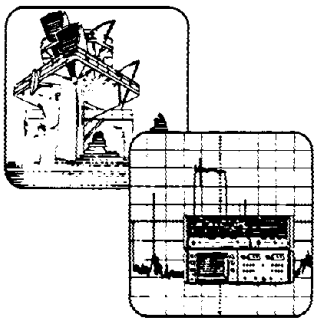
The Effects of Wireless and Advanced Technology on Existing 9-1-1 Networks

Management Briefing

Number 5

ONE OF A SERIES OF NOTES ON
TECHNOLOGY FROM ADCOMM



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This short paper offers discussion on nontechnical issues related to 9-1-1 systems. It is done as an aid to managers and others with limited technical knowledge of communications. The use of some telephone jargon and terminology is unavoidable, but terms are explained as needed. A slightly edited version of this paper appeared in the February 1994 issue of NENA News.

Introduction

To many public safety professionals, enhanced (E)9-1-1 is a way of life. We have been dedicated to the establishment of (E)9-1-1 throughout the country. After living and working in areas that have had (E)9-1-1 for many years, we could not even imagine going back to the days of Basic 9-1-1 or worse yet—back to no 9-1-1 at all. Many of these systems are based on technology that is over 20 years old (#1AESS Tandem Offices), and changes in the telephone networks and the way people will use them will render these systems obsolete. There are people that question the continued expansion of enhanced systems because new technology will obsolete the systems in a couple of years. Even systems using newer technology will be facing major changes because the very nature of the telephone network is changing. We are moving away from a network where the connections to the telephones are changing from being fixed to one where the connections are elastic as shown in Figure 1. A single telephone number may be used for a variety of different locations–all under control of the user, many times a day. If changes are not made in (E)9-1-1 systems, they will become a technological dinosaur and their usefulness severely decreased. What huge change will bring this about? **Personal Communications Services or PCS**. Currently in the early stages of licensing and implementation, PCS services have the potential to dramatically change the way we live. This technology is heavily based on wireless communications and eventually the use of a single telephone number no matter where a person is. While PCS is the current driving force for the change, other changes in the telephone network will continue to stretch the existing (E)9-1-1 technology.

Some (E)9-1-1 systems use technology that may be easily adaptable to the changing telephone network. While it may be possible to continue to "band-aid" the existing systems for a period of time, these systems will eventually not be capable of adapting. Now is the time to begin the process of planning and implementation of a new generation of (E)9-1-1 systems. The purpose of this article is to bring the issues to light and discuss some of the options available.

What is the Problem?

Virtually all (E)9-1-1 systems today route 9-1-1 calls and provide location information by keying on the caller's automatic number identification (ANI) information. This information is based on the same information used for billing long distance calls. The ANI is used to reference a PSAP location and to index the Automatic Location Information (ALI) database system. This is possible today because most telephone numbers are associated with a fixed, hard-wired network connection. The amount of movement of the telephone is limited to the length of the phone cord or in some cases the range of the cordless telephone. Imagine, a PCS cordless phone that will work anywhere in the United States and possibly the world. Imagine, also that approximately

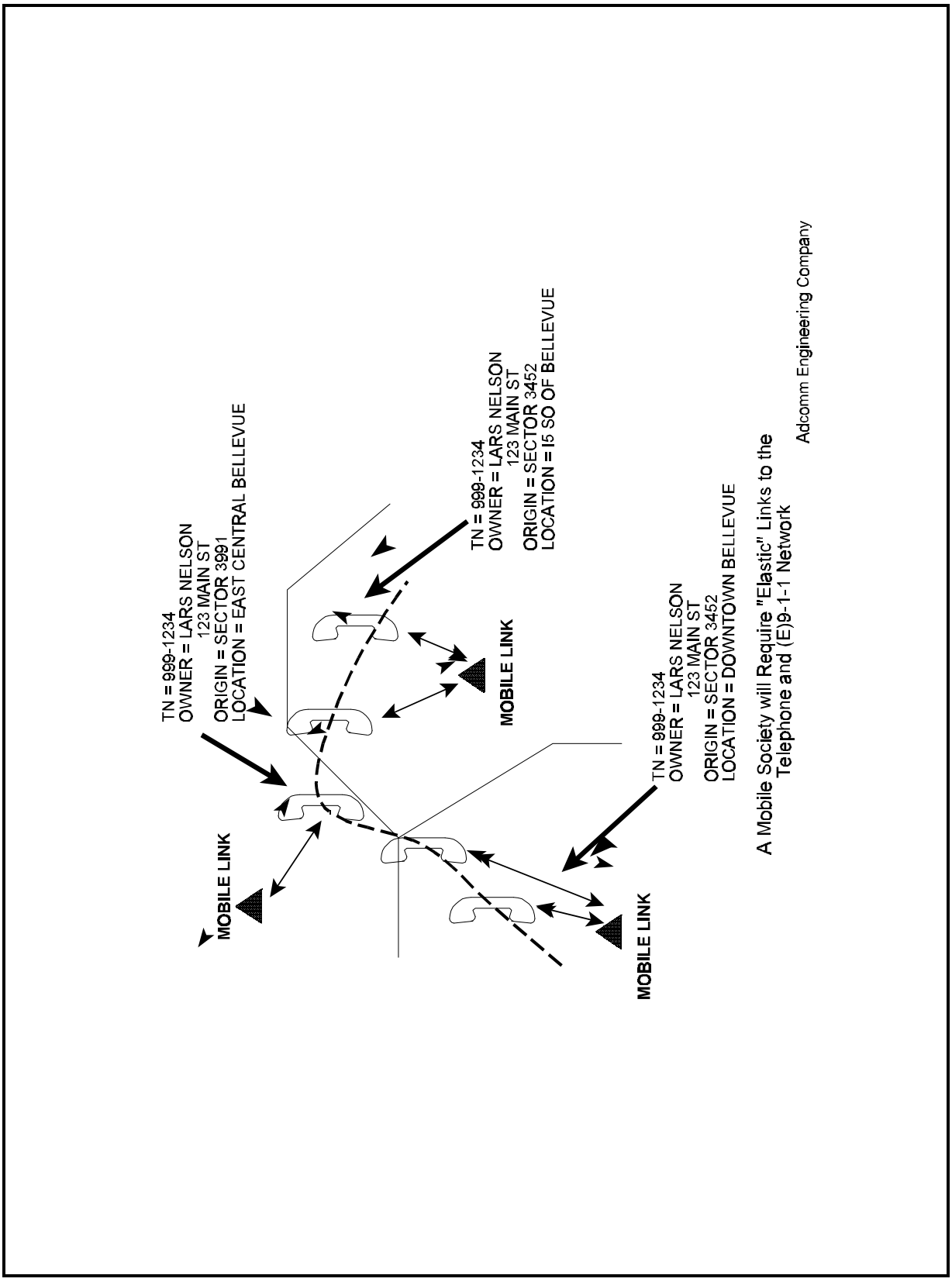
TN = 999-1234
OWNER = LARS NELSON
123 MAIN ST
ORIGIN = SECTOR 3991
LOCATION = EAST CENTRAL BELLEVUE
MOBILE LINK
TN = 999-1234
OWNER = LARS NELSON
123 MAIN ST
ORIGIN = SECTOR 3452
LOCATION = I5 SO OF BELLEVUE
MOBILE LINK
TN = 999-1234
OWNER = LARS NELSON
123 MAIN ST
ORIGIN = SECTOR 3452
LOCATION = DOWNTOWN BELLEVUE
MOBILE LINK
A Mobile Society will Require "Elastic" Links to the
Telephone and (E)9-1-1 Network
Adcomm Engineering Company

Figure 1

40 percent of the population is using these PCS cordless phones, often with whole neighborhoods using these instead of wired telephones. No longer will ANI provide a reliable fixed reference for routing calls and location information. What can be done? In the future, (E)9-1-1 systems will need to be able to dynamically route calls based on location information provided by the PCS system. This is a significant problem even today with calls from cellular telephone systems though they are used by only 6 percent of the population. Unlike PCS, cellular generally will not replace wired communications but will serve as an adjunct or extended communications system. Recognizing the potentially damaging effect of PCS on the effectiveness of (E)9-1-1, APCO (through Project 31) and NENA are working to establish location information and interconnection standards to be used by with the PCS service providers. The technology is moving fast and the (E)9-1-1 community needs to be ready to make changes in their systems to accommodate this new technology. The changes will likely be extensive, costly, and will need to be done within a few years' time. The exact method of identifying and locating PCS calls has not yet been determined, though the concepts of routing are the same regardless of the ultimate choice of location information format.

Existing Technology

Figure 2 shows a typical (E)9-1-1 system based on a telephone company (telco) tandem central office known as a selective router. The caller's ANI is forwarded along with the call from the telco central office to the tandem office. Special software in the tandem uses the ANI to determine which public safety answering point (PSAP) the call should be routed to. When the call is received at the PSAP, special terminal equipment receives the ANI and requests the ALI from the ALI database on a separate data system. The ALI information is then sent back to the PSAP from the database and is displayed at the console position that answered the call. The data in the selective routing software and the ALI database is derived from telco service order records and is usually updated daily. As mentioned earlier, the ANI is the key element in the process and is tied to a fixed location as known to the telco.

This approach has problems today with cellular calls that often do not have ANI or proper ALI, with PBX calls because the ANI may be for the PBX location and not for the location of the PBX extension, and with multiparty callers. The system as it is will not accommodate PCS because there is no method for passing along call routing information, and the software in the selective router would not know what to do with the information if it existed.

Some (E)9-1-1 systems use a selective routing system that is independent of the telephone company tandem office. In some cases these systems use the same approach as the tandem type selective router and in some cases they do not. The systems that use the same basic approach will have the same limitations as the tandem office except that it may be easier to modify the equipment for a new routing process. (E)9-1-1 systems that use a different technology such as data before voice may be able to adapt fairly easily and with a minimum effect on the PSAP equipment.

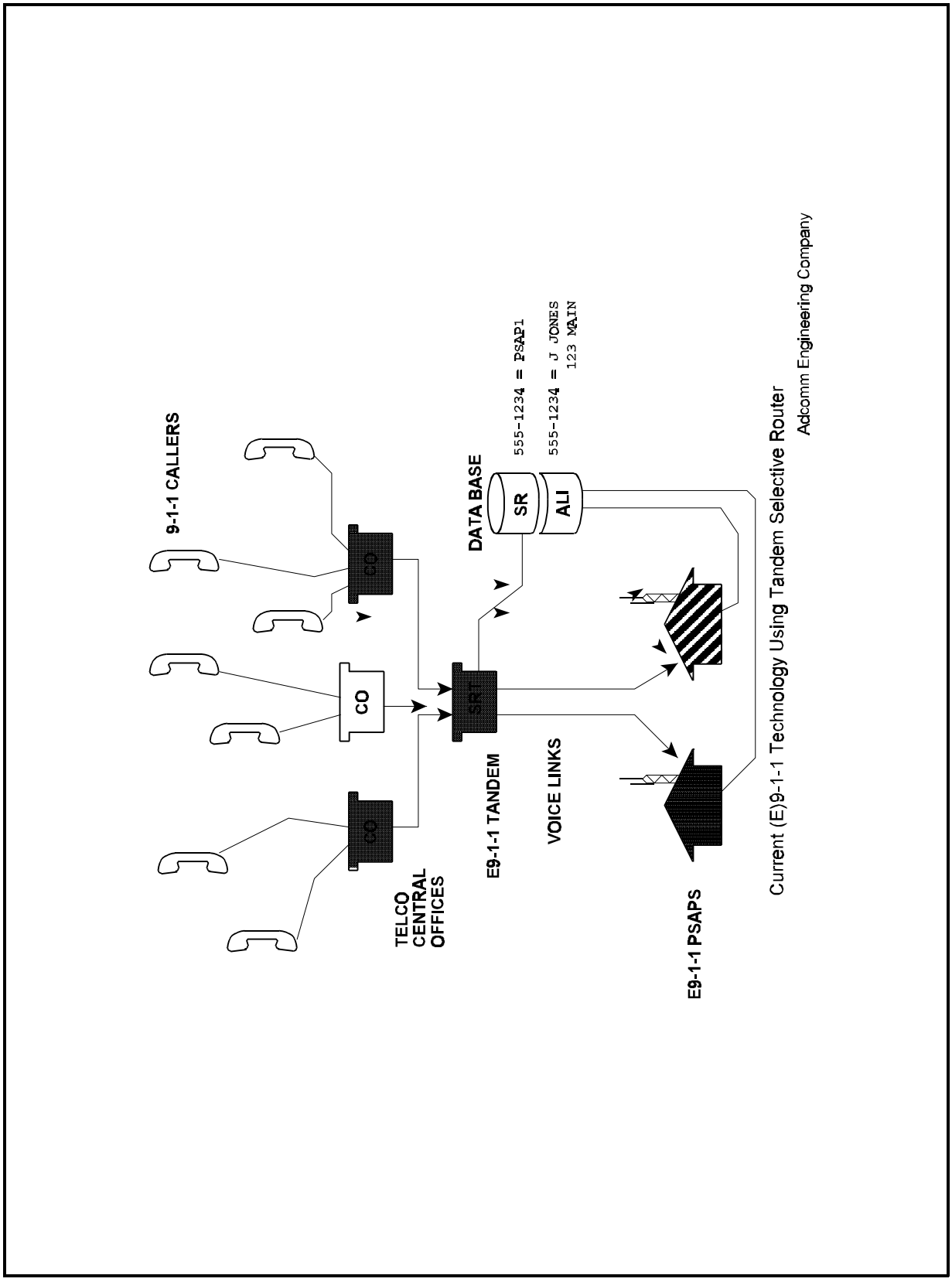
9-1-1 CALLERS
CO
CO
CO
TELCO CENTRAL OFFICES
DATA BASE
SR
ALI
555-1234 = PSAP1
555-1234 = J JONES 123 MAIN
SRT
E9-1-1 TANDEM
VOICE LINKS
E9-1-1 PSAPS
Current (E)9-1-1 Technology Using Tandem Selective Router
Adcomm Engineering Company

Figure 2

PSAP equipment will have to accommodate whatever data are sent. Locations based on longitude or latitude or a local grid system may require changes in the PSAP display equipment, CAD systems, local database systems, and any related equipment.

Figure 3 shows how the telephone network is evolving from a system that had one large dominate carrier that controlled the data and the technology to a system that allows for multiple carriers and provides flexibility and intelligence. These changes are being driven, in part, by the requirement for advanced features and the competitive environment.

PCS System and the Telephone Network

It is expected the exact method of PCS system interconnection may vary depending on who the PCS provider is (there could be up to five to seven in the same market area). Figure 4 shows what a typical arrangement might look like. The system consists of a radio base station called the radio port, a radio port controller that will control multiple radio ports, and a switching center that will control the radio port controllers and call routing. In some cases, this switching center may be a standalone switching system much like cellular switching centers are today. In other cases, the switching center may be part of the wireline telephone company office. It is also entirely possible for several wireless switching offices to be connected together before they connect to the conventional telephone central office. There could be significant and widely varying geographical distance between the location of the radio port and the point at which the PCS switching office connects to the wireline network. There will likely be issues related to routing the call to the correct jurisdiction and between different (E)9-1-1 jurisdictions and tandem offices. This will significantly complicate the switching process. Today, using the normal tandem selective router method, transferring calls between (E)9-1-1 systems is difficult. Many of these problems exist today with cellular but their effect on 9-1-1 calls could balloon with PCS because of the expected volume of users.

Since (E)9-1-1 systems use location data to route calls, continued effectiveness of the system means that the PCS service provider will need to send location information for every 9-1-1 call. This location keying is the crux of the problem. Not only will the PCS provider need to develop a method to do this but the (E)9-1-1 systems will need to be able to transport and process the information. Here are five possible ways to resolve this aspect of the problem. It is hoped that this discussion will help foster creativity and that an optimum solution will emerge before the next Ice Age! PCS needs to be integrated into the (E)9-1-1 system just like part of the regular network is today.

Adjunct Processor/Tandem Selective Router Option

Figure 5 is a diagram showing a standard tandem selective router connected to a PCS switching center with an adjunct processor between the two. The PCS switching center would pass along the PCS caller's ANI and on a separate data link the location information. Using this information the adjunct processor would provide routing information to the selective router and to the ALI

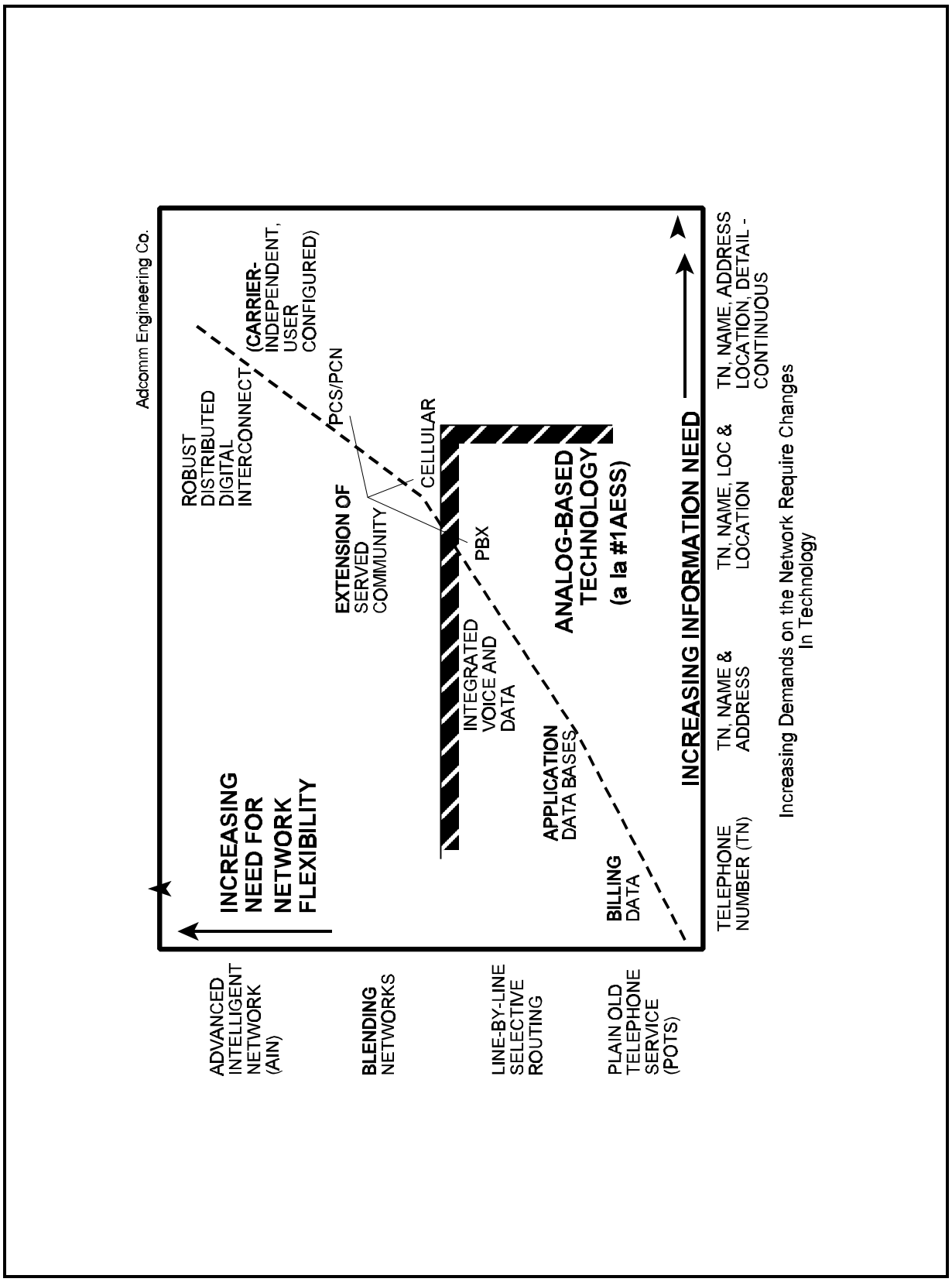
Adcomm Engineering Co.
INCREASING NEED FOR NETWORK FLEXIBILITY
ROBUST DISTRIBUTED DIGITAL INTERCONNECT
(CARRIER-INDEPENDENT, USER CONFIGURED)
PCS/PCN
EXTENSION OF SERVED COMMUNITY
CELLULAR
PBX
INTEGRATED VOICE AND DATA
ANALOG-BASED TECHNOLOGY (a la #1AESS)
APPLICATION DATA BASES
BILLING DATA
INCREASING INFORMATION NEED
TELEPHONE NUMBER (TN)
TN, NAME & ADDRESS
TN, NAME, LOC & LOCATION
TN, NAME, ADDRESS LOCATION, DETAIL - CONTINUOUS
ADVANCED INTELLIGENT NETWORK (AIN)
BLENDING NETWORKS
LINE-BY-LINE SELECTIVE ROUTING
PLAIN OLD TELEPHONE SERVICE (POTS)
Increasing Demands on the Network Require Changes In Technology

Figure 3

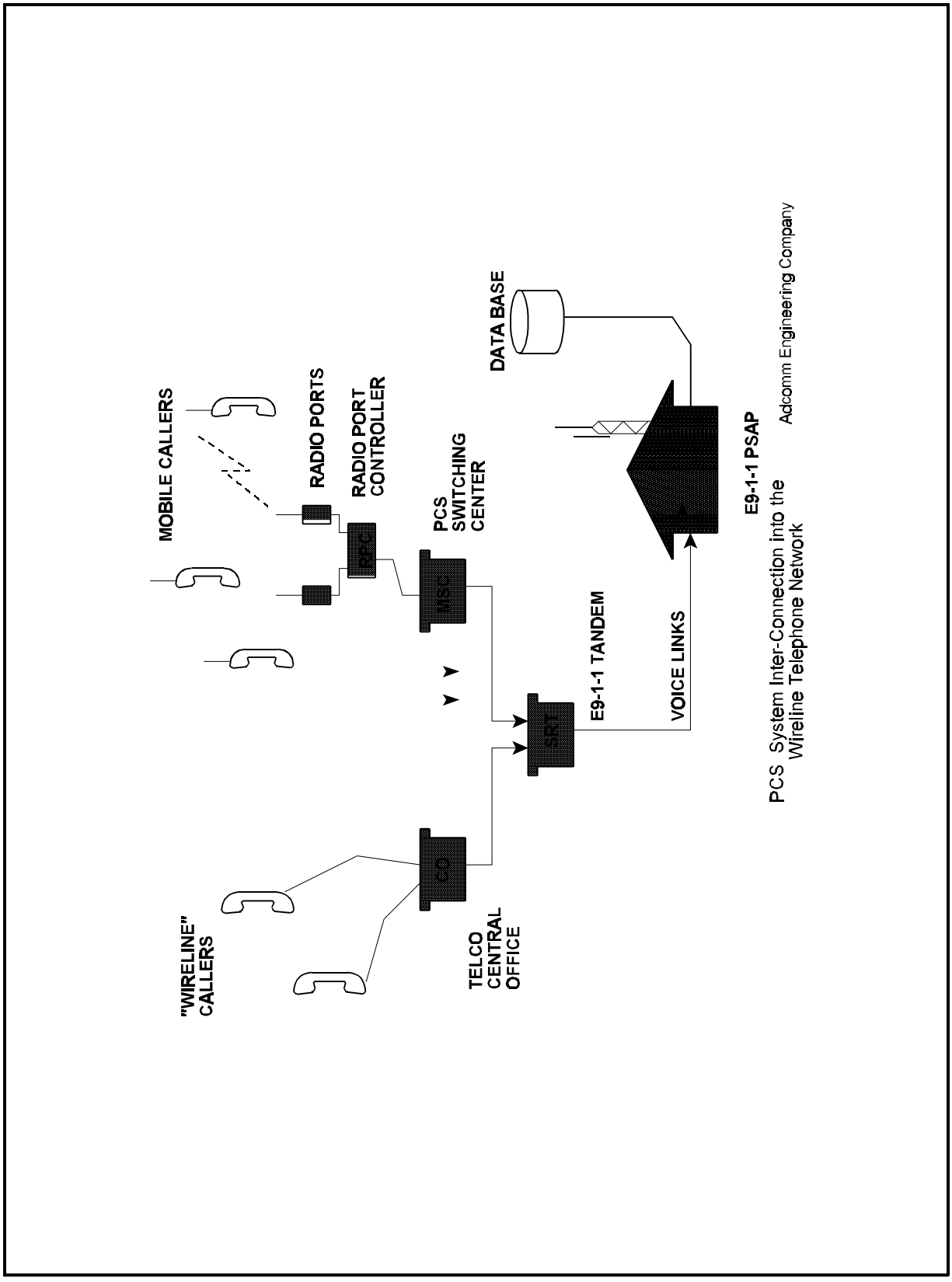
MOBILE CALLERS
RADIO PORTS
RADIO PORT CONTROLLER
RPC
PCS SWITCHING CENTER
MSC
DATA BASE
E9-1-1 PSAP
Adcomm Engineering Company
E9-1-1 TANDEM
SRT
VOICE LINKS
PCS System Inter-Connection into the Wireline Telephone Network
"WIRELINE" CALLERS
CO
TELCO CENTRAL OFFICE

Figure 4

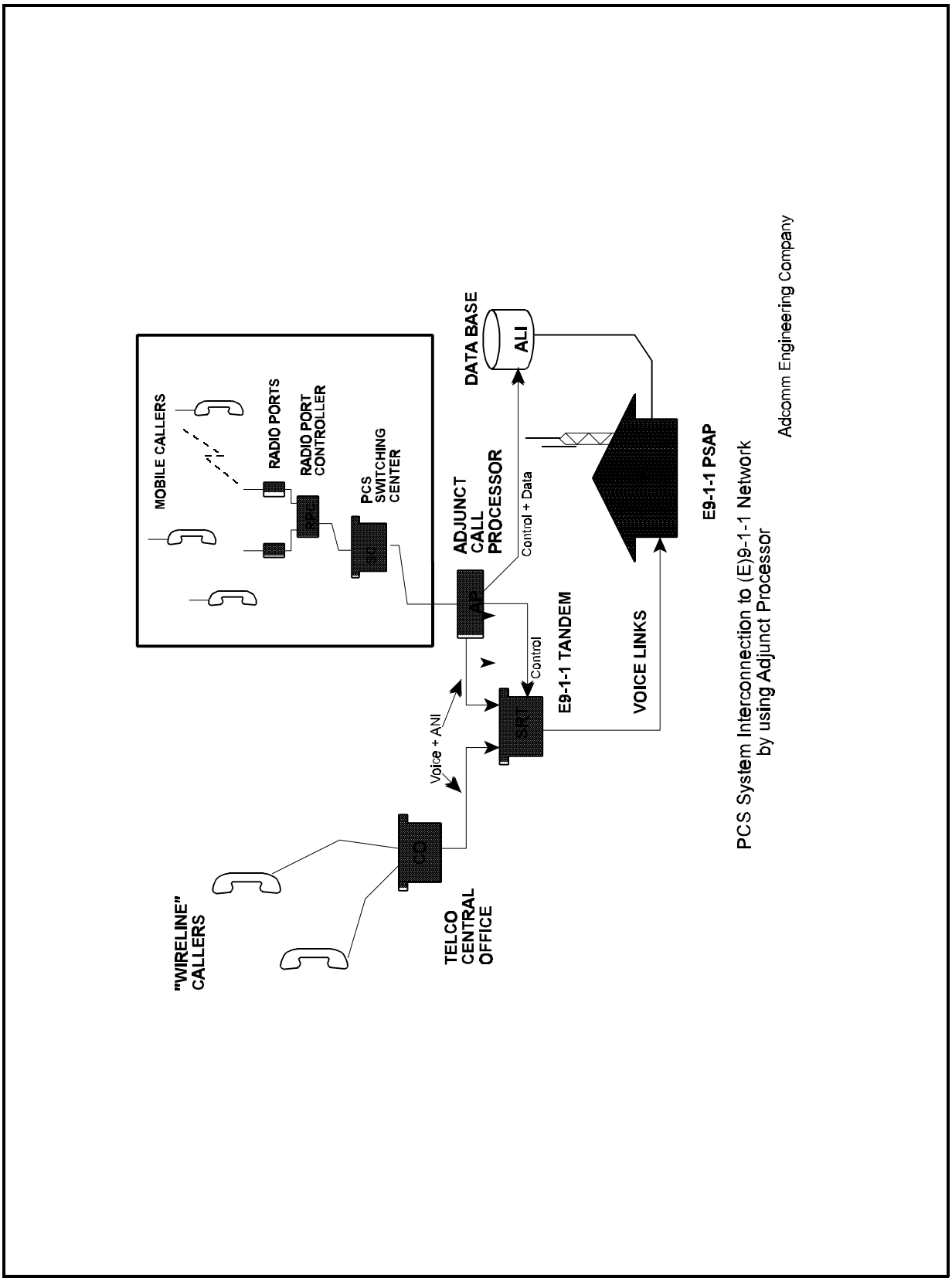
MOBILE CALLERS
RADIO PORTS
RADIO PORT CONTROLLER
RPC
PCS SWITCHING CENTER
SC
DATA BASE
ALI
ADJUNCT CALL PROCESSOR
AP
Control + Data
Control
E9-1-1 TANDEM
SRT
VOICE LINKS
E9-1-1 PSAP
Voice + ANI
CO
"WIRELINE" CALLERS
TELCO CENTRAL OFFICE
PCS System Interconnection to (E)9-1-1 Network
by using Adjunct Processor
Adcomm Engineering Company

Figure 5

database. From then on, the call would be handled the same as any other 9-1-1 call. In this case, the PSAP equipment would still receive the data from the ALI database and the tandem. While the data format may change, the basic operation of the PSAP equipment would remain the same. This option would essentially encapsulate the PCS system and require little change in the PSAP equipment.

Unfortunately, this approach does not address problems like routing across (E)9-1-1 system boundaries and is tied to the older technology used in the central tandem selective router approach. This approach does, however, offer a quick and short-term solution.

Data With Call/Tandem Selective Router Option

This approach uses data multiplexing to permit carriage of the PCS information by the existing system. This approach is used in some (E)9-1-1 systems today. Figure 6 is a diagram of this approach showing a standard tandem selective router connected to a PCS system through an adjunct processor. In this option, the call routing data is passed along with the call prior to the voice. The adjunct processor would receive the information, direct the routing of the call, and pass along the location information prior to voice cut-through. Such a system would require modifications to most types of PSAP equipment to allow the receipt of the data on the same lines as the voice call.

The advantage of this technique is that the telco ALI database does not need to be modified, and any security concerns the PCS providers have about the telcos handling or managing their data are reduced. This same approach could work with cellular and PBX calls if the systems provide location/routing information along with the call. This may solve more problems than the first option but still has the same limitations of routing across (E)9-1-1 systems. It is generally more adaptable to other new technologies.

Figure 7 is a diagram that shows the basic differences between the first two approaches.

(E)9-1-1 Call Routing by the PCS Provider Directly

This case is shown in Figure 8. The PCS provider would be directly responsible for routing the calls to the correct PSAP. This would require a close working arrangement with the public safety officials in the service area. The PSAP would then be receiving (E)9-1-1 calls from more than one network. This option would probably require the PSAPs modify or replace existing

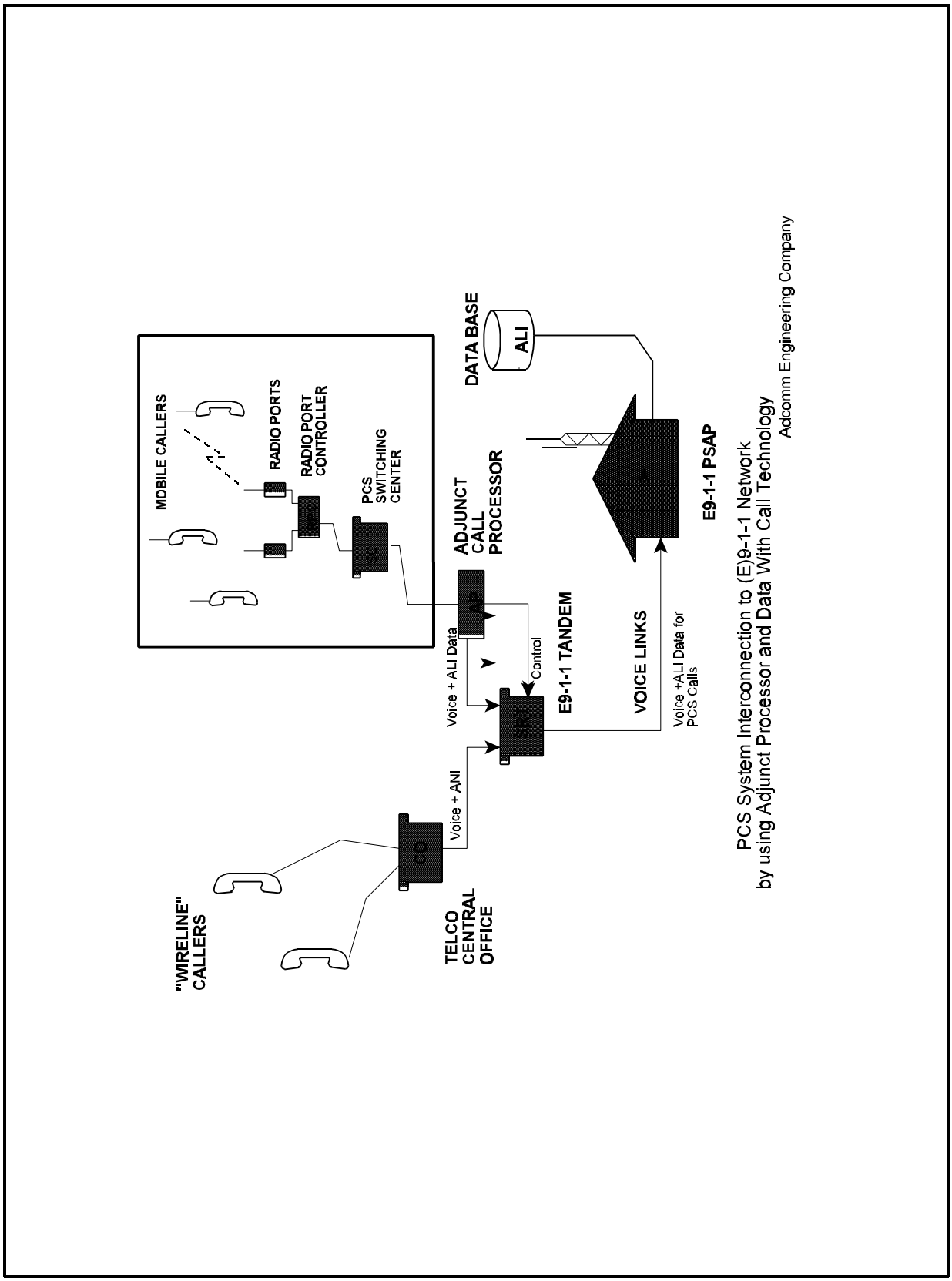
PCS System Interconnection to (E)9-1-1 Network
by using Adjunct Processor and Data With Call Technology
Adcomm Engineering Company
MOBILE CALLERS
RADIO PORTS
RADIO PORT CONTROLLER
PCS SWITCHING CENTER
RP
RC
DATA BASE
ALI
ADJUNCT CALL PROCESSOR
AP
E9-1-1 PSAP
Voice + ALI Data
Control
E9-1-1 TANDEM
SRT
VOICE LINKS
Voice +ALI Data for PCS Calls
Voice + ANI
CO
"WIRELINE" CALLERS
TELCO CENTRAL OFFICE

Figure 6

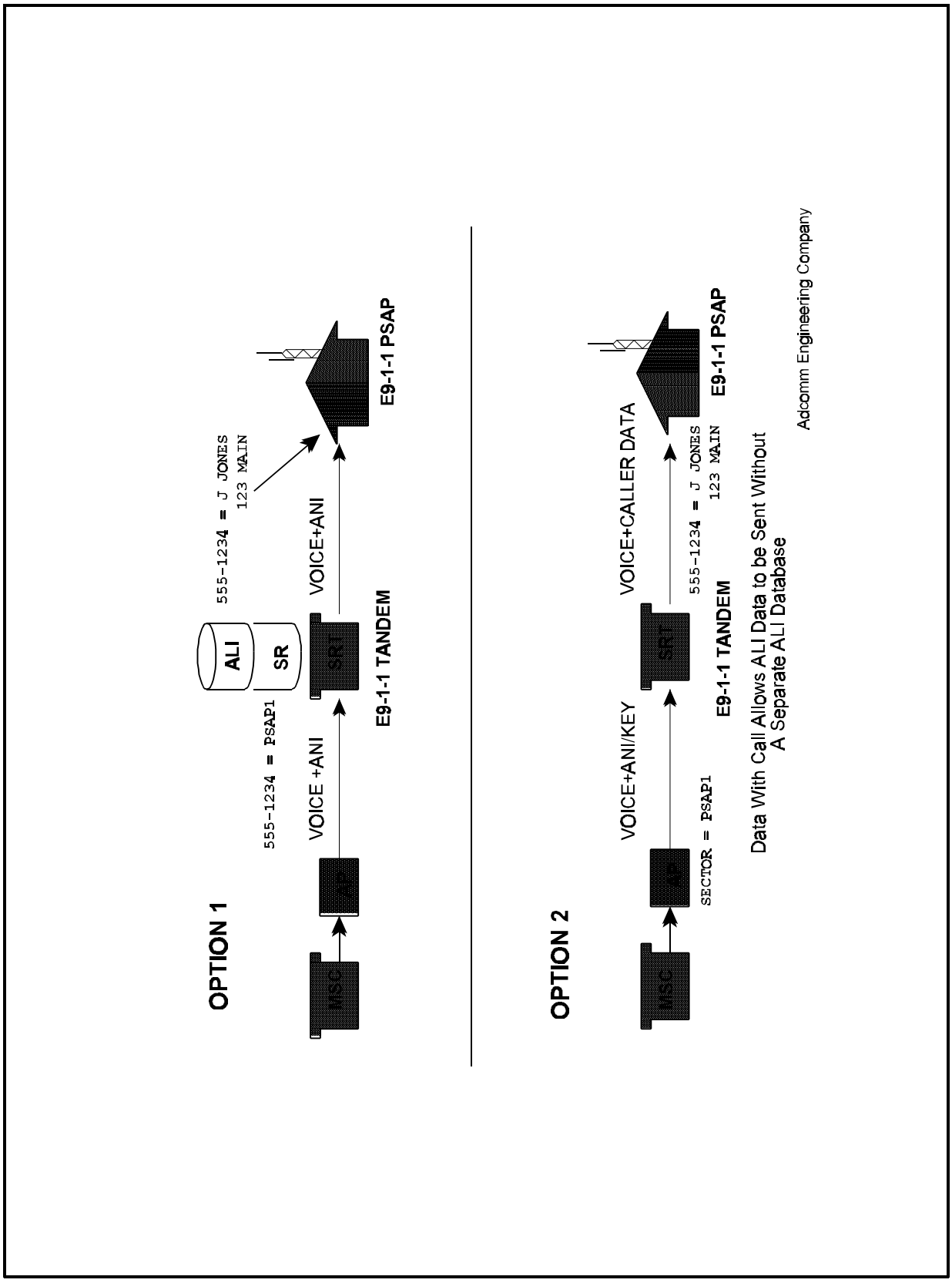
OPTION 1
MSC
555-1234 = PSAP1
VOICE +ANI
SRT
E9-1-1 TANDEM
ALI
SR
555-1234 = J JONES
123 MAIN
VOICE+ANI
E9-1-1 PSAP
OPTION 2
MSC
SECTOR = PSAP1
VOICE+ANI/KEY
SRT
E9-1-1 TANDEM
555-1234 = J JONES
123 MAIN
VOICE+CALLER DATA
E9-1-1 PSAP
Data With Call Allows ALI Data to be Sent Without
A Separate ALI Database
Adcomm Engineering Company

Figure 7

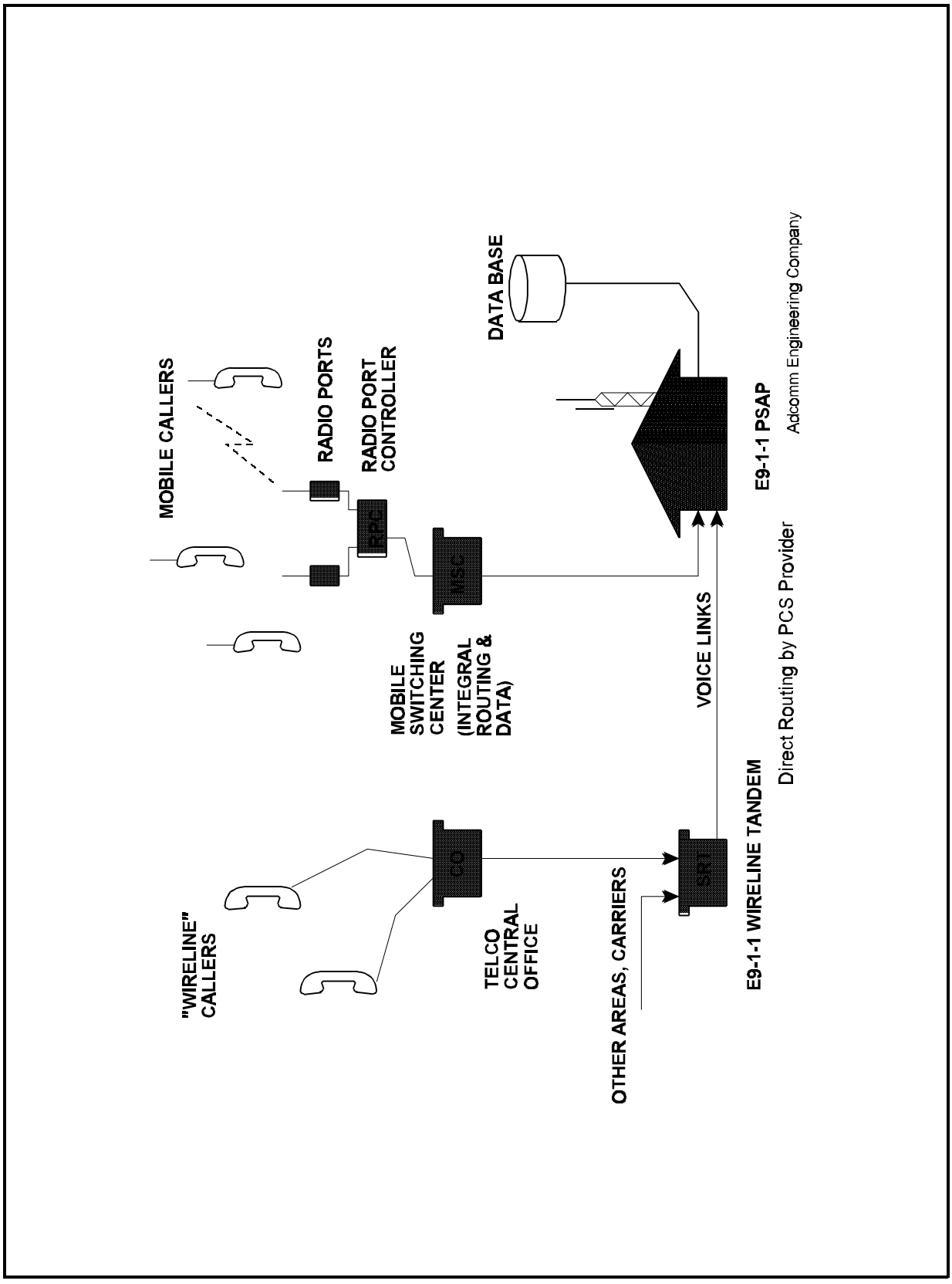
MOBILE CALLERS
RADIO PORTS
RADIO PORT CONTROLLER
RPC
MSC
MOBILE SWITCHING CENTER (INTEGRAL ROUTING & DATA)
DATA BASE
E9-1-1 PSAP
Adcomm Engineering Company
VOICE LINKS
Direct Routing by PCS Provider
"WIRELINE" CALLERS
CO
TELCO CENTRAL OFFICE
OTHER AREAS, CARRIERS
SRT
E9-1-1 WIRELINE TANDEM

Figure 8

equipment to be able to handle multiple data sources for ALI retrieval or by using the Data With Call approach discussed in the previous option.

This option has the advantage that the task of implementing the network portion may be able to be shifted to the PCS provider with little impact to an existing (E)9-1-1 network other than PSAP equipment changes. However, this option has potential problems routing calls between PSAPs unless the PCS provider provides full switching and transfer capability within their network. This approach only resolves the immediate problem of PCS 9-1-1 calls without addressing the problem of cellular or PBX calls. A drawback of this approach is that each PCS provider must build and maintain routing tables.

Separate (E)9-1-1 Network Option

An entire separate (E)9-1-1 network could be built as shown in Figure 9. This network would take input from any external switching system, PCS, cellular, PBX, etc. and process the calls accordingly. The network could be built with multiple interface capability for both switching systems and database systems. It would most likely use some type of Data With Call technology so the location and ownership of the database was not critical. This approach, if designed right, could be adaptable in the future to virtually any technology that develops. It could also be designed to provide for intersystem (E)9-1-1 call transfers assuming the correct protocols were in place. This approach would also allow other service providers to bid on providing the system or the service. The local government could own the equipment but contract out its operation.

This option has the disadvantage of high cost and requiring the replacement of the PSAP equipment. This system will be expensive not only to acquire but also to operate. Existing (E)9-1-1 systems have the advantage that much of the maintenance of the equipment and facilities is part of normal network maintenance and not specific to (E)9-1-1.

Use of Signalling System 7 (SS7) and the Advanced Intelligent Network (AIN)

Figure 10 shows a system that uses SS7 and AIN concepts for call routing and handling. This approach would use an expanded version of the existing SS7 network to provide call routing and data information transport. The SS7 network will be widely used in the future to add features and provide call routing information as we move to an ever increasingly complex telephone network. The PCS switching system would provide caller identification and location information to the SS7 network. The SS7 network database/application processor would determine which PSAP was appropriate and direct the voice network to route the call accordingly. The SS7 network would then pass the caller identification and location information to the PSAP by a data connection. This would operate in a manner similar to the 800-number routing that is currently being done.

This approach has the potential to provide several powerful capabilities. Because the SS7 network provides routing control of the voice network, it can provide alternative routes to PSAPs during equipment, network, or congestion failures. It has the potential to provide connections to cellular systems and possibly PBX systems. SS7 and AIN features are portrayed as the future of

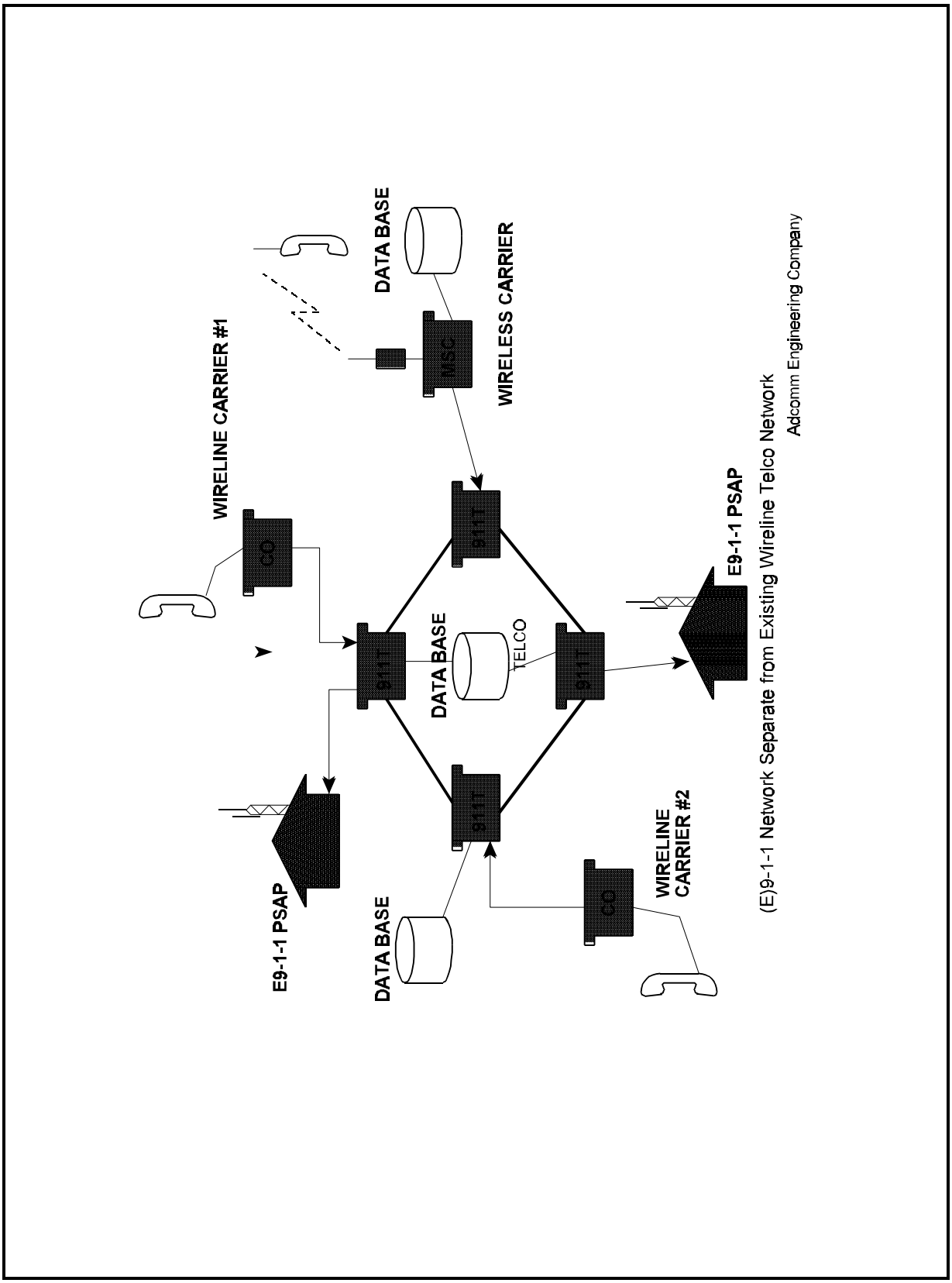
DATA BASE
WIRELESS CARRIER
MSC
WIRELINE CARRIER #1
CO
911T
E9-1-1 PSAP
DATA BASE
TELCO
911T
911T
E9-1-1 PSAP
WIRELINE
CARRIER #2
DATA BASE
CO
(E)9-1-1 Network Separate from Existing Wireline Telco Network
Adcomm Engineering Company

Figure 9

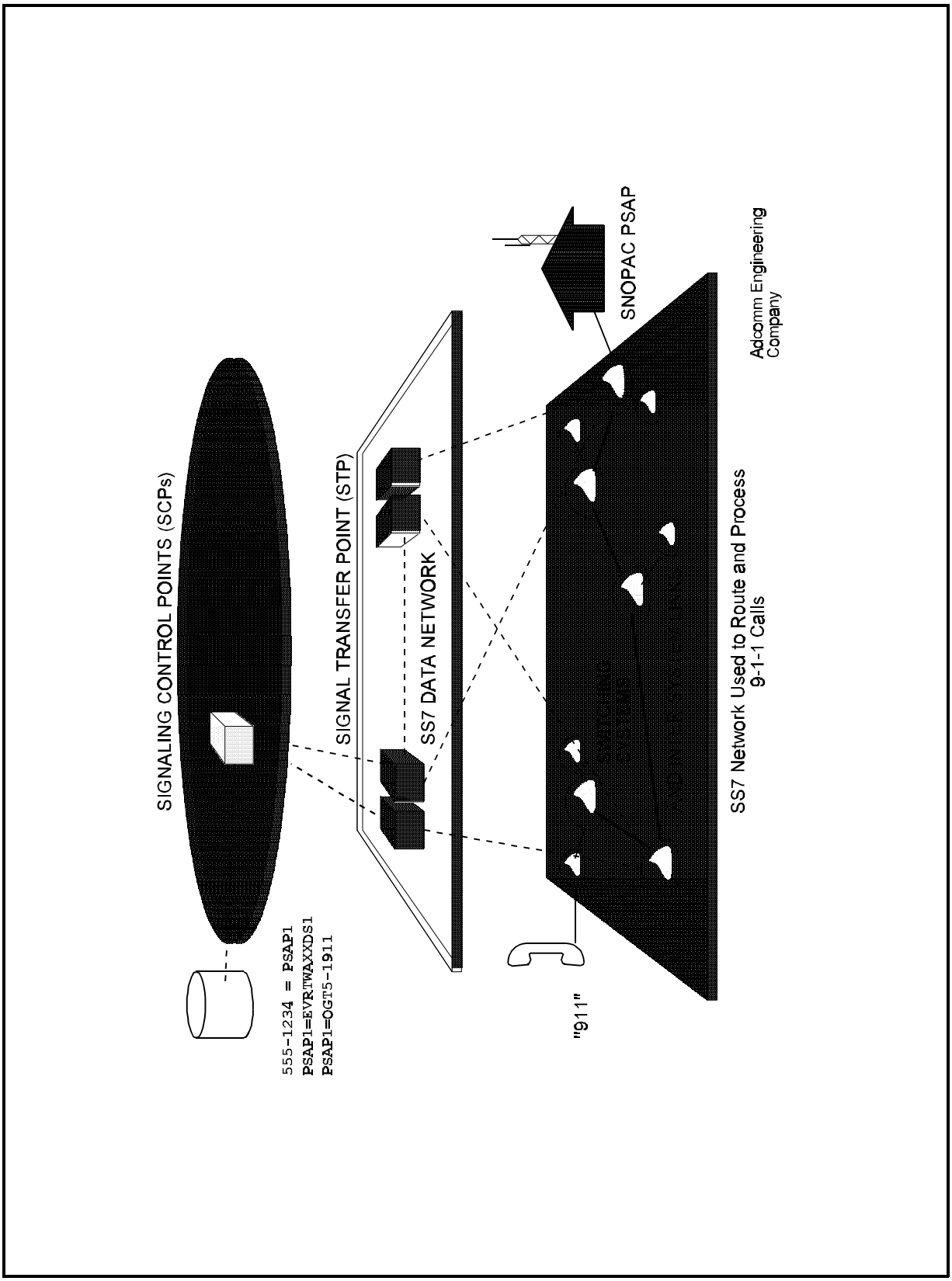
SIGNALING CONTROL POINTS (SCPs)
SIGNAL TRANSFER POINT (STP)
SS7 DATA NETWORK
SNOPAC PSAP
Adcomm Engineering
Company
SS7 Network Used to Route and Process
9-1-1 Calls
555-1234 = PSAP1
PSAP1=EVRTWAXXDS1
PSAP1=OGT5-1911
"911"

Figure 10

the telephone network and will likely advance and develop as the network advances. