The Next Generation CONUS AUTOVON

TOM M. SHIMABUKURO, MEMBER, IEEE

Abstract—The future evolution of AUTOVON, the largest network in the Defense Communications System, is considered from the standpoint of survivability, cost, and commercial technological developments. A study of alternatives conducted by the Defense Communications Engineering Center is summarized and the attributes of the Next Generation AUTOVON are postulated. Related studies and a concept called the Defense Switched Network developed by the Office of the Assistant Secretary of Defense for Command, Control, Communications, and Intelligence are summarized.

I. INTRODUCTION

AUTOVON is a worldwide circuit-switched network for telephone and data transmission serving the Department of Defense and other authorized users. Its essential role is to provide survivable command and control communications to meet important operational requirements without wasting unused capacity in time of peace.

Recent changes in the threat to the United States, developments in the regulatory and legal arena of commercial telecommunications, as well as technological advances in communications and electronics have motivated a fresh look at the Next Generation AUTOVON, particularly within the Continental United States (CONUS).

The discussion is organized as follows:
- Background,
- Motivation for Change,
- Results of a Study,
- Related Studies and Programs, and
- The Defense Switched Network.

II. BACKGROUND

This section on the background of AUTOVON discusses the history which led to the emergence of AUTOVON which, in terms of annual operating costs, is the largest of the switched networks in the Defense Communications System. It is a “transparent” network which also carries data service and alternate routes for AUTODIN trunks as well as narrow-band trunking service for AUTOEVOCOM.

As recently as the early 1960's, long distance military telephone services were provided via manual switchboards. On December 29, 1961, the U.S. Army activated a network of leased four-wire automatic switches called the Signal Corps Alerting Network.

On April 19, 1964, the CONUS AUTOVON was established by combining the Signal Corps Alerting Network with the U.S. Air Force North American Air Defense/Air Defense Command (NORAD/ADC) Networks into a single network. Coincident with the merger, the AUTOVON-unique Multi-Level Precedence and Preemption (MLPP) feature and polygrid routing were implemented to assure service for meeting important military operational requirements.

At the time of the birth of AUTOVON, the capabilities of forces unfriendly to the United States were such that the polygrid network dedicated for military use was adequate for the postulated threats. Furthermore, the existence of the SCAN tariff arrangement for the lease of switching machines and the TELPAK tariff arrangements for bulk leasing of circuits provided affordable solutions for countering the threat to military communications. The development of the No. 1 ESS (Electronic Switching System) as well as availability of No. 5 Crossbar machines and the 490L switch manufactured by Automatic Electric Company provided the technological capabilities for implementing AUTOVON.

The fortuitous convergence of affordability, favorable regulatory environment, and technology, to answer the perceived threat to the nation permitted the successful implementation of AUTOVON.

III. MOTIVATION FOR CHANGE

AUTOVON has met its original objectives for the past 15 years, but the environment has continued to change, primarily in the areas of the threat to the United States, the rising cost of AUTOVON, and the pace of technological developments. This section on the motivating factors which are dictating a change in the direction of AUTOVON discusses the following:
- Survivability and Endurability of Command Control Communications,
- Cost and the Changing Regulatory and Legal Environment, and
- Technological Developments Among Commercial Carriers and Manufacturers.

A. Survivability and Endurability

The capabilities of the Soviet Union have increased considerably over the past 15 years, such that the survivability of AUTOVON and its capability to provide enduring command control communications for our nation's command authorities has now been questioned.

In the early 1960's, it was considered illogical that the Soviet Union would target AUTOVON switches when its limited resources could be utilized for the destruction of more lucrative targets. As such, AUTOVON switches were located away from targeted areas and the prime consideration was the survivability of the switches from collateral damage. The polygrid structure further assured that enduring command control communications could be provided.

Such is no longer the case. Even if the Soviet Union decided to utilize a very small fraction of its capabilities against the...
network, AUTOVON would be seriously affected and could be rendered inoperable.

B. Cost and the Changing Regulatory and Legal Environment

Perhaps the most immediate motivation for exploring alternatives for the future of AUTOVON were changes in the regulatory and legal environment culminating in two actions in 1976 by AT&T and the FCC which altered DCA's assumptions affecting the affordability of AUTOVON to continue its important role.

The Carterfone decision of 1968 by the Federal Communications Commission was the watershed which influenced the later trends in telephony away from regulated quasi-monopoly. The FCC decision essentially made the American telephone network available to non-Bell supplied communications equipment, first in the arena of user stations, and subsequently in the arena of private branch exchanges. In 1972, the FCC authorized the common carriers to construct and operate satellite systems for domestic telecommunications in the "free enterprise" mode as opposed to the regulated mode. In the legislative arena, several bills have been introduced with the intent of revising the Communications Act of 1934. All of these bills generally tend to favor a more competitive environment in telecommunications.

These tendencies and trends manifested their impact on AUTOVON in 1976 when the FCC released a docket which required that SCAN rates produce a significantly higher ratio of net operating earnings to net investment, in a move to foster competition. AT&T responded with a plan implemented in four phases which greatly increased the SCAN rates and resulted in deactivation of six of 51 AUTOVON switches.

Furthermore, the FCC in 1976 concluded that TELPAK rates were discriminatory and did not foster competition. In early 1977, AT&T withdrew its TELPAK offering. Because the withdrawal has been the subject of a number of petitions, the District of Columbia Court of Appeals listed an injunction which, for the time being, resulted in the continuation of the TELPAK arrangement to the users of record.

The large increase in SCAN rates and the possible demise of TELPAK have triggered several studies to explore immediate and long-range impact on CONUS AUTOVON. The total impact has been estimated at between $35 and $46 million per year. The total charges for CONUS AUTOVON in 1976 were about $100 million per year.

C. Technological Developments Among Commercial Carriers and Manufacturers

By Department of Defense policy, the Defense Communications System has consisted of leased facilities or services wherever the private sector and common carrier can provide the service. The Defense Commercial Communications Office (DECCO), the leased communications arm of the DCA, expends more than $400 million per year in leased services and facilities. Hence, in addition to survivability and cost considerations, technology in commercial telecommunications is another important factor in the environment.

1) Digital Switching: In switching technology, the explosive development and growth of PCM/TDM based telephone switches since 1976 will undoubtedly influence telephony and AUTOVON. For example, the AUTOVON switch at Fairview, KS, will be converted to a PCM/TDM based switch by an independent telephone company. Fig. 1 is a partial list of the commercial digital switching products in operation as of 1979 [1].

At the high end of the telephone switching hierarchy, AT&T and two independent telephone companies are rapidly implementing the No. 4 ESS as part of a gradual evolution from the Switched Analog Network (SAN) to the Switched Digital Network (SDN). It is anticipated that 87 No. 4 ESS's will be operating by 1982 with 12-15 per year being added thereafter.

At the end office and PBX level of the hierarchy, a growing number of manufacturers are introducing digital switches such that as of 1979, all new switches under development are digital as opposed to electromechanical or analog stored program control machines.

Digital telephone (circuit) switches have certain common characteristics. They are not restricted to switching just the standard 3 or 4 kHz voice channel. Instead, the 24 channel digroup, consisting of the \( \mu = 255 \) PCM format of the D2 channel bank, becomes the basic unit in facilities provisioning [2]. Significant economies have been demonstrated by directly terminating the digroup carried on 1.544 Mbits/s facilities. The preservation of bit integrity through the SDN offers opportunities for simplified and enhanced maintenance.

This technology thus promises a relatively rapid implementation and availability of networks with a "transparent" flow of information discussed in an accompanying article in this issue [3]. Because of its wide availability, transparent networks will probably dominate the switching scene in the early 1980's.

However, the development of a much more complex switch/processor being introduced by Satellite Business Systems (SBS) may be the precursor of what may be an emergence and evolution to "transactional" networks [4]. The Satellite Communications Controller (SCC) associated with the SBS performs the following principal functions:

- analog/digital voice conversion;
- data signal forward error correction coding/decoding;
- voice activity compression;
- signaling;
- call processing;
- circuit switching;
- echo suppression;
- formatting, framing, synchronizing;
- multiplexing;
- multiple access control and demand assignment control.

2) Transmission: Certain developments in commercial transmission systems offer potential for reduction in trunking services in AUTOVON. The investment cost per circuit mile to AT&T Long Lines has been dropping due to technological improvements. However, the most dramatic potential appears to lie in satellite and fiber optic technology.

a) Satellite: Several carriers are planning to offer service with small satellite terminals at or near customer locations in
the early 1980's, offering the potential to reduce access line and interswitch trunking charges of AUTOVON. Fig. 2 lists examples of new satellite services which may impact AUTOVON [5].

b) Fiber optic: Fiber optic technology has made such rapid strides in the last few years that its application in long haul transmission along the densely populated Northeast Corridor is being considered by commercial carriers. AT&T has announced that fiber optic transmission extending from Cambridge, MA, to Washington, DC, will be implemented by 1983.

IV. RESULTS OF A STUDY OF ALTERNATIVES

As a result of the strong influences brought to bear by the motivations noted above, a major study was conducted by the Defense Communications Agency on alternatives for the future of AUTOVON [6].

This paragraph discusses the following:
- Description of Alternatives,
- Comparison of Alternatives,
- Attributes of the Next Generation AUTOVON, and
- Strategy for Implementation.

A. Description of Alternatives

Based on a review of commercial technology, three basic approaches for a future AUTOVON were postulated.

1) Continue the present concept; lease a dedicated AUTOVON from AT&T and the independent telephone companies. In this approach, the polygrid backbone would be retained with possible replacement of the current switches.

2) Follow the telephone industry service offerings and take advantage of their plans and developments as introduced to the public at large. In this approach, a virtual AUTOVON would be implemented with traffic switched via the commercial long haul system, overlayed on an operational network.

3) Create a new CONUS AUTOVON based on new technology. In this approach, a network of small switches located close to posts, camps, and stations would provide the required service. Satellite connectivity for reducing trunking and access costs was explored.

![Fig. 1. Commercial digital switching products in operation.](image-url)

![Fig. 2. New satellite data-communication system for private networks in the United States.](image-url)
B. Comparison of Alternatives

The results of the DCA analysis indicated that the first approach of continuing the current concept could result in very large cost increases by 1985.

The second approach did not offer very great opportunities for savings. However, the results may be misleading in that new tariff arrangements may be offered in the future by AT&T which potentially could reduce the costs of this arrangement.

The third approach offered the greatest for savings, particularly if satellite technology could be exploited. The cost analysis is too lengthy to be described herein. However, the essential results are shown in Fig. 3.

The survivability analysis indicates that in the new threat environment, the future CONUS AUTOVON could provide more endurable command and control service if it relied on the entire grid of commercial communications instead of trunks, access lines, and switches for dedicated use.

Fig. 4 is one of the analytical results of the DCA study which shows the traffic carried by AUTOVON under stress versus unstressed conditions with the number of switches in the network handled parametrically. Note that if a structure like the present AUTOVON is to be retained, the traffic handling capacity under stress is far less than optimum for a network of 45 switches.

The results were not conclusive enough for the selection of any one alternative among the various approaches. Hence, it was determined that an evolutionary implementation strategy should be adopted deferring decision making until certain uncertainties are removed. For example, if it is feasible to develop new tariff arrangements, a pilot program could be implemented to remove uncertainties about the workability of such an option.

C. Attributes and a Strategy for Implementation

The DCA study indicates that from the standpoint of cost and survivability, the preferred future attributes call for increasing the number of switches in the network and distributing them closer to the user communities.

Specifically, the following attributes are highlighted.

- Predominance of digital switching (at all levels of switching hierarchy) and short-haul digital transmission. Long-haul transmission is digital via satellite but analog via terrestrial microwave systems although T1 channels are available. Digital transmission elements should be protected (i.e., bulk encrypted).
- Use of off-the-shelf hardware/software to the maximum extent possible. Special software/firmware may be required for unique applications.
- Lease of available services and facilities to avoid long lead time and costly military specifications.
- Multiple homing from a base/facility digital PBX, or central office to an AUTOVON mix of media consisting of satellite services, access to the DDD network, T1 tie trunks to other local switches, and T1 interconnects to a regional AUTOVON switch to achieve a survivability level commensurate with the users.

Design approach 1; continue present concept.
- Alternative 0: do nothing.
- Alternative 1: add common channel signaling.
- Alternative 2: convert backbone to digital.

Design approach 2; follow telephone industry.
- Alternative 3: virtual VON via #4 ESS.
- Alternative 4: virtual VON via WAIS, DDD.

Design approach 3: advanced concepts.
- Alternative 5: distributed switching close to or at users.
- Alternative 6: alternative 5 with satellite trunking.

- Access area software control for least cost routing and survivability enhancement.
- Exercise of operational direction by a dynamic “nail up” capability. System control should be characterized by distributed local control in peacetime, centralized control in crisis, and elements of both in wartime.
- Exercise of management control (network administration) with the assistance of automatic message accounting systems implemented at the switches.
- Integration of technical controls and terminating facilities with digital switches. Special purpose circuits would not need to be manually wired at frames or patched at patch bays but could be “nailed up” by the digital switches if necessary.
- Development of cost-sharing arrangements to eliminate the adversary nature between overall system grade of service versus minimization of funding for access lines.
- Provision of economical trunking service to AUTODIN, secure voice, and Special Purpose Network users.
D. Strategy for Implementation

The DCA study indicates that instead of opting for one of the alternatives, an evolutionary, opportunistic strategy should be pursued.

This evolutionary strategy proposed for implementing the Next Generation CONUS AUTOVON can best be summarized by Figs. 5, 6, 7, and 8.

Fig. 5 depicts the AUTOVON as it exists today; the backbone switches are represented by large crossed squares interconnected by lines representing voice channels for interswitch trunks.

The small crossed squares represent PBX's (base central offices) which provide AUTOVON access to two-wire stations. The rectangles labeled "A" represent the hardware interface specified by the DCS AUTOVON Interface Criteria. AUTOVON 4-wire users who enjoy the benefits of MLPP are depicted by triangles under concave arcs labeled "VON 4W." The little squares labeled "A" depict the hardware interface for this subscriber. The lines represent voice channels dedicated via paired cable or a voice channel on FDM carrier equipment.

The precedent is well-established for specifying DCA criteria for elements within the confines of a post, camp, or station, if associated with DCS services, and for AUTOVON providing trunking services for AUTOSEVOCOM and AUTODIN I.

Fig. 6 depicts AUTOVON as it might appear in 1982. The disappearance of the large crossed square in the upper left of the AUTOVON backbone indicates the closure of six AUTOVON switches in 1979 and the inclusion of at least digital AUTOVON switches (at Fairview, KS, for example). At the lower right, note the change to a digital PBX with remote switching units. The crossed boxes and rectangles are labeled "D" to indicate digital switching units. The dashed line represents a T1 digitally multiplexed line in contrast to solid lines which represent unmultiplexed voice channels on paired cables. Military departments have plans to implement such digital PBX's in the near future.

If feasible, experiments could be performed to link AUTOVON switches to the Bell System's No. 4 ESS on a trial basis. For example, AUTOVON switches in the Washington, DC, area and the San Diego area could be linked to a No. 4 ESS to provide an alternate path to the AUTOVON polygrid. Should studies or trials performed at that time prove the scheme unworkable, the project would be abandoned. This is an example of deferred decision making noted above.

Other trials based on the availability of small satellite terminals, and satellites in the 12-14 GHz range could be made by 1984 with implementation by 1987 (Fig. 6). A trial could be set up with perhaps two or four satellite terminals on posts, camps, and stations on the East and West Coasts to take advantage of low cost transcontinental services. If the trial were successful, this type of AUTOVON service would be increased. Note that all changes would be made without disrupting the existing services. Digital switches are compatible with the existing services. Digital switches are compatible with the existing analog switches and they would be retained until the new
techniques are clearly demonstrated. Additionally, experiments and trials with special interfaces for multirate data and secure voice can be conducted to establish interface criteria and standards for these special subscribers.

If these trial projects were to prove successful, then it might be possible to proceed to the configuration shown in Fig. 8. This configuration represents a future AUTOVON wherein the majority of the digital switching functions are located on the posts, camps, and stations. The transmission media are provided by a mix-of-media established by survivability, technical, and economic considerations. Satellite earth terminals are collocated with digital central offices or AUTOVON switches and operate in a demand assigned mode with a 12/14 GHz satellite. A number of value-added benefits for satellite service are noted in the figure. Capabilities also exist for calls to traverse the DDD network, to be connected via 1.544 Mbit/s lines to other nearby central offices, and to be routed to other AUTOVON switches. However, in all likelihood, by 1992, the attributes of a desirable future system will have changed because of new technologies, and the system will bear no resemblance to Fig. 8. Nevertheless, some of the projects along the way may yield the payoff of reducing AUTOVON costs and making AUTOVON more responsive. In this sense, Fig. 8 does not represent a target system. Yet the desired attributes have led to trials and projects which may yield a high payoff while minimizing the risks of implementation and unforeseen cost growths.

The decisions as to when local posts, camps, and stations wish to convert to digital operation will depend on their local environments. This decision process further exemplifies the evolutionary strategy.

V. RELATED STUDIES AND PROGRAMS

In the previous section, it was noted that the military departments and the Assistant Secretary of Defense (ASD) for Command, Control, and Intelligence (C3I) have embarked on concepts, plans, programs, and projects for upgrading the on-base and metropolitan area communications. Much of this activity exploits developments in commercial switching technology to achieve savings. This section discusses:

- Base Communications Plan (BASCOP),
- SCOPE DIAL,
- Defense Metropolitan Area Telephone System, and
- AUTOVON Digital Switch Conversion/Activation.

A. Base Communications Plan

The Army’s Base Communications Plan (BASCOP) study examined several alternative architectures for the future of telecommunications on Army posts, camps, and stations [7]. It essentially recommended the use of digital switching with remote switching units integrated with T1 digital transmission lines as the most economical of alternatives considered. The first implementation of this concept is planned for Fort Hood, TX.

B. SCOPE DIAL

The Air Force’s SCOPE DIAL is a plan to acquire new digital switches with a common specification for air bases throughout the world to improve communications support to the Air Force mission [8]. The switches based in the United States are also motivated by rotational training needs and economy. The acquisition is being planned on a gradual basis as funds are made available. The first of the SCOPE DIAL switches will be acquired for Wright Patterson AFB, Vandenberg AFB, and Osan AFB in Korea.

C. Defense Metropolitan Area Telephone System

The Defense Metropolitan Area Telephone System (DMATS) concept was introduced by ASD (C3I) in a DoD directive to achieve the economies possible with stored program switches for servicing DoD long haul telephone needs [9]. The first DMATS switching complexes are intended for implementation in the areas surrounding Boston, MA, Norfolk, VA, and San Diego, CA.

D. AUTOVON Digital Switch Conversion/Activation

The conversion to or activation of digital switching for AUTOVON will first appear among those that are provided by the independent telephone companies. The AUTOVON switch at Fairview, KS, is scheduled for conversion to digital operation followed by the activation of digital switches near Anchorage, AK, and Fairbanks, AK. The switch at Toledo Junction, OH, is also being considered at present.

VI. THE DEFENSE SWITCHED NETWORK

Recent studies noted above concerning CONUS AUTOVON and Base Telephone switching systems have highlighted the advantages of employing digital switching/transmission equipments and techniques, and of placing AUTOVON switching facilities at or close to the users on military bases. Additionally, on-base or regional commercial satellite terminals are being advocated for handling portions of long distance AUTOVON traffic.

The Assistant Secretary of Defense for Command, Control, Communication, and Intelligence (C3I), aware of the ongoing efforts noted above, issued a memorandum on September 6, 1979, defining the planning effort for the Defense Switched Network (DSN) which tasked “DCA with MilDep participation” to “refine and enlarge on the concept studies already underway” [10]. The objective is to develop a well-defined Defense Switched Network concept which exploits the switches being acquired to obtain the maximum benefits for the Department of Defense Communications.

To ensure that the next generation AUTOVON will evolve in an orderly manner and will take advantage of all economics, it is necessary for DCA and the Military Departments to work closely together on this concept.

SUMMARY

A concern for the changing threat to the nation, the rising cost of AUTOVON, and the promise and potential of technology have motivated a fresh look at the system. An exhaustive study by the Defense Communications Agency recommends an evolutionary change in the direction of a proliferation of switching nodes with network intelligence as close to the user as possible using a mix of media exploiting the nation’s entire
telecommunications resources. The military departments concurrently are opting to gradually replace the telephone exchanges and PBX's on posts, camps, and stations. The convergence of these activities in a synergistic evolution to the Defense Switched Network offers great opportunities and challenges for the next generation AUTOVON.

REFERENCES


Tom M. Shimabukuro (S'61–M'70) was born in Makawao, Maui, HI, on January 17, 1935. He received the A.B. degree in liberal arts and the B.S. degree in electrical engineering from Columbia University, New York, NY, in 1957 and 1961, respectively.

Since 1965 he has been employed by the Defense Communications Agency, with assignments in Southeast Asia, Europe, and in Washington, DC. He is currently with the Systems Engineering Division of the Defense Communications Engineering Center, Reston, VA.