TRIDENT—A new maintenance weapon

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Everyone is familiar with maintenance. It is a necessary requirement for almost everything we have, from spacecraft and automobiles, to the heels on your shoes. The maintenance that this paper is concerned with is that of business machines and their associated products. These devices are the means to the end required for your business and other endeavors.

Business machine maintenance in the recent decade has become more and more important to the user, the manufacturer, and of course the maintainer. For example, this is a paper on business machine maintenance. A few years ago this subject would have had a difficult time even being a sub-topic during your coffee break. Another example is the IBM facility in Raleigh, N.C. which treats maintenance as a technology in itself.

In spite of this new found attention, business machine maintenance is little different in principle than any other maintenance service. There are two principal factors affecting the maintenance task. The first, and the most familiar one is that of the product to be maintained. Product maintenance requirements are based on what the device is, how hard we use it, how much we pay for it, how well we treat it, what it is made of, who made it, etc. This is the maintenance factor that is intrinsic to the product itself. Certainly, the service component of the product has been with it from its earliest design days. Within IBM, this principle of service is very well covered by the maintenance function being involved early in the product development cycle. Examples of this type of maintenance planning are familiar to you in the form of service aids such as the flight engineer's console on a commercial jet liner, the oil pressure light on your automobile, or the stop on error switch on various components of your business machine.

The other key factor of service is the maintenance delivery system. This is a facet of service that is always present but very rarely discussed. When examined closely, this principle of service shows that maintenance is also a classical study in logistics. Whether discussing the spacecraft or the business machine, the problem is getting the right man to the right place, with the right data and the right part, at the right time. There are five "rights" to that preceding equation and all of them must fit "right on" for a successful maintenance task.

In the last ten years, things have been changing. Up until then, three of the "rights" were variable and two of them were fixed. For example, the three variable "rights" were and still are, the right man, the right data and the right part. The fixed "rights" were the right place and the right time.

The equipment user of the past always knew where the right place was. This has changed. In the complex teleprocessing systems of today, how often can anyone pick the right place on the first try?

The equipment user of the past always knew the right time. It probably was immediately because he could not use it. In the system of today, the user must now decide, if it is immediately. It could be immediately and someone fixes the machine while the user also runs it. It could be immediately if someone diagnoses the problem while the user runs it and it is fixed later. Or it may be the equipment problem will be diagnosed and fixed at a time that will be convenient for all concerned.

Thus, the logistics problem is not a simple one. It is not only very complex, but constantly growing in complexity. Not only is the complexity of the logistics problem significant, but so is the magnitude. The number of times this logistic system is exercised is quite impressive. The magnitude must be expressed in gee whiz numbers like, "It is my estimate that the maintenance logistics systems used to support the business machine industry in the United States is put to the test in excess of one million times per month, and that is probably being conservative".

The effectiveness of this logistic system in delivering the goods is also clearly recognized because, "Most of
the time all of the previously identified five rights are done correctly." However, most of the time is no longer enough and "always," while it may never be, is certainly a rightful quest. It is only when the maintenance logistic system fails to deliver its first level of support that anyone acknowledges its existence and usually only then to condemn it. It must be repeated that a logistics system involves not only the maintainer, but the user. Remember, "where" and "when" are now variables.

There has always been a backup or second level support to the first level support system; it has many identities. However, it is familiar to most as "the specialist," the "factory man," or the "the guy coming in from out of town." In any case, at IBM this backup is part of an even more complex maintenance logistics system, because:

- There are fewer second level support people and they are more widely distributed.
- Second level support people face more difficult travel problems since they must go longer distances on unplanned activities.
- The second level support person may already be on another assignment and it would be difficult, if not impossible, to arrange an alternate support path.
- It is difficult if not impossible to have the second level support person bring with him extra data or information that he has collected at his home base.
- The time of day and the day of the week have a great bearing on how quickly and efficiently second level support can be brought to bear.

While these second level support problems are being resolved, the original problem has changed from the average or typical maintenance call to a long call. Second level support has a very high efficiency level. It can be said that "Most of the specialists fix most of the calls most of the time." This sequence can be repeated one or two more times depending on the problem and the service organization. However, each iteration and each sequence adds additional length to the call, especially as seen by the user.

