A Technical Description of the AN/TSQ-73 Missile Minder System

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Preface

As a result of the U.S. Army determination that the discrete-component state-of-the-art air defense system was no longer adequate to its Field Army needs, the decision was made to upgrade the system. Subsequently, a contract was awarded to the Data Systems Division of Litton Industries for the rapid development and deployment of an all-micro-electronic air defense system—the AN/TSQ-73, Missile Minder. The U.S. Army's AN/TSQ-73 combines **the latest state-of-the-art technology** with an **advanced maintenance philosophy** first implemented in the AN/GSA-77 Battery Terminal Equipment (BTE). **This combination offers the high reliability, low power, small size, and reduced weight to form the most cost-effective air defense system in the world today.**

This brochure provides a technical description of the AN/TSQ-73 by which Litton intends to initiate exchange of information sufficient to show that this system best fulfills the needs of potential users for a surface-to-air fire distribution unit with the capability to be employed as a command and control center for manned interceptor vectoring or as an air traffic control system.

The AN/TSQ-73 Program is managed for the Army by the Project Manager, Army Tactical Data Systems (ARTADS).

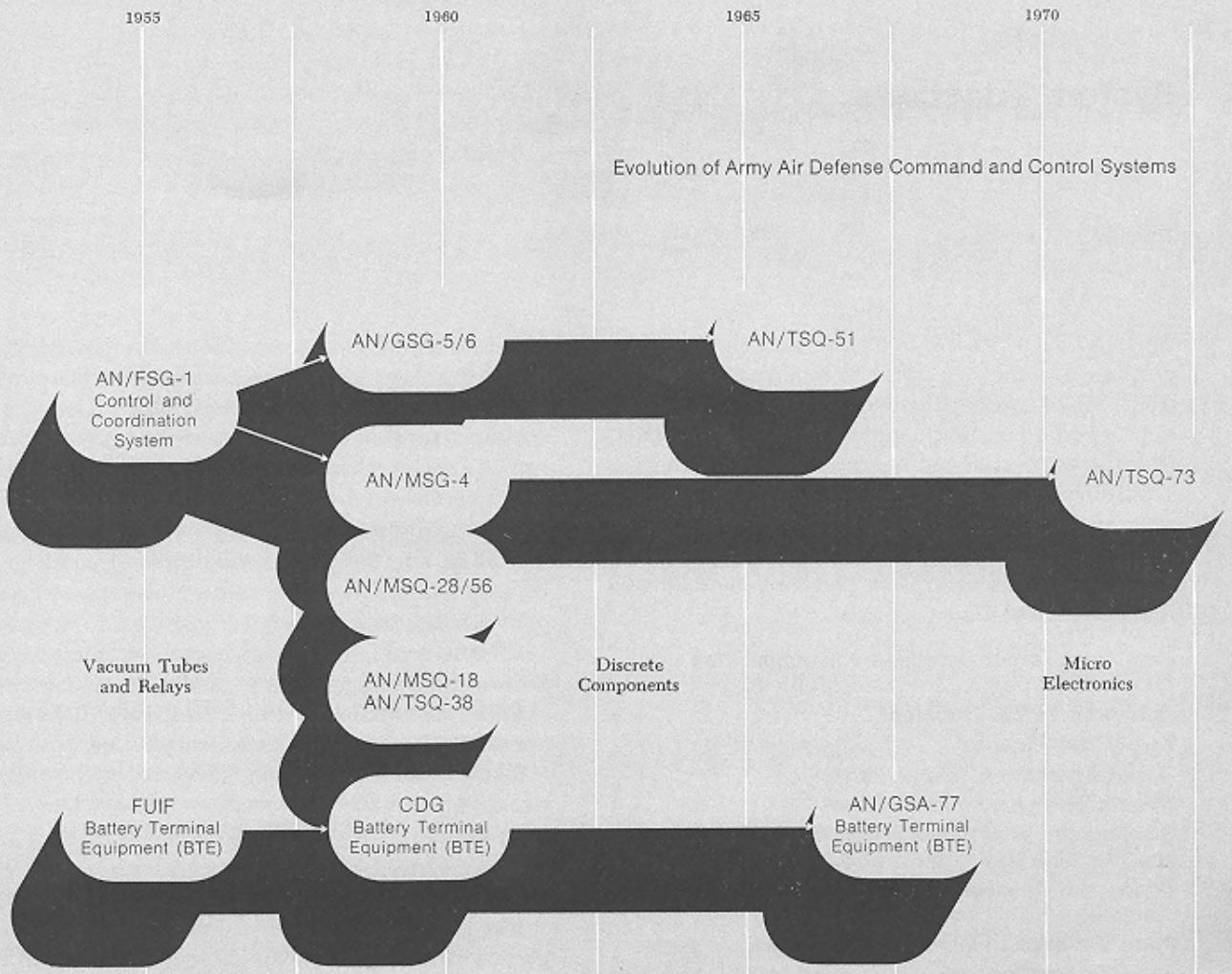
Evolution of the AN/TSQ-73 Missile Minder

In the evolution of aerial warfare, the United States Army was quick to realize that complexity of the air defense problem increases as a direct function of the technological advances of the attacking forces. Thus, increased capabilities of hostile subsonic and supersonic aircraft, increased numbers of these aircraft, and increased use of advanced electronic warfare techniques by the aircraft dictate requirements for corresponding sophistication in systems to counter these threats.

Fortunately, just as the advancing technology has increased the magnitude of the threats, that same technology has provided the means and the capability to meet these threats. As indicated in the illustration, the last 10 years have seen a number of advances in development of air defense control and coordination systems. In 1960, the AN/MSG-4 System represented the state of the art in air defense command and control equipment. By 1965, greater capacity, accuracy, and speeds were represented in the AN/TSQ-51. The greatest advancement, however, occurred in 1966 with the application of microelectronic integrated circuits in equipment such as the AN/GSA-77 Battery Terminal Equipment. In addition to increasing equipment reliability by over an order of magnitude, significant reductions were possible in the size, weight, and power requirements of the equipment.

With the advent of the AN/TSQ-73 still another generation of advances has been made. The application of medium-scale integrated circuitry provides further reliability increases comparable to those attained by use of integrated circuits in place of discrete components. Again, application of this state-of-the-art circuitry advance permits added capability and capacity to be packaged in even smaller, still more reliable units.

In system performance, the AN/TSQ-73 also offers significant improvement over earlier systems. For the first time, the user is provided with a flexible command and control system that can be easily reprogrammed to combine the features of a surface-to-air fire distribution unit, a command and control center for manned interceptor vectoring, or an air traffic control system.



