AUTOVON

■	4W #5 CROSSBAR	9
▲	NO. 1 ESS	45
●	AUTOMATIC ELECTRIC	16
	Total	70
EFFECTIVE DATE		12-22-73
ACCESS LINES		15,672
TRUNKS		7,418
TOTAL CIRCUITS		23,090

*Controlled circuits from E5A20A's

Switched Services Bureau and Switching Maintenance Shown in ( ).

WHEATLAND AUTOVON 871-3118

3. Absence from Class. A student may be excused from class for legitimate reasons. In this case, the student reports to the course office to make the necessary arrangements. As this course is extremely short (30 hours), requests for absence should be restricted to genuine emergencies.

HISTORY AND FUNCTION OF THE AUTOVON SYSTEM

The "Overseas" portion of the AUTOVON (AUTOmatic VOice Network) system comprises 17 "switches" with capacities of 100 to 2000 lines each, installed in 14 countries to form, with similar facilities in the US, a worldwide, end-to-end, circuit-switched communication system for the Department of Defense: capable of switching voice, data, and teletypewriter messages. Overseas AUTOVON is a four-wire, nonblocking, spacedivision system, with correed crosspoint matrices, controlled by electronic common-control equipment. Electromechanical elements in the lines and trunks permit connection to HF, VHF, UHF, troposcatter, microwave links, four-wire instruments, and land lines.

In the past, military networks have been based upon point-to-point direct links, with backup facilities to assure reliability. This approach provided rapid communications to selected points, but did not offer the diversification necessary to meet modern military needs. The Department of Defense undertook an investigation of the possibility of providing an equivalent high-speed service through a switched system, with the inherent advantages of alternate routing and survivability routing, and at the same time reducing overall costs. An Overseas AUTOVON specification was prepared to implement this program and Automatic Electric Company was subsequently awarded the contract to provide the hardware for the 490L Defense Communications System (DCS) switches.

The requirements called for a total of twenty-two overseas sites--fourteen in the European and Mediterranean Area, seven in the Pacific area, and one in the Carribean area. Each switch was required to handle up to 2,000 terminations (line and trunks) and be capable of switching four-wire circuits on a nonblocking basis. Space-division switching with electronic controls is provided, along with electromechanical line and trunk equipment to connect to the outside facilities. The crosspoint element employs electomagnetic switching devices (correeds) with hermetically sealed contacts because of their excellent transmission characteristics and their ability to interconnect with electronic and electromechanical circuitry. These devices provide the interface between electronic and electromechanical devices.

The electronic circuitry employs standard electronic building blocks to perform the logic functions. The basic building blocks utilize two types of germanium transistors as the basic memory element in the system, and provides both permanent and temporary storage lines; trunks and other peripheral circuits employ combinations of electromagnetic and electromechanical devices and are all terminated on the switch matrix on a four-wire basis. Four-wire subsets were developed, with signaling provided by TCMF (touch-calling-multifrequency) means, and contain additional keying equipment to provide the priorities that are required. These elements meet the electrical, mechanical, and enviromental specifications of the AUTOVON System, and provide the required transmission characteristics.

ROUTING AND SIGNALING PLAN

The routing plan associated with AUTOVON must be highly flexible, not only to provide normal alternate routing but also to fulfill military needs for survivability routing. To meet these requirements, the routing

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plan for Overseas AUTOVON is based on originating offices control or end-to-end signaling with spill forward in certain specific instances. End-to-end signaling, rather than point-to-point signaling, lends itself quite readily to a network which has a limited number of offices being capable of quick reaction to routing changes in the network. The AUTOVON Switch, with its electrically alterable memory, has the capability of incorporating routing or trunking changes very rapidly. Certain offices, however, do not have extensive routing capabilities and are considered tributaries or "spill-forward" offices; they must pass all routing information to an office having the routing capabilities.