The objective of any service organization is to collapse calls in the shortest possible time. This objective becomes a delicate balance between the maintenance characteristics of the unit and the maintenance logistics system of the service function. With new products, this balance must be reached as soon as possible. To do this, some of the items to be considered are the rate of a specialists learning curve, the initial distribution of the product, quality of the pre-shipment qualification, the initial stocking of the parts logistics system, engineering and sales change activity, and the complexity of operating system support.

There are solutions to the second level logistics problem. The easiest, of course, is to have all of the first level support be specialists. This is like saying, in music, that we need all composers instead of some composers and lots of arrangers. Maintenance does not require a composer or specialist all of the time, but when it needs one, the need is immediate.

The potential value added to a service organization by specialists is very great, and must be well controlled or the resource is wasted. Popular notion is that if a specialist could take or assist on every call, there would be a tremendous reduction in the length of calls. This just is not so. As stated before, during the first level of support, most of the men fix most of the calls most of the time. There is no value added by a specialist if the on-site maintenance package has already isolated the problem to a Field Replaceable Unit. There is no value added by the specialist if the tape drive motor is burned out and the only decision that can be made is to replace it.

The specialist must be used only on those calls where he can make use of his ability. The expense of a second and third support level is great and the service function must always balance the need against the cost. Otherwise, too much support exists when not needed, or not enough support when needed.

So, the proposition, which was to use only specialists, was not really a good answer. What seems a better answer is to build a logistics system that not only insures the right part is available, but that the right specialist and the right data is available at the right time. This new logistics system must function to the same or higher degree of accuracy than that which is built into a parts system. Parts logistics systems have been with us for some time; human and data logistics systems are something else.

One thing is for sure. One system is tough to control, two are mightily difficult, three may be nearly impossible. There is a great deal to look at when attempting to define such a complex system. However, as in any such effort, some part of the system will be completely new, but most of it will be built on previous experiences or facilities.

As a normal first step in system design, there must be a name for the system. For the purpose of this paper, the name "TRIDENT" was chosen. Since there are three major sections to this system, it seemed fair to name it after the three-pronged spear of Neptune, God of the Sea. Since "TRIDENT" must also be an acronym for something, let's say it stands for TRImple DEfender of New Technologies.
In building “TRIDENT,” we can use existing parts logistics techniques. The other two delivery systems related to specialists and data are going to be the tough ones. The next easiest system to build seems to be the data system. However, very little is known about technical data. For example, what is its life cycle? More important, what is its half life cycle by user? What are the different index requirements required by the developer and the maintainer? How can one identify which data “must know” versus “nice to know.”

The thing to do is get started and create a data system that will not only produce results, but will also provide the experience base and information necessary to complete the second step of “TRIDENT.” In building this part of the system there is another “given” parameter that can be used. The first level support team does fix most of the problems most of the time with data that are already on site. The new logistics system will not try to replace this data, but will attempt to supplement it when necessary.

The goal, then, is to be able to deliver data when the first level of support needs it. Initially, to whom is it given? Enough is known about the distribution problems of data to decide to deliver it to those who will always be involved on the tough calls—the second level support team. In this way, early costs are reduced while getting the best level of return on investment. To send the data out to everyone is of great cost, especially when not all can make use of it, therefore, give it only to those few who have a great need.

What does this data look like? Most of it starts as precautionary or preventive information. It says, “Warning, safety change. Make the following modifications immediately.” Another message may be, “Do not put this engineering change on machine Type A with Feature X unless you do the following.” Or, “If you experience intermittent problems on Function J, check the following items.” And even, “We are having trouble keeping Item Q from wearing. If you have this problem, call XYZ immediately.”

There will be a lot of this type of information, therefore, good abstracting techniques will help reduce user reading time. This enables the user to read the text only if the abstracts interest him. Deliver the data daily to the users home base, also classify it in some way so that he has only to look at data concerned with his specialty. This creates a well informed specialist who has a good idea of the national picture of his product. You have boosted the learning curve by exposing maintenance personnel to the national picture of problems on his machine or specialty.