While the AN/TSQ-73 makes maximum use of advanced technology, the system is implemented by use of proven techniques and hardware developed for previous Litton systems. The unique maintainability concept developed for the Battery Terminal Equipment is again used in the AN/TSQ-73 to provide greater system availability and reduced maintenance costs.

System hardware developed for the AN/TSQ-73 also represents repackaged and improved elements employed in other Litton systems. The central element of this new air defense system is a repackaged version of the Litton developed AN/GYK-12 computer. Other system elements such as the display consoles, data terminal modems, and radar interface units all have their origin in proven Litton designs.

The balance of this document details the manner in which the combination of **advanced technology with proven system and hardware techniques** has been applied to **make the AN/TSQ-73 the most advanced army air defense command post yet devised.** The extraordinary **reliability,** the **rapid and simplified maintenance** and the **elimination of extensive special test equipment have contributed to a system availability never before possible. These factors, in addition to the low acquisition cost of the system, make the total cost of ownership of the AN/TSQ-73 over a 10-year period much less than that of its predecessors.**

System Functions

The AN/TSQ-73 basic functions are general purpose, and through software modification the AN/TSQ-73 can be adapted to Air Defense Direction (Missile and Interceptors) and/or Air Traffic Management (civil and military) Command, Control and Coordination Missions. By processing radar data from 2D or 3D radars, the AN/TSQ-73 applied to an Air Defense Mission, e.g. U.S. Army Air Defense Command Post, performs the following functions in real time:

Automatic Target Detection and Acquisition (Track Initiation)*
Automatic Target Tracking*
Target Identification
Threat Assessment (Evaluation)
Weapon Assignment and Control
Displays the Area Situation on CRT's and System and Fire Unit Status on a LED display
Codes and Decodes exchanged data with other systems
Performs Fault Detection and Isolation
Provides Simulation and Recording (ADP controlled)

* Targets may also be manually initiated and tracked.

The AN/TSQ-73 has **more than twice the automatic track handling capacity of the previous generation air defense system.** The high speed logic and advanced track correlation program for track handling and the special built-in features, i.e., clutter mapper, dual quantizer, and target detector prevent track saturation.

The system is organized functionally in the manner of a classic command and control system. A two-channel highly sophisticated radar interface equipment (RIE) processes the sensor data provided by any of a wide variety of local radars and IFF sets and automatically detects, acquires targets, and sends target position reports to the automatic data processor group (ADP).

The ADP establishes a track file and automatically tracks the targets, establishes identification with operator aid, performs threat assessment, assigns weapons, furnishes track data to the display file, and formats messages for assigned weapon fire units and adjacent Air Defense Command Posts.

The ADP also performs fault detection and data recording, decodes, stores and displays incoming messages, and updates the status panel as new information is acquired.

The system automatically manages any identification friend or foe interrogation initiated by the operator. All such returns are presented to the operator. The AN/TSQ-73 System also has beacon decoder for track identification and beacon tracking.

The system simultaneously evaluates, for any of the several designated defended areas or points, the threat posed by unknown or hostile targets. This threat evaluation program automatically evaluates all targets to determine the relative threat level based on criteria preselected by the operator.

Display functions provide the operator with the broadest possible flexibility in terms of capacity: extensive, flexible, easily learned controls for filtering, readability, selection of data, and capability for expansion. The system also **stores and automatically updates various forms of data** on the status of its assigned fire units. It displays all requested data and continually displays weapon status data on the auxiliary readout display as well as on the Light Emitting Diode (LED) electronic status board.

Extensive voice and data communication facilities, interfacing with standard Army field communications equipment permit interchange of data with adjacent and higher echelon systems as well as multiple surface-to-air missile fire units. The data communications permit the use of varied data rates and formats as well as frequency shift keying and differential frequency shift keying modulation techniques.

A simulator, under the control of the automatic data processor, provides preprogrammed synthetic targets, electronic countermeasures jamming, and chaff or previously recorded raid targets for insertion into the radar interface group for total system evaluation and training. With an available data reduction computer program, the recorded raid information can be reduced on site to determine operational readiness and quality.

It is the method of implementation and not the organization that sets the AN/TSQ-73 apart from previous command and control systems. Every subsystem has been designed to provide the flexibility and capacity necessary to immediately respond to the changing threat. **The entire system provides for individual subsystem expansion** without compromising other subsystems. For example, the AN/TSQ-73 can grow from two (2) to eight (8) display consoles by simple connector coupling. Similarly, the automatic data processor can add additional memory without design changes.

By recognizing the advantages and by the judicious use of the 1970's advanced **state-of-the-art technology,** Litton system designers (not just subsystem specialists) have assured the **total system flexibility,** and extensive **component commonality** in the implementation of AN/TSQ-73.

The high reliability of the selected components and functions and the redundancy in critical areas have produced **the most dependable Command and Control System in history.**

The automatic fault detection, semiautomatic fault isolation, few different spares, easy access to all cards and modules, and the "repair by replacement" maintenance concept results in a very low MTTR and a short maintenance training course for the AN/TSQ-73 repairman.

System Elements

The AN/TSQ-73 System is organized on the basis of four functional subsystems of equipment: display; radar interface, automatic data processing, and communications. The widespread use of microelectronic digital circuitry to replace discrete component digital and a number of analog elements has resulted in size, weight, and power reductions that enable the entire system to be housed in a single, highly mobile shelter.

Because of the modular nature of the system equipment, the baseline AN/TSQ-73 can be easily expanded for increased air defense missions or for modified roles and missions without design modifications.

The following pages of this document summarize the equipment elements provided in the system and indicate the functions afforded by this integrated air defense system.

The AN/TSQ-73 System Design Features

- ***Fully Microelectronic System Elements***
- ***Design Based on Proven Hardware***
- ***Real-Time Processing Capabilities***
- ***Air Transportable Shelter***
- ***Automatic Fault Detection and Isolation***

Display Subsystem

The display console provides the primary interface between the operator and the AN/TSQ-73 Control and Coordination System. Two situation display consoles with both PPI and auxiliary readout (ARO) displayed on a single CRT provide the operator with the essential data to make fast accurate decisions based on up-to-the-second displayed information. Adequate console controls allow him to communicate directly with the system for callup or insertion of additional data, for limiting the amount of displayed data, or for modifying existing data.