With originating-office control it is necessary to employ more signals between offices within the network, and to recognize different signals from other networks when they interconnect with AUTOVON. Military needs for highly reliable signaling means over various transmission facilities are best met by confirmation signaling. This was therefore made a system requirement. Information exchange within the system consists of two-out-of-six (2/6 MF), TCMF, or dial pulse (DP) signals. The frequency combinations are as follows:

Digit	2/6 MF (cps)	TCMF (cps)
1	700 + 900	697 + 1209
2	700 + 1100	697 + 1336
3	900 + 1100	697 + 1477
4	700 + 1300	770 + 1209
5	900 + 1300	770 + 1336
6	1100 + 1300	770 + 1477
7	700 + 1500	852 + 1209
8	900 + 1500	852 + 1336
9	1100 + 1500	852 + 1477
10	1300 + 1500	941 + 1336
KP	1100 + 1700	
ST	1500 1700	

The 2/6MF is currently used extensively on trunk signaling, and is quite satisfactory as long as voice frequencies do not coincide with these frequencies. The TCMF offers excellent protection against interference from voice simulation, and therefore is used as the signaling means from the four-wire station instrument.

Supervisory signals such as off-hook, on-hook, ringing, etc., are based on the use of standard E & M control leads and multifrequency tones. For example, trunk seizure from the calling to the called switch is accomplished by a dc signal on the E & M leads; after the register is seized, the called switch acknowledges the signal by key pulsing, which utilizes frequencies from the 2/6 MF group (see above). The 2/6 MF tones also indicate line or trunk group conditions at the called switch.

NUMBERING PLAN

The AUTOVON System, as part of a worldwide communication system requires a unique address for each user or special trunk destination. The numbering is "closed" allowing the digits to be keyed one after the other, without waiting for intermediate dialtone. The numbering plan provides for a seven-digit subscriber address, consisting of a three-digit switching-center identification code and a four-digit terminal number. A three-digit area code is assigned, and must be prefixed to the seven-digit number, on calls made outside the subscriber's area. These digits are decimal value and consist of the following:

NYX-NNX-XXX

N is any of the digits 2 to 9

X is any of the digits 0 to 9

Y is either 0 or 1

PRECEDENCE SERVICE

To assure that calls from certain telephones will receive more than routine service a system of priorities is incorporated into Overseas AUTOVON. Some stations including all dial-pulse (DP) subscribers, are limited to the routine service; each of the other stations is assigned a maximum precedence available. In calling from one of these stations, a precedence digit, utilizing digit values outside the decimal range, may be prefixed to any number. It is used to preempt calls of lower precedence and takes the following form: (See Foldout 1.)

PRECEDENCE DIGIT VALUE	RANK	FREQ. COMBS.
0	Flash Override (FO)	697-1633
1	Flash (F)	770-1633
2	Immediate (I)	852-1633
3	Priority (P)	941-1633
4	Routine	

The subscriber may establish routine calls in the usual way; or he may establish calls of higher priority, up to his maximum allowable, by prefixing the precedence digit to the address.

In addition, a two-digit route code may be prefixed to the 7 or 10 digit address to discriminate between data and voice grade calls, and to alert the switching equipment to a call outside the AUTOVON. Thus the subscriber may key a maximum of 13 digits.

In addition to the general numbering plan, certain subscribers may employ abbreviated dialing service, or hotline service to a specific telephone. To provide these services, stored addresses are recorded in the memory and associated with the subscriber line identity. For abbreviated dialing, a maximum of 80 destinations are available to a number of four-wire subscribers simply by keying an abbreviated (two-digit) code, and pressing an "end-of-send" button. The two-digit code, together with the line identity, is translated to a 7 or 10 digit telephone address. The end-of-send button (key) is available on all TCMF instruments.

Where hot line service is provided, the subscriber merely goes off hook to establish connection. A special stored address is activated in the memory, which presents special routing instructions to the prearranged destination for this call.

SYSTEM CONFIGURATION

As the transmission switching device, Overseas AUTOVON employs a correed switch matrix, arranged in modular fashion and capable of switching up to 108 kc circuits. The switch matrix is nonblocking, while it is not readily apparent, the switch matrix array is folded, and terminations on the A stage are tied directly to like numbered terminations on the C stage. This mirror image effect is described

more fully under the matrix section (later in this paper) and is required to provide the nonblocking capability. Each line, trunk, test termination, conference trunk, register-sender, DSA trunk, and other facility that requires switching is terminated on one of the inputs of the switch matrix. The inputs and outputs are tied together as indicated above, with a total of up to 2,000 terminations capable in the Overseas AUTOVON switch.