Now, the second level support man is getting armed on a daily basis with new information. He is better able to render on-site assistance. At least, he has a pretty good idea if someone else has either solved the problem or is already working on the solution to it. But there is still a difficulty here. When dispatching a specialist to an on-site call, he is moved away from his new found data base. He is now running on memory again. Agreed, this is better than it was before, but maybe there is also an even better way.

It does not take long to find out what is really wanted for a second level support technical data base. Output is wanted on a graphics device, with hard copy as an alternative. The user must be able to scan read large quantities of data to find what is wanted. All of the data scanned must relate to the problem. Also, the data that can solve a problem may be found under many headings in many different places. It may also be hidden in the text of data that is not even indexed under the required specialty or machine type. The technical data base must be searched not only by title and abstract, but also it must be searchable by each word in the text. The search must be fast. Certainly the search to identify what items must be reviewed should be consistently done in under ten seconds. Also, the stepping or paging through of the data while scan reading is in process must certainly consistently be achieved in under three or four seconds.

Another item that will set our TRIDENT design is the advantage of keeping the data base with the specialist. There are two ways to do this. One is to insure availability of graphics devices having access to the data base wherever the specialist is. The other is to keep the specialist and his data base access device fixed and move the difficult calls to him.

Neither alternative is easy to do but the second has the most going for it. If the call can be moved to a specialist, a major part of the third logistics problem is solved. Concentrations of second level support personnel can now be made. Skill backup and total coverage around the clock can be provided. Second level travel time can now be used for problem solving time, thereby increasing specialist efficiency. A problem solving environment can be maintained at all times. Also, all of this can be done without making any major technology breakthrough.

A call can be moved to a specialist in two ways. The most familiar is by voice connection. This one makes excellent use of the specialist’s experience and his second level support data base. The first level of support man can identify the problem. The verbal exchange will soon identify a search argument for the data base. Answers will be developed and hopefully a high hit rate of problem solving capability will be achieved.

If the voice sequence fails, there is one more way of
moving the call to the second level of support. That is via a teleprocessing connection between the equipment experiencing the problem and the second level support location. But this is not applicable to all types of equipment. Initially, where is a good starting point? The best place is with teleprocessing devices that can use the switched telephone network. Where else? Certainly, switched network teleprocessing capability can be added to other business machine equipment so that it can be manipulated by a specialist from a remote location. Some of the considerations that go into the selection of the devices that will have this new type of support are as follows:

- One connection must allow access to more than one unit or system to reduce cost.
- The device that has this connection must be capable of running an on-site maintenance package, even while the equipment that it is running on, is malfunctioning.
- The connection must be able to operate in any one of the maintenance environments selected by the user—concurrent, or dedicated. It must also offer significant growth advantages for new uses to insure it can make use of new applications without major new costs.

The choice is not too difficult, based on the following reasoning:

- The connection should be to a central processor so that more than one device can be supported by the single connection.
- The connection should be capable of connecting to multiple processors if they are in a single location.
- The connection should be to a large enough processor so that a sophisticated on-site maintenance package can be used.
- The connection should be into processor complexes that offer both maintenance environments.
- The connection should be into processor complexes that will offer new applications growth.

In summarizing all of these items, what is really desired is to connect into computer based systems that will insure long term usage.

Having completed the general design parameters of the third prong on our "TRIDENT" project, it is known that it will not be 100 percent effective in solving the second level personnel logistics problem. Dispatching men to the problem site to resolve some of the tough ones is still needed but every experience both good and bad will be valuable. As was pointed out in the beginning of the paper there are two principal factors to maintenance, the intrinsic maintenance factor and the logistics factor. The business machine can be maintained without a "TRIDENT" system. The mission of the "TRIDENT" system is to increase the effectiveness of the maintenance delivery system and reduce the length of the call as seen by the business machine user.

IBM has a "TRIDENT" in place today. In the Field Engineering Division of IBM it is known as the Parts Inventory Management System, the Field Support System, and a Remote Maintenance Support System made up of the Teleprocessing Test Center and RETAIN/370.

The Field Engineering Division's Parts Inventory Management System (PIMS) is based in IBM's Distribution Center in Mechanicsburg, Pennsylvania. PIMS uses a System/360 Model 65 teleprocessing system to maintain both the parts flow and the administrative data required to insure a highly effective maintenance parts posture. This system makes use of the IBM corporate teleprocessing network as its prime branch office communications path.