The display subsystem is the key element in the performance of the following system functions:

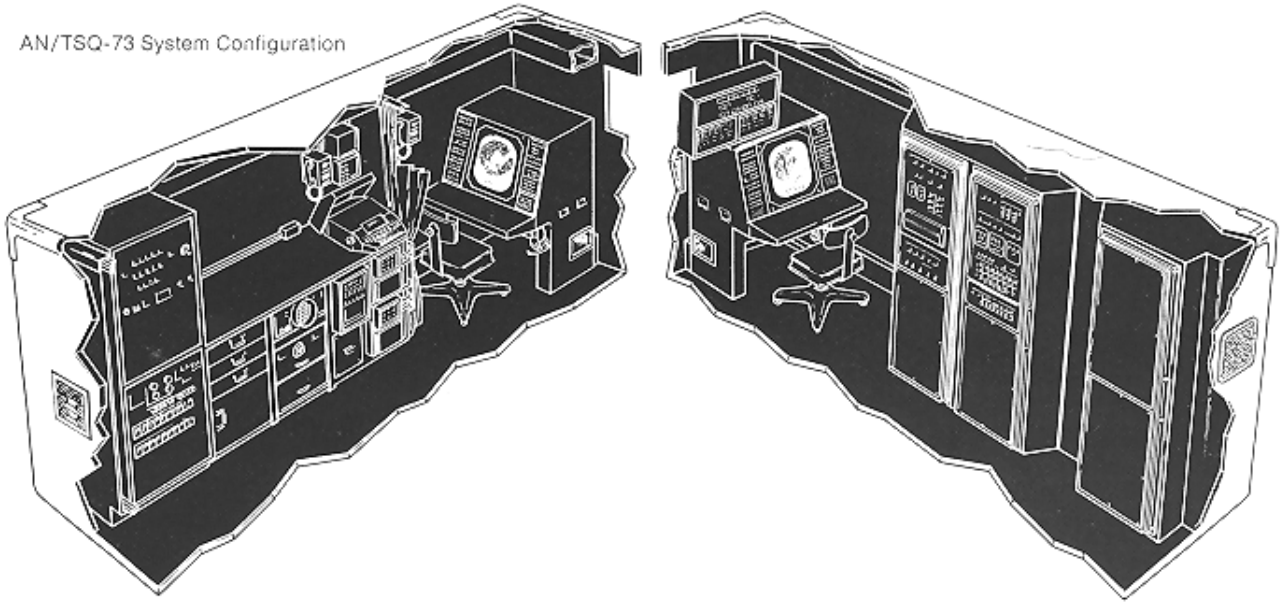
Display of the tactical situation data consisting of radar returns and associated computer generated synthetic symbols, maps, lines, and alphanumeric characters.

Operator participation with the computer in tactical data processing operations.

Computer driven, tabular, alphanumeric status panel.

Auxiliary readout for additional track data.

AN/TSQ-73 System Configuration



As self-contained units, the display consoles operate independently of each other and of the status panels. While only two consoles are presently required, the display group has a built-in growth capability for expansion to as many as eight consoles for increased mission tasks without design modifications. Each console also can be located remotely up to 150 meters from the shelter. Although sophisticated components are used throughout, the display group design provides a rapid means to detect, isolate, and repair faults through use of both built-in on-line fault detection and off-line fault isolation. Ease of repair is facilitated by accessibility of components and test points.

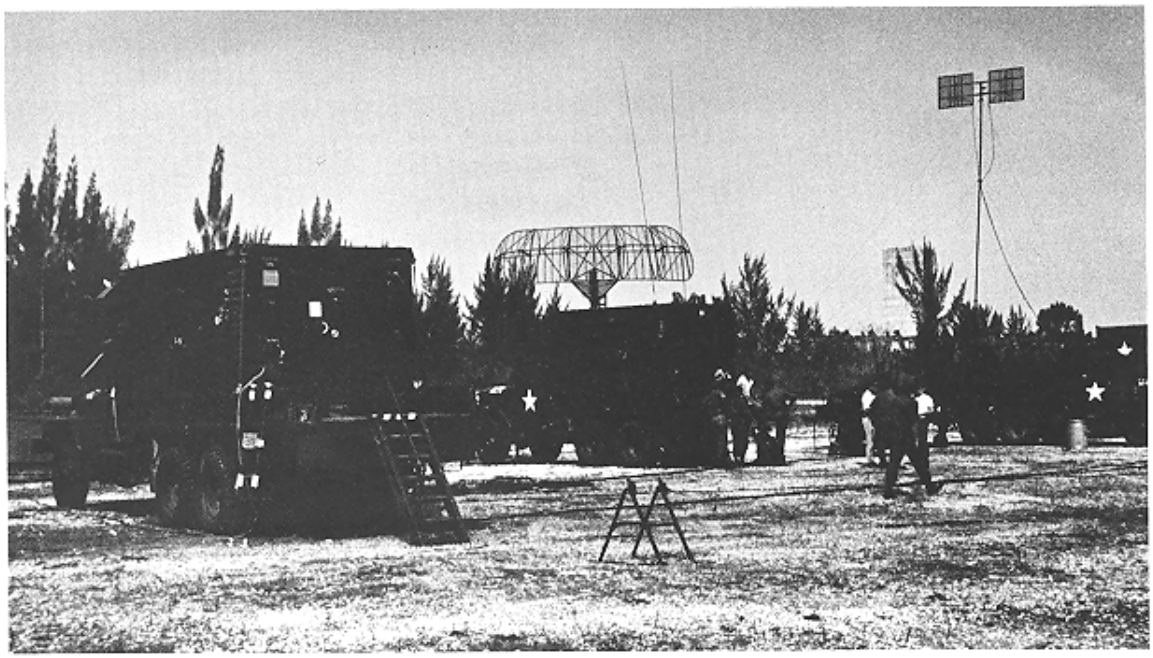
The Litton-designed AN/TSQ-73 display group presents advantages in important design innovations that increase reliability and reduce size, weight, power, and system complexity, all of which enhance combat effectiveness of the system.

The general-purpose display console used in the system is of minimum weight and volume in keeping with the design goal of providing a system in one **air-transportable shelter,** while providing the latest in display technology.

To achieve these goals, Litton has employed a number of design features to provide the following display data:

Track Positions
Weapon Positions
Maps
Jam Strobe
Velocity Vectors
Safe Corridors
Pairing Lines
Defended Areas and Points

The arrangement of the display console controls and CRT optimizes operator effectiveness and minimizes operator training requirements. The general-purpose nature of the console controls takes full advantage of the alterable processor, which can be easily programmed to meet the specific operational requirements of the user.



AN/TSQ-73 Missile Minder System, left foreground, in operation during field tests, integrated with AN/GSS-1 Surveillance Radar and AN/TRC-145 Communications Facility at Homestead Air Force Base, Florida.