The switch matrix closes transmission paths under direct control of the electronic marker. The marker communicates with the Common Control Electronic complex by means of a marker data bus and also has direct connections to each line and trunk terminated on the matrix. The Common Control provides the logic and memory for processing and routing the call. The register sender portion of the common control provides the interconnection between the space division matrix and the time division common logic and memory.

The DSA (Dial Service Assistance) matrix provides a full availability (but not nonblocking) connection to DSA cordless positions, through associated link circuits.

SETTING UP A CALL

When a party goes off hook, a request for service is initiated to the switch marker. The scanner associated with the switch marker determines the location of the call for service, and the group and line number associated with the calling subscriber. Once this number has been determined, the switch marker requests association of a register from the Common Control. If a register is available the Common Control indicates its location to the marker, via the data bus. The marker then hunts for an idle path from the subscriber (in the primary A stage) to the register (in the final C stage) when the idle path is established, the marker pulls the crosspoints associated with that path, thus connecting the subscriber to the register.

The register must also know what type of line is connected so that, if required, a TCMF receiver can be associated with the register. The marker releases from this connection and becomes available for other traffic. Dialing tone is now returned and the calling subscriber proceeds to key the called number. Upon receipt of the necessary digits, the Common Control determines the translation and routing instructions for this call. Once the routing instructions have been determined, the Common Control requests the services of the marker (note that this is the second marker operation for this call). When the marker is associated with the common control via the data bus, the common control passes information to the marker, including the location of a sender and the identity of an outgoing trunk circuit. The marker now establishes a connection from the sender to the outgoing trunk.

When the connection to the trunk circuit has been established, an off hook indication is transmitted to the distant office via the E & M leads of the trunk circuit. The distant office assigns an idle register to the trunk circuit and returns a key pulse signal which indicated that the distant office is now ready to receive the digits. The origination office now transmits the priority digit a routing digit, and the first three address digits each of these digits is confirmed before the next digit is transmitted. The distant office performs a code translation on the three address digits to determine whether more digits are required or whether this is a tandem call and routing

to a trunk is necessary. If cutting through to a foreign office is required this will now occur in the distant office, and the originating office will receive a KP signal, indicating that transmission of all digits should be reinitiated. The previous sequence of events will occur at each tandem link, until the terminating office is located as the call leaves the network.

When the terminating office is reached, the originating office is requested to transmit all address digits. Once the sender has completed its function, the marker is called a third time and is given the following information from the Common Control; the location number of the calling subscriber, the location number of the register, the location of the sender, and the location number of the outgoing trunk. The marker drops the original connection between the calling subscriber and the register, and between the sender and the outgoing trunk; it establishes connection from the calling subscriber direct to the outgoing trunk and then releases from the connection. Since the matrix is nonblocking, a path will always be found.

Cut through between the calling and called subscriber now occurs, and ringing tone is returned to both parties, when the called party answers, a signal on the E & M leads is transmitted through all switches associated with this connection, to indicate that both parties are off hook. During the conversation period, the supervision and priority of the call are stored in the segment of the common controls ferrite core memory that is associated with the line and trunk.

When one of both parties go on hook, the associated line and trunk circuits are automatically released without calling the marker. This is again accomplished through supervision of the E & M leads.

PRIORITY PREEMPTION SPECIAL HANDLING

If the subscriber desires to exercise his precedence privilege he will key or operate one of his precedence keys before the address digits. This precedence will now be permanently associated with the connection. The subscriber then proceeds to key the address of the called subscriber. If the subscriber exercises his priority option and an all trunk busy ATB condition is encountered on the primary direct route, the originating office does not attempt to override existing connections until all existing alternate trunk groups have been attempted. Should all routes test busy, the switching machine will return to the primary route and attempt to override existing calls in that group. If no trunks of lower priority are detected in the primary group, the preempt process is repeated throughout the alternates.

When a switching center is functioning as a tandem point for calls, preemption can occur between the tandem point and the primary route to the destination. If no trunks of lower priority are detected on this primary route the call is returned to the originating switch for further routing.