The Field Engineering Division's Field Support System (FSS) operates out of the Division's Management Information System Center in Sterling Forest, New York. FSS uses a System/360 Model 75 connected to hard copy terminals located in Division Headquarters in White Plains, New York and in branch offices and plant sites. FSS hosts two major applications. The first is a technical information distribution system. This is the application that keeps field specialists aware, on a daily basis, of the latest technical information in his area of expertise. The technical information is provided in both abstract and text form. After reviewing technical abstracts the specialist can retrieve full text information as required.

The second application on the Field Support System is called the Field Instruction System (Figure 1). FIS is a coast-to-coast computer-based instruction system that provides self-study training for IBM customer engineers with the Field Engineering Division, which installs and services information handling systems and equipment.

The availability of computer-assisted instruction in every branch office has two benefits:

- It reduces the time that customer engineers otherwise would have to spend away from their office while training at an education center, thereby increasing the availability of key resources at the point of application.
- And consequently reduces the cost of education while achieving the course objectives.
The branching capability and storage capacity of the system permit the student to:

- Master a new topic at a personalized pace.
- Skip over topics already mastered through experience or previous training.
- Receive help upon request from sequences prepared to clarify difficult points in the course.
- Test his new knowledge.

The student's interaction with the system and its flexibility in meeting different student needs increases his acceptance of this form of training, and prepares him to perform his service skills effectively.

Today, as one customer engineer studies through the Field Instruction System, he will be sharing the computer with classmates from Maine to California. The other students could be studying the same course or any of the other courses stored in the computer.

The courses, as written and programmed into the computer, simulate the interaction which might take place in a conventional classroom between a student and his instructors, and supplement education activities at the division's education centers throughout the nation.

IBM customer engineers have immediate access to a remote source of maintenance information called RETAIN/370, (Remote Technical Assistance and Information Network/370) which combines technical support with comprehensive computer files of maintenance information. It helps minimize the duration of interruptions to customer operations due to problems with IBM equipment or programming. It saves time by reducing the need for specialists to travel to the customer site, and by enabling customer engineers to quickly obtain information on a wide variety of problems and solutions.

RETAIN/370 is used by the IBM customer engineer when a problem cannot be defined or resolved with on-site diagnostic techniques within a short period of time (Figure 2). To access RETAIN/370, the customer engineer contacts his technical support center via the dial-up network and describes the problem. The specialist then searches the data base for fixes that relate to similar problems, or together, the customer engineer and the specialist may use the data link to run maintenance programs. The output can be dis-
An IBM service specialist at a strategically located Field Technical Support Center uses RETAIN/370 (Remote Technical Assistance and Information Network/370), a teleprocessing network, and the power of a computer in Raleigh, N.C., to diagnose malfunctions remotely. The specialist, working with the customer engineer at a customer location, can search a data base for solutions, or together, the customer engineer and the specialist may use a data link to run maintenance programs. The output can be displayed both on the customer's System/370 and on the specialist's display terminal.

The specialist in a Field Technical Support Center is equipped with a display terminal, a printer, a data phone and a microfiche viewer, all of which provide rapid access to maintenance information. The support centers are also equipped with machine log diagrams and reference manuals, program listings and other normal maintenance publications.

The third major component of the system is the RETAIN/370 Center in Raleigh, North Carolina. It utilizes a System/360 Model 65 with teleprocessing links to Field Technical Support Centers as well as to Domestic IBM laboratory sites. A centralized data base and a data link are the heart of RETAIN/370.

Included in the data base are such standard service aids as:

- An index to service publications covering theory of operation and maintenance manuals.
- An Engineering Change Announcement index.
- An index of service aids providing reference to microfiche text and service aid abstracts.
- An index to programming documentation.

The data base also contains special information files, such as:

- Symptom/Fix file, a temporary data storage built from experience data provided by customer engineers, and support personnel.
- Incident Log, a running log of statistical and technical information developed during the resolution of problems.
- Specialist Log, used by each specialist for notes of technical interest.

RETAIN/370 provides two data searching and retrieval methods: one interpretive, and the other incremental.