System Elements

Operator entry is made by action switches, a full 36-character alphanumeric keyboard, and a force stick for entering position coordinates. Standard display content and quality controls are provided.

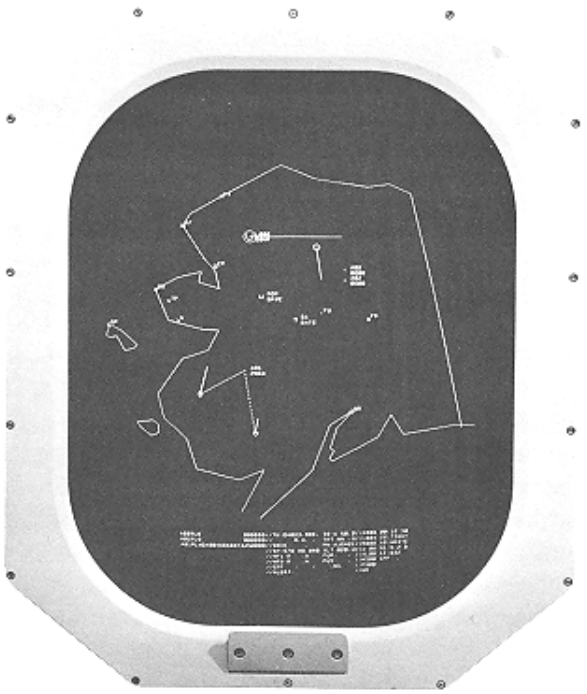
Track symbols displayed include position and identification, track number, raid size, height, velocity, extended vectors, and source code. Two area maps, operator selectable from a list of ten maps, may be displayed simultaneously, with up to three air-defense-safe corridors displayed for friendly aircraft protection.

Defense weapons position and status is also presented for total operational control. The defense weapons information includes site position, engagement positions, site number, status, raid size, commands, and pairing lines.

The auxiliary readout displays computer-generated alphanumeric data that provides more detailed track and fire unit information than can be presented on the situation information display. The auxiliary readout also permits the console operator to edit the displayed data.

Voice communication controls, input, and output are conveniently mounted on the console.

Through the technique of time division multiplexing video and alphanumerics, the console displays data on a rectangular single-gun CRT. The display surface includes a PPI area 14½ inches in diameter, occupying the major portion of the display surface, and a rectangular area 8 inches wide by 2 inches high at the lower edge of the display surface. The situation information display is presented on the circular area and the auxiliary readout display is generated in the lower rectangular area.



Situation Information Display

This technique contributes to lower weight, overall size, and power, and its application is unique to the AN/TSQ-73 display. The principal advantages of utilizing a single-gun cathode ray tube such as this results in:

Higher reliability.

Maintenance simplicity.

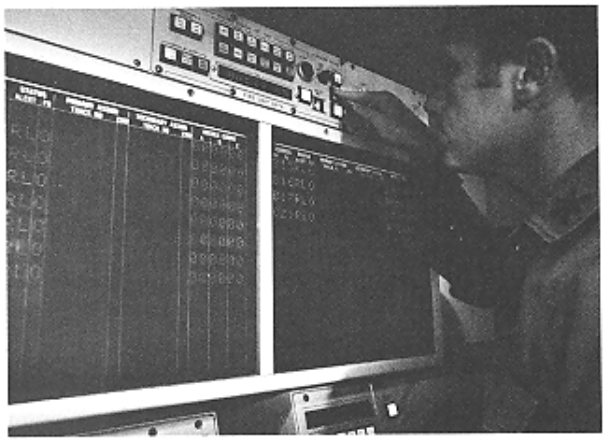
Better display resolution.

Lower cost.

Elimination of registration error of two-gun system.

Uninterrupted video.

Emphasis is placed on safety, reliability, producibility, and compatibility with other AN/TSQ-73 electronic module building blocks. The functional electronic modules are packaged in a console 51 inches high, 33 inches wide, and 29 inches deep. The console weighs 488 pounds and requires only 800 watts of power.



Status Display Panel

The status panel used in the AN/TSQ-73 display subsystem provides an orderly, readable, automatically updated array of fire unit and system operational status data which is visible to all personnel within the shelter. The status information displayed on the panel is:

Fire unit number
Fire unit status
Alert condition
Fire unit track assignment
Missile count
Communicat ons link status
Time of day
System status

The data is automatically updated by the automatic data processor as new data is received to prevent time lags or incorrect data.

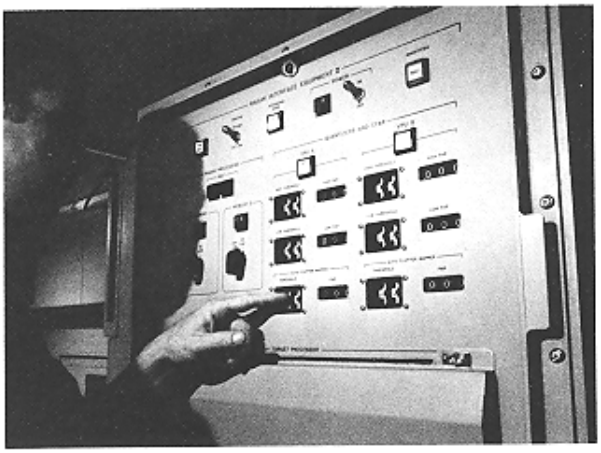
The status panel is made up of two side-by-side arrays of light emitting diode electronic readouts. The diode readouts present a 5 x 7 dot matrix per character with each matrix 0.5 by 0.3 inch, and provide 20-foot-lamberts of illumination. The status panel is approximately 20 inches high, 33 inches wide, 6 inches deep, weighs 105 pounds, and requires approximately 280 watts of power.

Radar Interface Equipment

The radar interface equipment (RIE) provides the system interface with a wide variety of radar types to obtain radar target and sweep position data. It also distributes the various normalized radar data and video target, and internally digitized data throughout the AN/TSQ-73 System. Any one of the following video inputs may be selected by the operator: (1) normal, (2) moving target indicated, and (3) four types of electronic counter countermeasure-fix video. Equipped with an identification friend or foe beacon decoder, the RIE will provide identification friend or foe position and code data.

Features of the RIE include:

Input compatibility with a number of 2 dimensional and 3 dimensional radar types.
Dual channel video processing.
Multilevel quantizing in each video channel.
Clutter mapping.
Target processing.
Fault detection and isolation.
Response to simulated synthetic targets.