Once the terminating switch is reached, and if the called line is found busy, the terminating switch will force the release of the existing connection if of a lower priority and establish a connection from the calling party to the called line. The party whose connection has been forcibly released will receive a distinctive tone until he hangs up, indicating the preemption has occurred.

Certain preference is also provided for hot line and special four-wire subscribers in accessing a register. Although the marker is not aware of the priority of the calling subscriber, it does offer an arrangement (a marker preference chain) such that a call for service from this special group is given preference over other groups when registers become idle. Because of this, and short holding time of the registers, hot line will always be connected almost immediately to an idle register.

In addition to this special handling of hot line traffic, this system can also provide preference to four-wire subscribers and trunk circuits during overload conditions. PBX subscribers, whose traffic is considered routine, are taken off the network either by preemption if they have completed a call or by automatic line load control which prohibits new PBX attempts from entering the network and accessing the registers. This is necessary since the switch does not know the priority of a four-wire line or trunk circuit until the first digit is received. The switch does know that PBX traffic is routine.

There is one other feature incorporated in this system to aid the flow of traffic; this is related to the switch marker, which responds to requests for service both from switch terminations and from the common control. In order to insure that traffic leaves the registers, the switch marker is arranged to alternately serve line and trunk terminations, and calls for service from the common control.

LINE AND TRUNKS

Intertoll trunks, PBX trunks, and line circuits are arranged for E & M signaling and four wire directional transmission. Each circuit is terminated on the switch matrix and is arranged to present information concerning its class, priority, idle or busy status, etc., to the switch marker and Common Control, to aid in assignment and call processing. Each circuit also switches six wires for transmission and controls between the various circuits and switches.

The instrument associated with a four-wire line circuit is normally equipped with a pushbutton key set to transmit TCMF tones to the AUTOVON switch for addressing the switch. The four wire line circuit can also be arranged to serve a hot line, which requires no addressing since the routing instructions are stored in the memory.

The PBX trunk circuit can be arranged for dial pulse, TCMF for manual access to the switch from the PBX, for dial pulse or manual access from the switch to the PBX, for special precedence and preemption arrangements, and for echo suppressors and idle line terminations. An additional feature of the PBX circuit is the line load control, which prohibits part or all of the PBX trunks from initiating calls into the switch under peak load conditions, until traffic has been restored to normal. The line load control can be operated either automatically as a function or manually. With automatic operation it is controlled by the number of register-senders which are busy.

The intertoll trunk circuits are used to interconnect to the transmission facilities between switches. These transmission facilities may be HF, VHF, UHF, troposcatter, microwave links, or land lines.

The circuit elements employed in the four-wire line circuits, PBX trunks, and intertoll trunks are electromechanical or electromagnetic. Electromagnetic switching devices with hermetically sealed contacts (correeds) are used for the talking path because of their excellent transmission characteristics, and for interconnection with electronic

circuitry because they operate with the necessary speed (approximately 1 millisecond) for this interconnection. In addition, the extremely long life expectance of the correeds makes them ideally suited for applications requiring high repetition rates. (See Foldout 2.)

THE SWITCH MATRIX

The A, B, and C stages, as a unit, can be considered a three stage nonblocking array, while the B stage alone is also a three stage nonblocking array. However, these two arrays are slightly different in the relationship of inputs to outputs.

The A, B, C matrix can be shown to be nonblocking, that like-numbered terminations be employed on the A & C stages, and that the array be "folded"--that is, hunting can occur from A to C or from C to A.

However, it was necessary to devise a packaging technique that would lend itself to easy growth and minimum wiring. The cabinet arrangement consists of five drawers, each capable of mounting eight 5 x 10 matrix cards or forty 5 x 10 matrix cards per cabinet. The matrix array is divided into two sections--the line matrix, which consists of stages A, BA, BC, and C, and the center matrix, which consists of the BB stage. The line matrix is divided into increments of 50 terminations, requiring 5A stages, (10 - 5 x 10 cards) 10 BA stages (10 - 5 x 9 cards), 10 BC stages 10 - 5 x 9 cards), and 5 C stages (10 - 5 x 10 cards) a total of 40 5 x 10 cards the 5 x 9 card is derived by omitting a row on a 5 x 10 card. Hence, the line matrix for 50 terminations is contained within one cabinet, and a number of such cabinets can be supplied for each AUTOVON switch, in accordance with the size requirements.