The interpretive method is used when the existence or location of specific maintenance information is not known. With this method, the data base can be searched by using a series of key words entered by the specialist from information provided by the customer engineer.

The incremental retrieval method uses progressive index levels, such as the master index, which lists all machines by unit type. When a unit type is entered, a sub-index lists related information categories. A selection from this page produces a list of abstracts on the selected category. When an abstract is selected the full text of the selected record is shown.

The data link feature of RETAIN/370 transmits the results of diagnostic programs operating in the customer's System/370 to the Field Technical Support Center. Then the customer engineer and specialist can...
examine the same information to further diagnose the customer's problem.

After obtaining customer approval to use the data link, the customer engineer uses the 2955 data adapter unit and changes from voice to data mode. The results of the diagnostic programs can be simultaneously reviewed by the customer engineer and the specialist at the Technical Support Center. Where security is a concern, all data transmitted can be stored or printed for customer inspection.

The RETAIN/370 support system is available 24 hours a day, 7 days a week.

IBM customer engineers servicing teleprocessing equipment anywhere in the country can telephone the Teleprocessing Test Center in Raleigh, North Carolina. They use on-line diagnostic tests similar to ones that are available to run in the customer's system to track down difficulties in teleprocessing terminals and other communications equipment. The customer engineer can also confer with a test center specialist.

In operation since October 1969, the center has proved to be a fast, efficient service aid. It provides the customer engineer with remote diagnostic data and verifies IBM teleprocessing equipment operation—usually within minutes—without interrupting the customer's system. In effect the Teleprocessing Test Center is a substitute host system for a teleprocessing terminal.

Using the regular telephone network, the customer engineer calls the test center from the customer's teleprocessing machine (Figure 4). After dialing and signing on with a special number the center's computer runs a general diagnostic test. A specific test tailored to a particular problem also can be requested. The diagnostics test the customer's terminal and control equipment with a series of exercises. The results of the exercises are sent to the customer engineer for his analysis.

If during the testing, the customer engineer needs more information, he can press the "talk" button on the data set and confer with a test center specialist. This action flashes a signal to the display terminal alerting a specialist that assistance is required. From his display terminal, the TP specialist can monitor the diagnostic tests being run by the customer engineer (Figure 5). The experienced specialist can often recognize the difference, for example, between a properly operating terminal and one that isn't, by merely listening to the signal.

Besides handling trouble calls, the test center reduces installation time of new teleprocessing systems. As each machine arrives, the customer engineer can install and check it, whether or not other parts of the system are installed.

A small portable diagnostic device also allows IBM customer engineers to test IBM's teleprocessing equipment that do not normally attach to the switched network.

This portable device, the 1200 Baud Terminal Diagnostic Analyzer and Tester (1200 TDAT) is especially useful to teleprocessing installations using dedicated lines because it makes available the facilities of the
Teleprocessing Test Center. Previously, only teleprocessing installations with access to the telephone dial network could connect to the TP Test Center (Figure 6).

TDAT features an acoustic coupler, tape recorder, and a modem that allows connection through leased, or dedicated telephone lines, from a teleprocessing terminal at one location to another at a remote location.

Besides the acoustic coupler feature, the portable testing instrument can do the following:

- Simulate a data set, another teleprocessing terminal or even a remote central computer by being able to play recorded data into a terminal.
- Monitor a teleprocessing system, and when an error occurs, stop and store data leading up to, and including, the failure for analysis.

By recording data as it is transmitted from or to a terminal, the Terminal Diagnostic Analyzer and Tester in effect verifies transmitted data. The tape recorder also can be used as an exerciser to service a terminal with a malfunction. In this way, a customer's central processing unit need not be tied up exercising the terminal.

IBM has demonstrated that the power of data processing equipment can be successfully applied to solving the logistics problems of maintenance.

In conclusion, it can be stated that IBM, and therefore IBM's customers, have benefited from the Field Engineering Division's endeavors based on two concepts. The first is the concept that maintenance is a technology in and of itself and, therefore, just as with other technologies, is amenable to investment for innovation.

The second item is the concept that successful maintenance involves the effective solution of a total system problem in logistics. By clearly defining the problem, the application of innovative effort is being accomplished in an optimal fashion.