Radar Interface Group

System Elements

The AN/TSQ-73 RIE has five distinct but complementing functions. The functions are designed for universal use from standard Litton basic building block hardware:

The shelter demarcation panel and local radar junction box are combined to provide a simple, versatile connection point between the radar sets and the AN/TSQ-73. This combination permits quick cable deployment and connections.

The video distribution unit provides the capability of switching between 6 video signals at a constant level (normalized) to all displays and the video processors.

The radar integration unit contains a microminiaturized, solid-state servo which digitizes radar position data.

A dual channel video processor automatically detects targets in areas of high clutter and provides target positional information to the Automatic Data Processor.

The IFF Interrogation Unit provides capability for Mark XII IFF/SIF so as to improve track correlation, identify aircraft rapidly, recognize aircraft emergencies, obtain aircraft height, and track aircraft which may be undetectable by the primary radar.

A target processor correlates the target starts and stops to determine azimuth and range reports, update continuing target reports, declare valid targets, and perform the beam-splitting function. The processor also provides the video processor interface with the AN/TSQ-73 automatic data processor.

Automatic Data Processor

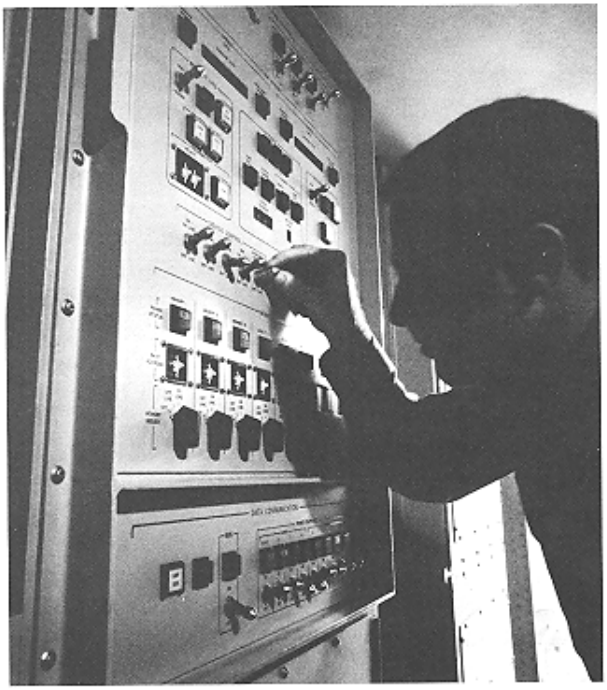
Data processing for the AN/TSQ-73 Control and Coordination System is performed as a real-time function which allows evaluation of incoming radar target data to determine threat conditions and assignment of an appropriate surface-to-air missile battery to the hostile threat. The data processor continually and automatically updates the status and location of air defense forces, and through the digital communications terminal equipment, informs adjacent defense units of status changes in local conditions and activities.

The AN/TSQ-73 Automatic Data Processor (ADP) implementation:

An L-3050 computer with two Central Processor Units (CPU's), seven 8,192-word 33 bit memory modules, an Input/Output Unit (IOU) with two, eight-channel Input/Output Exchangers (IOX), an Input/Output Multiplexer (IOM), and, a Display Output Unit (DOU).

Two magnetic tape memory units, one for program entry and one for recording.

A Keyboard/Printer Unit for data entry to the computer and hard copy print out.



Automatic Data Processor Status and Control Panel

The L-3050 is a general purpose, microelectronic computer designed for tactical use. In the AN/TSQ-73 System, the L-3050 makes full use of the modularity and building block approach used in the AN/GYK-12 computer developed for the U.S. Army. The seven 8,192-word internal, 4-port memory (57,352-words) provide extensive flexibility and memory capacity for continued operation in the rare instance of failure of any one 8,192-word module.

Desirable features for any automatic data processing group are optimized by balancing hardware and software functions. In the L-3050, balance is achieved by a hardware design which responds to 101 different software instructions. The 16 multipurpose registers, with register-to-register transfer, provide the programmer extensive flexibility in program overlapping, interrupt response priority allocation, and parallel compare, without standard core memory access. Word fractionalization (i.e., bit, byte, half word, etc.) is another programming aid to permit single memory access for a desired word portion. Level changing hardware provides the system with a multiprogramming capability, with the hardware interpreting priority levels before program switching is accomplished.

The L-3050 was developed to provide the computing and automated control capability for sophisticated and advanced real-time command and control system functions. The ability to perform these functions depends on high computer throughput to assure a coordinated effort. In the L-3050 series, this high throughput is achieved by:

...the unique architecture of the computer which has 33-bit memory words, 32 bit multiple register words, 32 bit instruction words, and variable data word lengths to save computer time when fixed data formats are required.

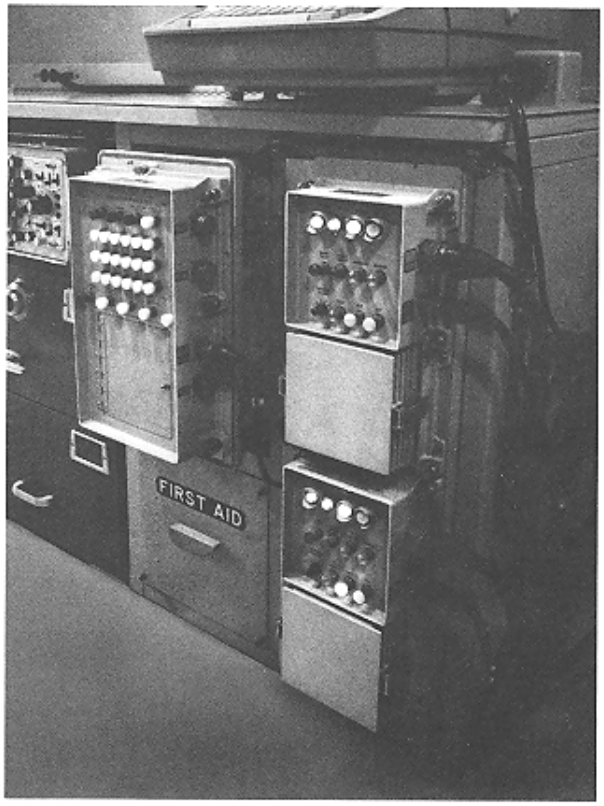
...the repertoire of 101 basic instructions and variations which reduce the memory access required in program executions. Some examples of these instructions are: (1) Bit Set, Reset and Test, (2) Byte Manipulation, (3) Formatting, (4) Gated Compare, and (5) Call Supervisor and Executive Program.

...the multiprogramming features of hardware and software interrupts, 64 priority program levels selected by hardware, and the software controlled mask that save core and execution times.

...the input/output features that make the input/output function independent of program execution.

...the L-3050 4-port memory that assigns one port to the display string for direct refresh without program execution.

System Elements



Dual Magnetic Tape Memory Unit

The microelectronic design of the L-3050 lends itself to building block design concept, highspeed logic, high reliability, and ease of maintenance. Further, such features as the power fail-safe, memory access protection, and the privileged instructions are designed-in operational features that ensure against data loss.

The peripheral equipment provided with the automatic data processor consists of two magnetic tape units and one keyboard/printer unit. The two magnetic tape units each provide memory storage of 300,000 words. One magnetic tape unit is assigned to enter AN/TSQ-73 programs although both may be used for recording. The features of the magnetic tape units include: (1) tape, read/write heads, and drive sealed in a single removable unit (cassette type) that plugs into the front of the electronics package, (2) tapes that are changeable within the sealed unit at a depot, and (3) a simple drive that eliminates clutches and complex drive assemblies.

The keyboard/printer is the Kleinschmidt Model SCN 311. This unit is available for system initialization testing, program constants, and hard copy recording of memory data. The basic features of the SCN 311 include:

72 characters per line

40 characters per second print speed

Full alphanumeric keyboard plus special characters

A 4-row ASCII code

Capability to accommodate paper in rolls or fan fold.

The AN/TSQ-73 ADP growth capacity:

Space is available for one additional 8,192-word modules (65,536 words) while the total capacity of the L-3050 is 131,072 words (sixteen 8,192-word modules).

The IOU is wired for one additional eight channel IOX for a total of three and provides for a maximum capacity of seven IOXs.

For reduced missions, the L-3050 may be quickly configured with one CPU and fewer memory modules.

Communications Subsystem

The communications group not only provides the capability for automatically processed digital data communication via the data terminal set but advanced voice communications to ensure positive control and coordination of area/point defense missile fire units.

In addition to performing its primary mission of missile fire unit control and coordination, the AN/TSQ-73 provides the following digital data exchange capabilities:

Exchanges information with adjacent AN/TSQ-73 command and control systems. This exchange enables track handover between AN/TSQ-73 Systems.

Exchanges information with other service and Allied command and control systems.

Message exchanges with assigned Missile Battery Fire Units for assignment and for status reporting.

Exchanges information with other U.S. Army Systems (such as ATMS, TOS, etc.).

Each AN/TSQ-73 Universal MODEM is adjustable by switch action to select one of two modulation modes (frequency shift keying and differential frequency shift keying), one of four data formats, and one of four digital data rates. The selected data formatting and addressing structure is under the control of the operational software programs stored in the automatic data processor.

The voice communication function has growth capability for up to 96 subscribers (60 provided) that are functionally netted to assure access to the net assigned operator. The netting system is designed to permit emergency break-in on a busy net. As a result, operators answer only those calls on their assigned net. However, a subscriber may be transferred to one of two private channels when required.

The communications patch panel provides data-circuit/voice-circuit monitoring and patching capabilities for maintenance and test functions. The patch panel accommodates 140 four-wire circuits and includes capability to "patch around" MODEMS in the event of failure.

The AN/TSQ-73 data terminal set provides growth for the addition of identical full duplex MODEMS as required and provides for back-up battery data link operation providing a relay function for communications between batteries in the event of automatic data processor failure.

Channel status combines hardware and automatic data processor software to determine open/noisy lines, unknown line conditions, missed messages, and parity failures.

System Elements

Because of the data terminal set complexity, physical size, and power requirements, a thorough investigation of implementation hardware was required for the AN/TSQ-73. These problem areas were reduced to a controllable value by the application of digital techniques implemented with medium-scale integration logic devices as opposed to the conventional analog MODEM approach. Medium-scale integration constitutes approximately 80 percent of the logic; the remaining 20 percent consists of a mixture of integrated circuits and discrete components. The MODEMS have been partitioned to permit the replacement of the medium-scale integration devices with large-scale integration logic devices as they become available.

Maximum use of digital techniques ensures reliability and maintainability, and eliminates frequent adjustments that are common to analog systems.

The AN/TSQ-73 voice communications element interfaces with all major units of the air defense system. Operator personnel require access to voice communications circuits for command activities, backup of automatic data links, and for administrative and maintenance functions. Each emplaced AN/TSQ-73 has 60 netted voice subscribers with capabilities of accommodating 96, as well as 4 subset terminal instruments, which can be expanded to 10.

The coupling of the call director to the outside activities is achieved via the patch/monitor facility and the line distribution and demarcation panel.

The AN/TSQ-73 shelter is equipped with four voice communication stations, one at each situation display console and two others for maintenance, supervision, training and command activities. The system has growth capacity to ten voice communication stations by the addition of one at each situation display console added to the system.

AN/TSQ-73 Software

The kinds of programming packages provided within each category of software for the AN/TSQ-73 include:

Operational.

Simulation.

Diagnostics (fault detection and isolation).

Support.

The AN/TSQ-73 System Applications (operational) program includes all the functions necessary for controlling and coordinating a number of surface-to-air missile batteries. These functions include: air-space surveillance, target tracking, identification, display, and data link communications. These functions also include operator communication with the computer through the console control and automatic recording of important operational data for later review. On-line confidence testing is also part of this program.

In-place card testing using hand-held test set.

Simulation programs drive the built-in target simulation hardware to produce a realistic raid environment. Use of this equipment allows operator training and equipment exercising on-site. The raids generated are complete with electronic countermeasure effects. The simulator features include:

Programmed targets.

Electronic countermeasure jamming (AM noise, FM noise, random or sync pulse, spot or barrage).

Chaff.

Fault Detection and Isolation programs provide a capability to detect and isolate faults to a single card when used in conjunction with the hand-held card tester.

The final category is support software which consists of two types; Field Utilities, and assembly functions for support center usage.

Application (operational) programs are tailored for each user and mission to assure compatibility with local operating procedures and criteria.

A primary concern of command and control systems users is the cost of computer software. It is a known fact that software tends to be much more difficult to define or understand than hardware.

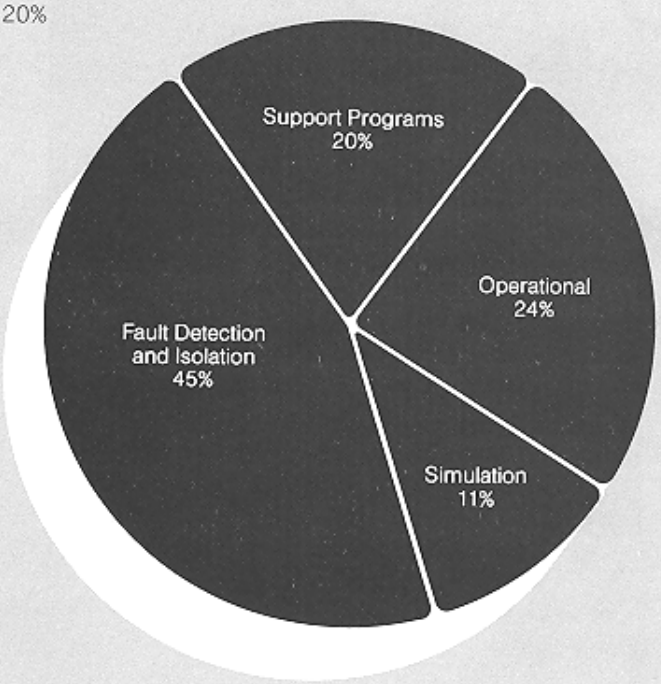
The accompanying pie chart illustrates division of the AN/TSQ-73 computer programs into four major categories. Of these categories, the Operational and Simulation programs are unique to the U.S. Army AN/TSQ-73 Mission. Therefore, a mission change such as air traffic management, would require that the Operational and Simulation programs only be redesigned to meet requirements of the new mission.

AN/TSQ-73 Software

The number of instructions in each of the categories is anticipated based on the criteria established by one scenario. Each user of the AN/TSQ-73 equipment may establish his own requirements, and the Operational and Simulation programming subpackages can be redesigned based on the established requirements. The Litton programmer's knowledge of the L-3050 and the AN/TSQ-73 programming package, as well as other similar programs, reduces the new AN/TSQ-73 owner's programming task to an absolute minimum.

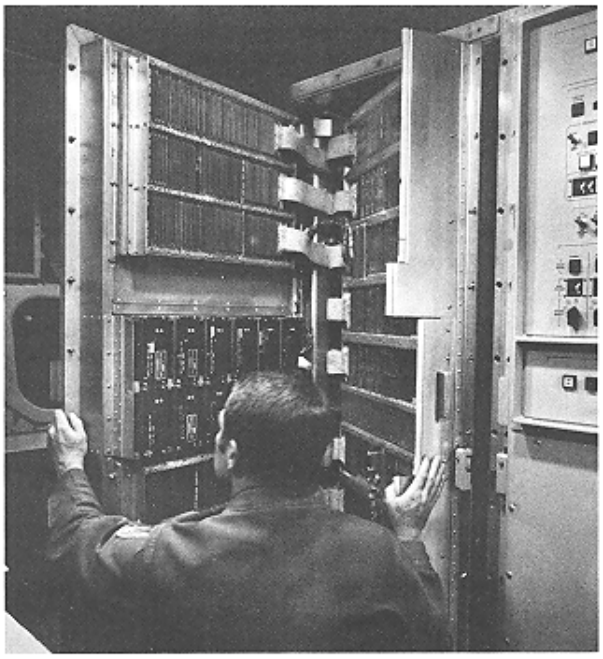
Programming Scope and Distribution

Operational	(AN/TSQ-73 Unique)	20,500 Instr. 24%
Simulation	(AN/TSQ-73 Unique)	8,900 Instr. 11%
Diagnostics	(Fault Detection and Isolation)	38,500 Instr. 45%
Support		16,800 Instr. 20%
		Total 84,700 Instr.



Note:
The operational and simulation software provided specifically for the U.S. Army is not releasable to foreign users. New operational and simulation programs can however, be readily tailored to any user's requirements.

Maintainability



Typical Card Bay

In 1965, Litton DSD, under the direction of the U.S. Army MICOM Control and Coordination System Office, developed and produced the AN/GSA-77 Battery Terminal Equipment. It utilizes creative equipment design that provided the Army with a true throwaway maintenance concept for the first time in any production military electronic system. The proven success of this throwaway maintenance concept has led to its adoption on both the TACFIRE and TSQ-73 programs.

The automatic fault detection and semiautomatic fault isolation and the very few different types of self contained spares result in a low mean time to repair (MTTR) and allow short maintenance training courses. For example, only 56 hours of maintenance training are required for the AN/GSA-77.

The entire maintainability approach to sharply decrease system downtime and greatly decrease expensive support requirements is keyed to the extensive studies Litton conducted to develop common building-block digital cards to replace functional cards in the system and the total maintenance concept encompasses the following:

Multiple use of common cards.

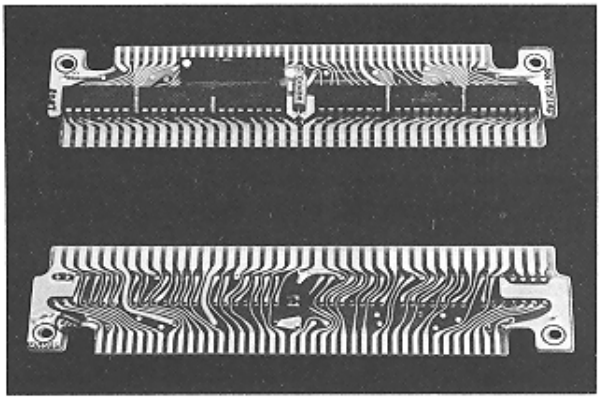
There are 166 different card types in the entire system.

Ten card types constitute 60 percent of the entire circuitry.

Built-in automatic fault detection and isolation.

Easy accessibility.

Throw-away cards, self contained spares, no special or general field test equipment, easy field maintenance, and low mean time to repair.



Throwaway Card

By the use of effective diagnostic programs and the integral hand-held module test set, the maintenance technician can perform the entire fault location, detection, and replacement process. The maintenance sequence is briefly described in the following paragraphs and illustrated in the accompanying illustration.

Maintainability

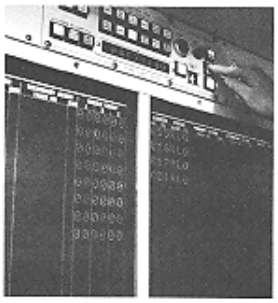
If a fault occurs in the AN/TSQ-73 System, the operator is alerted by visual and audible alarms (Figure A). The visual alarm identifies the specific subsystem that has failed. The operator then calls the maintenance technician and initiates the automatic fault isolation program for the failed subsystem (Figure B). Readouts on the Automatic Data Processor front panel indicate the fault by location code (Figure C).

By referring to the fault location tables, the maintenance technician translates this area indication to a specific group of digital circuit cards or to a single card for analog circuit types (Figure D). He next goes to that piece of equipment and tests each of these few cards with the integral module test set (Figure E). With the hand-held module test set, the faulty card can be located within the isolated group without removing any cards or using extenders.

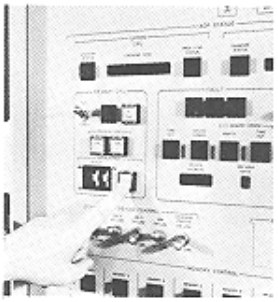
Because of the AN/TSQ-73's high degree of card commonality, spare cards are immediately available in the shelter's spares storage cabinet. The operator replaces the faulty card and recycles the system to verify normal operation (Figure F).

This short downtime, along with the high system reliability, enables the AN/TSQ-73 System to meet the stringent availability requirements essential to air defense control systems.

Maintenance Sequence



Visual & Audible Alarm
0.0 (Fig. A)



Initiate Diagnostic Program
0.2 min (Fig. B)

Readouts Indicate Faulty
Area 1.0 min (Fig. C)

Locate Faulty Card Group
2.4 min (Fig. D)

Test Cards in place with
MTS 5.9 min (Fig E)

Replace Faulty Card
9.3 min (Fig. F)

Reliability, Low Life Cycle Costs, and Support

Litton's designers have been quick to utilize integrated circuits; medium scale integration; and, more recently, large-scale integration. Taking advantage of the improved reliability and other features of modern digital techniques, they have designed the AN/TSQ-73 as a new concept in militarized equipment and not simply as a retrofit of previous systems. Thus, **through the intelligent application of integrated circuits, the reliability of the AN/TSQ-73 has reached a level which was impossible with the limitations of discrete component circuitry.** The system design accomplishes maximum operability while at the same time designed-in capability has provided maximum system availability. **The combination of long operation, high mean time between failures componentry, and automatic fault diagnostics ensures the kind of combat availability in the field for which Litton DSD is well known.**

The AN/TSQ-73's technology and design features have also sharply reduced the operating and support costs for the user.

Assuming that the acquisition cost of one of the older air defense command and control systems is no more than that of the AN/TSQ-73*, **the total cost of ownership for the older system over a 10-year period is far greater.** The accompanying chart contains a partial list of the support factors which make up life cycle costs. For example, savings in manpower resulting from the AN/TSQ-73's high degree of automation and simplified maintenance are not considered. By placing costs on the total life of the AN/TSQ-73 after acquisition, it is evident that the 10-year cost of ownership of the older air defense command and control systems is several times that of the AN/TSQ-73. It can be seen then that the AN/TSQ-73 System has cost advantages as great as its technological and operational advantages.

*U.S. Army experience has shown that the acquisition costs of new technology systems are substantially lower than those of the systems they replace.

Low Life-Cycle Cost Factors

- ***Lower Initial Acquisition***
- ***Lower Power Consumption***
- ***Fewer Spares***
  Higher Reliability
  Fewer Unique Types
- ***Shorter Training Schedule***
- ***Less Documentation***
- ***Near Zero GSE***
- ***Smaller GSE Support***

Reliability, mandatory for today's air defense command and control systems operations, has increased by orders of magnitude since 1965. Technological advances, such as integrated circuitry, followed by medium scale integration circuitry have substantially reduced the number of circuit interconnections which are the least reliable area of any system. **The results of these technologies has been substantial increases in device reliability over the technology implemented in the AN/MSG-4 and AN/TSQ-51 systems**

The system-level impact of this current technology can be seen in Litton's AN/GSA-77 Battery Terminal Equipment. Battery Terminal Equipment units have operated for over 2500 hours in a field environment without failures, and Litton's AN/TSQ-73 uses technology similar to the Battery Terminal Equipment.

Reliability, Low Life Cycle Costs, and Support

Additionally, the support requirements of the AN/TSQ-73 have been drastically reduced due to the combination of high reliability, ease of maintenance, and low spares level of card types (based on card commonality and throw-away concept).

Due to the AN/TSQ-73's maintainability concept, training requirements can be reduced. Since the need for specialized maintenance personnel for the AN/TSQ-73 System is minimal, lengthy maintenance training courses are not required. Requirements for detailed field and technical manuals can also be reduced.

The AN/TSQ-73 does not require special field test equipment which so often engulfs the operational air defense equipment. In addition, the system's low power requirements reduce the number of motor generator sets that must be deployed with the system. This approach toward "Zero Ground Support Equipment" feature in turn almost eliminates the provisioning and maintenance support normally required for this type of equipment.

AN/TSQ-73 Support Design Features

- ***High Reliability***
- ***Ease of Maintenance***
- ***Card Commonality***

Impact On Support

- ***Low Spares Level***
- ***Spares Replenished from Multiple Supply Points***
- ***Major Repair at the Contractors Factory or a Depot***
- ***Minimum Field Documentation***
- ***Minimum Training Requirements***
- ***Minimum Support Equipment***

Expansion Capability

The general-purpose nature of the AN/TSQ-73 System and its increase in computing, display, and communications capacity greatly enhance its operational utility and growth capacity.

Programmability of the system and its compatibility with a wide range of radars and other command and control systems permit it to be deployed anywhere in the world. Its use can be expanded to a variety of other prime and/or backup functions.

The baseline AN/TSQ-73 can be expanded for increased missions or have its role and missions modified without design modification. The growth capacity is as follows:

Situation display (situation information display and auxiliary readout console) expansion to 8 consoles.

Memory expansion (space to 65,536 words, and growth to 131,072 words).

Plug-in additional digital data link terminals.

Track expansion through software.

The Litton Data Systems Division is one of the pioneers in the application of integrated circuit technology to military equipment. This technology has been realistically employed in the design of the AN/TSQ-73 in order to prevent early obsolescence. In addition, the Litton AN/TSQ-73 System is designed for easy conversion to a maximum large scale integration system as the technology further advances. This includes the subsystem designs which have been partitioned to allow replacement of functional groups of circuit cards with medium scale integration or large scale integration devices when specific devices emerge from the research and development cycle. Replacement of these functional groups with medium scale integration and large scale integration circuits will provide space and power for the addition of even greater system capability.

Because of the number of technical innovations designed into the AN/TSQ-73 System and its high reliability, built-in test features, easy maintainability, uncomplicated logistics, and growth capacity, the U.S. Army's AN/TSQ-73 System truly provides a greatly improved capability to operate in fixed installations and the mobility to operate in the field at the earliest possible time.

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