The size of the BB matrix is determined by the number of 50 termination modules. Thus, a 150 termination switch requires a 3 x 3 BB matrix (50 x 3, while a 750 termination switch needs a 15 x 15 BB matrix 50 x 15). To facilitate growth, however, it was decided that the BB matrix modules would be produced in multiples of 5 - e.g., 5 x 5, 10 x 10, 15 x 15, etc.

SYSTEMS CONTROLS

The system controls of Overseas AUTOVON can be divided into four categories--markers, register senders, common logic, and memory; the last three constitute the common control.

Switch Marker

The function of the switch marker is to provide the control necessary to interconnect the inlets and outlets of switching units, over an available idle path through the matrixes. The following operations are required: inlet identification, path selection, path checking, completion of connection, and communication with the common control. The tasks performed by the marker are controlled by a sequence and supervisory circuit which also synchronizes operations within the marker. Included in the sequence and supervisory circuit is a fixed, wired program for controlling the steps of the marker, and a "scratch pad" memory which provides current information concerning the progress of the call, so succeeding operations can be planned. The marker handles one call at a time, either from a call for service of a line or trunk, or from the common control. Once the inlet and outlet identities have been placed in the marker, it begins a sequence of up to 28 operations in accordance with its wired program, to connect the inlet to the outlet.

Since each termination is connected to both the A and C stages, the marker may hunt either from inlet to outlet or from outlet to inlet. The highspeed scanner and supervisory circuit insures a rapid connection.

Register-Sender

The Overseas AUTOVON switch is a space division system which is controlled by a time division common control. The interface between these two modes of operation is the register sender circuit, which is accessed from the A and C stages of the switch matrix, serving lines and trunks on a real time basis and, in turn, is sequentially served by the common logic and memory through a time division multiplex unit. The number of registers is determined by the traffic requirements of a switch.

Two terminations are provided for the register sender; one for the register, and one for the sender. Since the sender is an extremely simple circuit, it was most economical to permanently associate the register and sender, even though the sender is held for less time than the register; operation is thus simplified. Since pulsing into the register is generally on a dial pulse (DP) basis, a DP receiver is included in each register. However, DTMF or 2.6 MF pulsing may also be used; receivers associated with DTMF and 2/6 MF are placed in separate pool so they can be assigned to a register-sender when required.

Sending can be either DP or 2.6 MF, and since the latter is used on most interoffice trunking (which requires confirmation signaling), the 2/6 MF receiver is used also for sending, as a "transceive."

Common Logic

The common logic is the programmed portion of the common control, and provides the decisions, timing and communication between circuits. The common logic is concerned only with the manner in which a routing is obtained on each call; the memory (described below) is concerned with what the routing is. The fixed common logic insures smooth flow of traffic through the system, while the memory may be altered from time to time as necessary.

The common logic is provided with two active units, both of which process each call, although only one unit is considered "online" for control. A third, passive, unit acts as a comparator for the other two units, and if the outputs of the two circuits should disagree at any time, the passive unit will act as a "referee" (majority-rule logic) in deciding which unit should be taken "offline." Test points are provided for this majority-rule logic at various stages, to pinpoint trouble. This makes it possible to quickly locate faults, and since the common logic is a fixed program, the faulty unit may be repaired and placed back "on-line" as quickly as possible.

Memory

The Overseas AUTOVON switch employes ferrite cores as memory elements, arranged in 1000 modules (actually 1152 words), each containing 44 bits. Each office is capable of growth to 6000 (6,912) words, although initially not more than 3000 words will be supplied, the number of words being directly related to the size office.

There are two areas in the ferrite-core memory. One area contains a fixed number of cores for each register-sender that will be required--not only initially but ultimately. The second area contains the permanent

"table look-up" storage, from which routing instructions are extracted. This area and office codes (3 or 6 digits), trunk-group and trunk-number indexes, class of service, busy-idle, routing digit, route transfer and sequence, abbreviated dialing, and zone network indications.

