i.e., Test OK). The use of LSV allowed a large percentage of these trouble reports to be closed out during the initial customer contact, resulting in less handling and faster processing of those reports. The mechanized combination of MLR and LSV, as separate stand-alone systems, provided a prototype for the ARSB.

In the processing and clearing of trouble reports, the RSB can be envisioned as consisting of seven basic functional operations. These operations are trouble report taking, screening, testing, dispatching, clearing, closeout, and line record maintenance. The impact of MLR and LSV on these operations will now be described.

2.1 Trouble report taking

Incoming calls from customers were routed by a call distributor to a person available for taking trouble reports. Upon answering a call, the attendant obtained the telephone number and entered this information into MLR using a computer terminal equipped with a cathode-ray tube (CRT). The MLR system responded with a trouble report mask which served as a vehicle for entering the trouble report. The trouble report mask also contained line record data for use by the attendant in interaction with the customer. This information included customer name and address, class of service, and status of pending troubles, as well as historical data covering the last trouble cleared.

While talking with the customer, an LSV test was initiated from a separate LSV console on the customer's loop. The LSV system accessed the customer loop and ran an automated "GO/NO-GO" series of tests. The attendant was notified of the results. If the LSV did not detect a fault on the customer loop, the attendant would so notify the customer and attempt to close out the trouble report. If the customer refused to accept the closeout of the trouble, or if there was a positive indication of a trouble (either by test result or customer description), the attendant negotiated a commitment time with the customer. A suggested time, based on internally stored time intervals given to MLR by RSB managers, was displayed on the CRT. The actual commitment negotiated with the customer was entered into the system. The calculation of the suggested commitment time and intermediate jeopardy times for testing and dispatch was a major improvement over the manual RSB.

2.2 Screening

The purpose of the screening function was to provide a method of distributing trouble reports to the appropriate work stations. The screener routed a BOR* to the appropriate person based on trouble description, LSV test results, and the type of service.

2.3 Testing

Under ARSB with MLR and LSV, the testing function remained relatively unchanged, except for a decrease in the test load at the local test desks. The decrease was due to the detection of some faults and the verification of Test-OK's† by LSV at the time of the customer contact.

2.4 Dispatching

The dispatching function was handled in a variety of ways. In some RSBs, testers of dispatchers with dedicated repair crews were responsible for dispatch of their individual repair people. In other RSBs, there was a group of dispatchers for the entire repair force, usually controlled by a first-level supervisor, who decided which trouble to dispatch next and to which repair person.

This function, too, remained relatively unchanged with MLR and LSV, with the exception of the use of LSV to verify that repairs had been made correctly before the craft left the trouble site.

2.5 Clearing and closeout

With mechanization, the recording clearing and closeout operations changed significantly. These operations involved repair of the trouble, customer notification and concurrence, and entry of final status into the MLR computer. In addition, MLR edited and validated the input and provided significantly more information about the customer's trouble and equipment involved to down stream analysis systems. (Refer to the paper entitled "Automated Repair Service Bureau: The Trouble Report Evaluation and Analysis Tool," appearing in this issue.)

2.6 Line record maintenance

With MLR, line record maintenance work was done manually by clerks with CRTs. This turned out to be a major expense for the Bell Operating Companies (BOCs), and mechanizing the records' update

* The BOR is a report automatically printed out as the result of entering a trouble into the system; it includes line record information, a description of the trouble, and LSV test results. As noted later in this article, the LSV results were eventually replaced by more sophisticated results.

† A "Test-OK" occurs when a trouble is caused by a transient condition that is no longer present when the test is performed. The test indicates that the condition of the loop is satisfactory.

process proved to be a major needed future enhancement as described below.

III. THE EARLY DAYS—SECOND GENERATION

The MLR and LSV systems were developed on short time schedules to solve some of the more pressing RSB problems in urban areas. Experience gained with MLR and LSV dictated changes needed in the operational procedures used with these systems. In addition, experience indicated that a single centralized computer would not handle the projected load economically in a wide variety of operating companies. Hence, the second generation of the system had a distributed architecture. This second system was applied to a second BOC (Southwestern Bell Telephone Company) to determine the generality of operating procedures and the viability of the system.

The need for an automated method of updating and maintaining the data base was recognized, and appropriate software was written to process service order information automatically from the service order systems of the BOCs.

Also, since the number of functions being performed by the system was expanding, MLR became the Loop Maintenance Operation System (LMOS).

To meet the objectives outlined previously, LMOS provides the following:

- Mechanized data base with automatic line record update
- Computerized trouble report processing
- Management and analysis reports on demand
- Mechanized aids for more efficient repair force deployment and more accurate commitment times.

In addition to LMOS, a second-generation automated testing system, the Mechanized Loop Testing (MLT) system, was designed and replaced LSV. The MLT system, unlike LSV, was not designed as a stand-alone system. It was designed as an addition to LMOS, and the two systems, LMOS and MLT, were fully integrated to form the basic ARSB system. As an interim step in the development process, LSV was partially integrated with LMOS to allow tests to be automatically initiated by the entry of a trouble report in LMOS and to provide for the automatic storage of LSV test results on LMOS. However, LSV was still basically a stand-alone system to be replaced by the integrated LMOS/MLT design. The MLT system provides the following:

(*i*) Improved testing of circuits under computer control using an adaptive series of tests, generated in real time, based on the electrical characteristics of the customers equipment in the idle state. (The data are available from LMOS.)

(*ii*) Test data interpretation based on the same customer equipment data.

(*iii*) Simplified test results to the Repair Service Attendant (RSA) as a basis for more Test-OK closeouts while the customer is on line.

(*iv*) Analyzed detailed test results in hard copy as a result of RSA initiated tests with indicated routing.

(*v*) Automated sequential testing of lines or equipment in a list.

3.1 Overview of LMOS

The LMOS is based on the MLR design, but has some significant system improvements that were added as a result of the MLR experience. Thus, LMOS represents an expansion of the MLR concept. For example, LMOS has the capability of automatic service order input that significantly reduces the manual effort for entering changes to the computerized customer line records. The system also has the operational report structure redesigned and expanded to reflect experience gained from the New York field test of MLR and tests of analysis systems in other BOCs.

In addition, several new features were added to LMOS. They allowed more effective management of the repair forces, as well as greater overall efficiency of the repair operation. These enhancements are described in the following paragraphs.

3.2 Major LMOS features

3.2.1 Trouble report and status entry

The trouble report and status entry feature was retained from MLR to provide fast and effective tracking of each trouble report through all intermediate statuses. In addition, the feature provides a major input to operational and administrative reports.

3.2.2 Bureau personnel and repair force administration

Bureau personnel and repair force administration is a new feature. It is a management tool for assessing, on a minute-by-minute basis, the utilization of bureau personnel, as well as outside repair forces.

The trouble report status feature and the mechanization of line records, combined, provide a capability that allows dispatching of trouble reports by any person using LMOS. The utilization of RSB personnel is increased, while MLT reduces tester/dispatcher requirements.

3.2.3 Dynamic bureau operational reports

The operational report structure of LMOS provides two types of reports: on-line bureau operational reports and the trouble report and data base analysis reports. The on-line bureau operational reports are structured to predict and identify bottlenecks and problem areas in repair force operation and are based, in part, on the on-line report structure of MLR. An example of the use of this type of report is the detection of personnel work overloads in the functional areas of screening, testing, and dispatching.

3.2.4 Trouble report and data base analysis reports

These reports involve the statistical analysis of the repair operation for periods of from 1 to 40 days and are available on demand. Included are reports associated with employee work summaries, Customer Trouble Report Analysis Plan (CTRAP) output data, cable and originating equipment analysis reports, and the mechanization of the manual Repair Force Management (RFM) program. These reports will, for example, aid in pinpointing particular parts of the switching machine or particular work groups that need attention.

3.2.5 Line record administration

Storage of line records and recent trouble histories in the computer alleviate the problems of losing line cards, inaccuracy of records, and excessive clerical posting effort.

Automatic update of the line records from existing BOC service order networks resulted in significant clerical savings associated with line record upkeep. After initial conversion of line records, the only clerical forces required were those necessary to resolve conflicts between the BOC service order network and LMOS.

3.3 Mechanized Loop Testing (MLT) overview

The MLT system provides complete and accurate single-ended three terminal measurement parameters at dc and 24 Hz, which are analyzed by an adaptive test algorithm that is generated in real time. The selection of the tests to be performed and the analysis of the results are both based on data relating to the service and equipment of the particular customer's line being tested. These data are provided by LMOS. Two outputs are provided: one in text that tells the clerk, during the customer contact, if the line is good, faulted, or in use; the other output provides the values measured and the results of the analysis, e.g., one side open 18,400 ft from central office, etc. This analysis is enhanced by the on-line availability of records that provide data on the subscriber's service and equipment. The MLT system is also used for testing prior to dispatching a craft person, to verify that a fault is still present, and for post-dispatch testing to verify that a line fault has been corrected.

3.4 *Mechanized Loop Testing (MLT)* features

The MLT system provides expanded capability (beyond LSV) for verification of troubles on initial customer contact. The basic tests include the following:

(*i*) Hazardous EMF Check

(*ii*) Improved Busy Tests (including electronic speech detection and receiver-off-hook detection)

(*iii*) AC FEMF Measurement (each side-to-ground)

(*iv*) DC Leakage and FEMF Measurement (3 terminal)

(*v*) Longitudinal Balance Measurement

(*vi*) Termination Test (3 terminal)

(*vii*) "Open" Test

(*viii*) Ringer Counting

(*ix*) Rotary Dial Measurements

(*x*) Draw and Break Dial Tone (noncrossbar office).*

Comparison of measured analog values to thesholds occurs in the computer and allows Go/No-Go type results to be returned to the bureau attendant, while still in contact with the customer. Analog data are also retained for use by screeners and other bureau personnel as required.

3.5 *Operational strategy—ARSB*

With the advent of LMOS and MLT, the RSB was again significantly impacted. The operational strategy of this second-generation RSB will now be described.

The principal work functions of LMOS and MLT are associated with RSAs (who receive incoming trouble reports), the MLT tester (a screener/analyzer who may request additional automated tests), the regular tester (who performs interactive manual testing with craft personnel using a manual test desk and who also can access MLT for automated testing), and the dispatch controllers (who coordinate and manage the outside plant craft).

A simplified work flow diagram is shown in Fig. 1. The RSA, upon receiving the trouble report call, enters the telephone number of the reported line into LMOS via an interactive CRT. The LMOS responds with a display containing selected line record information, such as name, service address, and location, to the RSA. The RSA can then verify this information with the customer. If a previous trouble report is pending, then this information is also displayed to the RSA, so that the status of the pending report can be discussed with the customer.

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* These two checks are not made during the initial contact, or on every reported trouble.

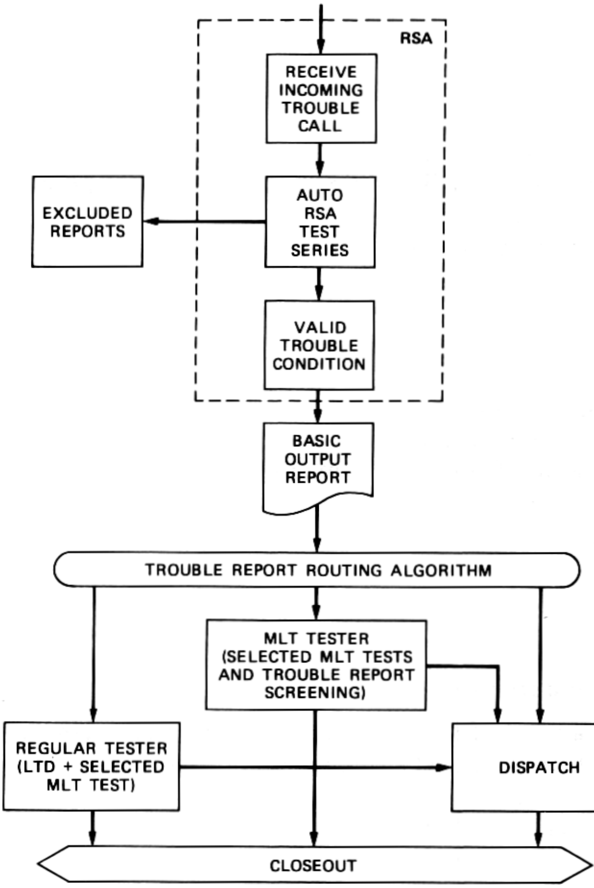

Fig. 1—Bureau work flow for ARSB (LMOS/MLT).

The RSA enters the trouble information (or any additional information for subsequent reports) gathered from the customer onto the CRT screen.

When the telephone number for a reported trouble is entered into the system, LMOS transmits the data required for testing to MLT and causes a test series to be initiated. This test series is performed concurrently with the RSA entering the trouble information (as described in the preceding paragraph). The results of the tests are displayed on the CRT, in a simplified format, while the RSA is still in contact with the customer. If the customer is calling from the same line on which they are reporting trouble, MLT will detect that the line is in use and display this result to the RSA. A test series, if required, can then be requested after the customer hangs up.

The RSA can use the test results to attempt a closeout of the trouble with the customer (in the case of a "Test-OK" or Receiver-Off-Hook") or negotiate a short commitment (for trouble in the central office) or an appointment time (for troubles outside the central office) with the customer.

At this point, the RSA transmits the gathered data to LMOS, and LMOS responds with a CRT-formatted mask for the entry of the next trouble report.

Thus, the MLT test results, coupled with the line record data, assist in resolving certain reported troubles directly without further processing. Those reports which cannot be excluded* by the RSA are entered into the system, and a hard copy BOR† is sent to the responsible RSB.

Certain additional tests may be automatically suggested by the system when the initial RSA test result is returned, and such a suggestion is identified on the BOR. For example, a trouble may need testing with an MDF test clip.‡

Based on the results of the RSA test, the screener routes the BOR to the appropriate position. Troubles for which the test results clearly indicate the need for a station or central office dispatch are routed directly to dispatch controllers. Some trouble reports, involving facilities not testable by MLT, are routed to the regular tester at the local test desk (LTD). The objective is to route as many BORs as possible directly to the next probable function to be performed.

The MLT tester is responsible for coordinating the inside forces (i.e., central office and frame personnel) and, when necessary, passing the BOR to the regular tester or dispatch controller. To perform this function, the MLT tester may request retests (supplementary tests not made in the series automatically initiated when the RSA enters a trouble report into the system), tests covering groups of telephone numbers, cable pairs, or central office equipment, or retests to be performed over a period of time. These test capabilities provide a level of precision and thoroughness not available from the manual test desk. In addition, a number of LMOS equipment inventory and analysis reports are available to help RSB personnel localize troubles or analyze recurring troubles.

There are normally only a small number of troubles that cannot be resolved completely by MLT tests and, therefore, go to the regular tester. However, the regular tester has access to all MLT tests, as well as the LTD. The regular tester is responsible for lines that require line

* The RSB is allowed to exclude certain types of trouble reports, such as a report on a service that has been suspended for nonpayment.

† The BOR contains all of the available line record, trouble history, trouble report, and test result information for the reported line.

‡ An MDF test clip is used when tests requiring the switch and other central office equipment to be "bypassed" are performed.

conditioning prior to test application (e.g., on four-party lines with full selective ringing using three element gas tubes) and tests of other troubles that require interaction with other craft or the customer. The regular tester can coordinate the inside forces or give the trouble to the dispatch controller for outside troubles.

A cable tester/dispatcher (in the RSB or elsewhere) has access to the MLT tests and the LMOS data base to assist in cable trouble repair. The input of known cable failure data will allow new trouble reports within a cable failure to be automatically identified so that only minimal processing will be required in the RSB. Automatic tests covering groups of cable pairs will assist the cable tester/dispatcher in identifying the range of a suspected cable failure.

At each stage of the flow of a trouble report through the RSB—say, from MLT tester to regular tester to dispatcher—a report status should be entered into LMOS. The status information includes the employee code of the person doing the work, "work done" (e.g., tested), intermediate status (e.g., pending dispatch), routing information (i.e., next employee code), and test results (if any). This information allows anyone looking at the trouble report to determine exactly which functions have been performed and what the status is. It also allows the RSA to give accurate information on the status of the trouble to a customer calling in with a subsequent report.

As a final status, the report can be closed out from any position in the RSB when the trouble has been cleared or resolved. At this point, the trouble report and its related data become part of the trouble history for the appropriate RSB.

IV. INTRODUCTORY STRATEGY

The expectation, now essentially on target (see Figs. 2 and 3), was that LMOS would penetrate 100 percent of all Bell System lines and MLT, 80 percent. The objective was to penetrate as rapidly as possible. However, from the formation of a BOC study team, through planning, funding, procurement, data conversion, and cutover of the first bureau, would have required a minimum of three years. Therefore, a major cooperative effort of AT&T, Bell Laboratories, Western Electric Company, and the BOCs was launched. This effort involved the following:

(*i*) A joint steering committee, which included representatives of the early users, with enough authority to make the decisions required to clear road blocks and balance timeliness with feature enhancements.

(*ii*) Economic planning guidelines to help BOCs prepare estimates for approval.

(*iii*) Telephone company timetable guidelines for detailed planning, installation, data base conversion and a cutover schedule.

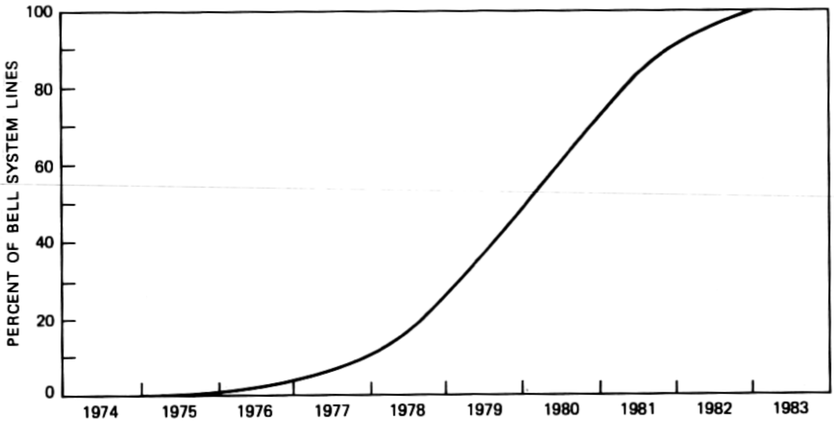

Fig. 2—Bell System implementation of LMOS (year-end 1980 estimate).

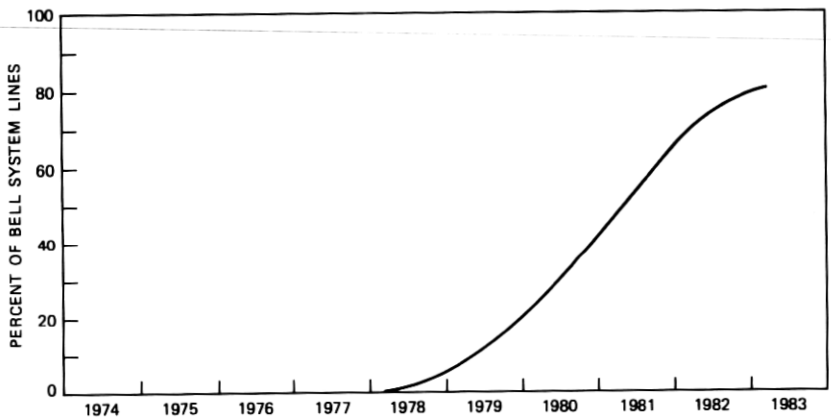

Fig. 3—Bell System implementation of MLTS (year-end 1980 estimate).

(*iv*) Telephone company letters of intent and joint AT&T/Western Electric scheduling of installations.

(*v*) A Western Electric planning and installation team to support the BOCS.

(*vi*) A Bell Laboratories "shock troop" to move in when tough problems were encountered.

(*vii*) A formal system change request process and committee to establish priorities for telephone company requests to tune the system to the user needs. (At one time these requests were being processed at the rate of one every other day, and 80 percent of the continuing development effort was involved.)

(*viii*) Operational reviews to ensure that the potential savings were being realized.

The net result was an overwhelming acceptance by the BOCs and the rapid introduction shown in Figs. 2 and 3. At one time, two million lines were being converted each month and, at another, one MLT frame was being installed every working day.

V. Continuing evolution

The ARSB is continuing to evolve. Some of the major changes, both completed and partially underway, since the development of the integrated LMOS/MLT system, are as follows:

- A context-sensitive data switch which facilitates large-scale centralization of the repair answering function.
- A Loop Cable Administration and Maintenance Operations System (LCAMOS), integrated with LMOS/MLT, which provides for the prediction, tracking, and analysis of cable troubles.
- A new generation of Mechanized Loop Testing System (MLT-2) designed to be cost-effective for very small population centers and functionally expanded to allow for the elimination of the need for local test desks.

The remaining papers in this special issue of *The Bell System Technical Journal* provide more detailed information on the design, implementation, operation, and evaluation of the ARSB and give descriptions of the improvements outlined above, as well as others.