The ferrite-core memory is of the destructive-read-out type; it is, therefore, required that a code that is read out be written back immediately (during the same time-slot) to continually up-date the program. Since the memory is electrically alterable, it can be programmed from an external source--e.g., a typewriter--either initially or on a day-by-day basis to provide for additional trunk groups, class-of-service changes, priority changes, etc., thereby minimizing the time required for programming tasks, and permitting rapid response to changes in the network.

WE DO NOT HAVE DSA AT OUR SITE

DIAL SERVICE ASSISTANCE (DSA)

The function of the Dial Service Assistance (DSA) operator is to provide services such as directory information, intercept, conference assistance, and call-recording.

To access DSA positions from the switch matrix, DSA trunks are directly terminated on the switch matrix, with two appearances per trunk--one to extend the call to the operator and one to allow the operator to extend the call (this duplicates the "front-" and "rear-" cord operation of a manual switchboard). Each console has eight link circuits for handling traffic, and each link can handle one call at a time. Once a call is routed to a DSA trunk, with its class and priority marks, the call is switched--through a DSA matrix under control of a DSA marker--to an idle link and position. The DSA matrix is a full-availability three-stage array, arranged to handle both incoming calls to the position and outgoing calls from the operator.

The marker associated with the DSA group has the function of connecting a DSA trunk to a position that is arranged to handle calls of the proper class and priority. Through a sequence and supervisory control circuit it analyzes the class and priority of the calling DSA trunk. This is then compared to available positions, and a selected position and link on it are assigned to handle the call.

When the call is routed to the position, the class and priority are visually indicated to the operator.

CONFERENCE ARRANGEMENTS

Random Conferences

The operator at a DSA switchboard can set up random conferences, of either the "meet-me" or the "progressive" type, by activating "conference bridge" circuits. "Meet-me" conferences require each participant to dial a code which automatically brings him into one of the bridge accesses; "progressive" conferences are established by the operator, who can thus prevent entry of unauthorized persons into a "progressive" conference.

Preset and Broadcast Conferences

Selected subscribers can initiate "preset" conferences (providing full-duplex voice communication) or "broadcast" conference (one-way only) by dialing programmed codes. When such a code is received, a "combination switch" circuit is activated; this is a wired program unit that is prearranged by the maintenance man to establish connections

to various groups of stations. Different codes will result in different stations (up to 30) being signaled.

Reliability and Maintainability

The specific requirements concerning maintainability were that the Mean Down Time (MDT) (service-affecting) will be 800 hours. Since MTBF and MDT, taken together, determine the overall system reliability, it was necessary not only to design a highly reliable system but also to provide means for rapidly locating the fault, when an error does occur. Recognized Reliability Engineering techniques (de-rating of components, redundancy, modular constructions, etc.) were employed, together with build-in self-analyzing and maintenance features, effective trouble-indicators and reporting systems, "plug-in" circuit modules, etc.

The testing equipment integrated into the Overseas AUTOVON maintains continual surveillance over its operation, yet never interferes with the progress of a call. Any unit that is found, by the "self-checking" operation, to be in trouble, is immediately taken "offline", and the call is served by the "backup" unit. Testing of peripheral circuits is performed only when they are not processing a call.

A control center serves as the focal point for maintenance effort. The test equipment includes a register-sender routiner which places test calls through the switch. Automatic trunk routing equipment places calls through intertoll trunks and PBX trunks; it employs a teletypewriter for printing results, a patching field, a maintenance console for housing alarms and displays, and maintenance monitor circuits for collecting fault-reports.

SUMMARY

The Overseas AUTOVON switching system demonstrates that end-to-end circuit-switched communications are not only feasible for military networks but provide capability beyond that of existing point-to-point networks. The system meets present-day military requirements, and its design and configuration makes it readily adaptable to future requirements. The feasibility of combining conventional electromechanical devices to produce a practical communication system is now clearly apparent.

Finally, an emerging pattern suggests that features and techniques developed for and applicable to todays's military networks are the forerunners of tomorrow's commercial communication systems.

QUESTIONS

1. How many countries will AUTOVON be installed in? _____

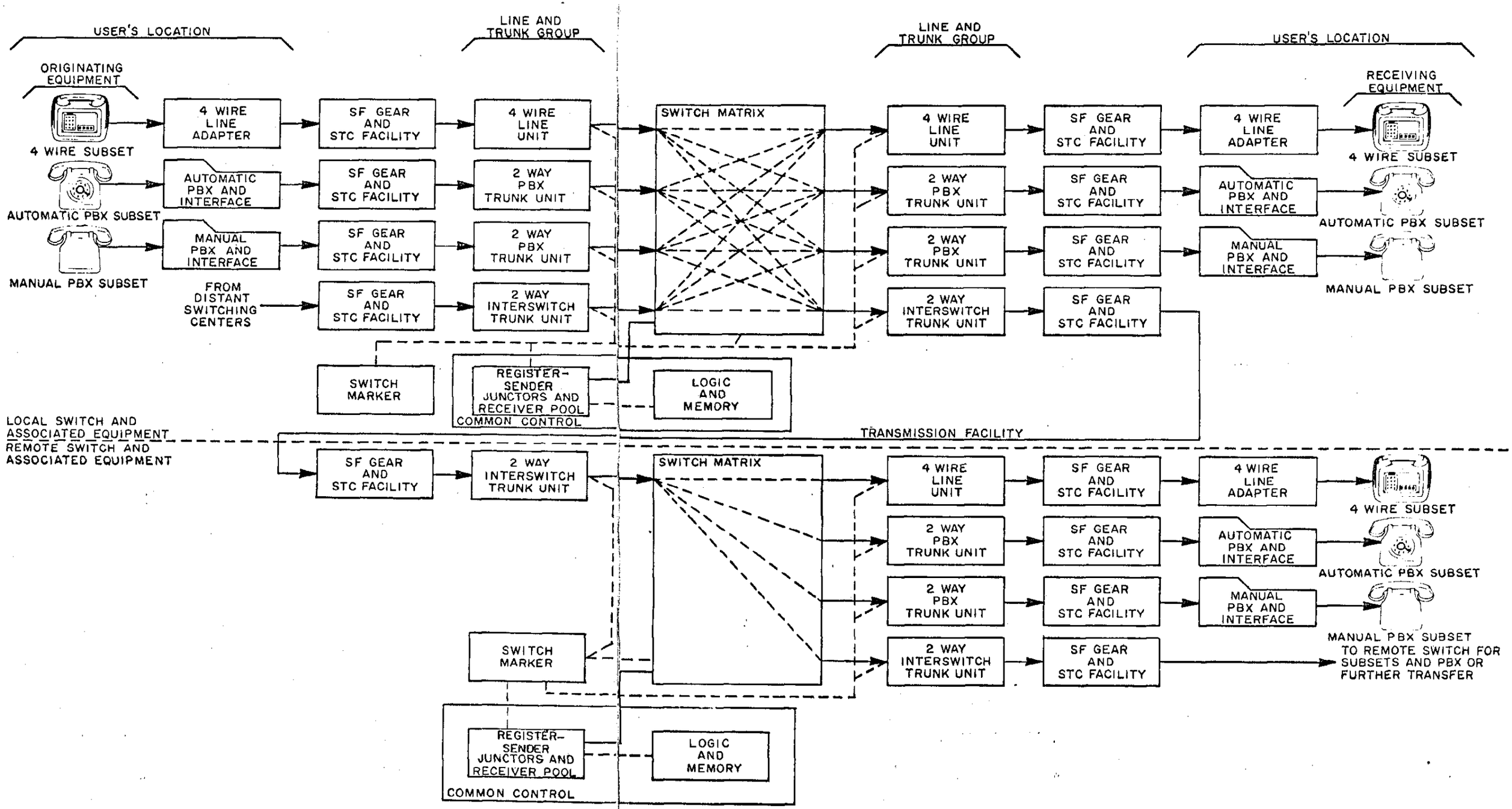
_____

2. The requirements for the AUTOVON switch is to be able to handle how many terminations? _____

_____

3. Where do we use 2/6 MF signaling extensively in the AUTOVON system? _____

_____



Foldout 3. Call processing, overall functional diagram for tw switching centers.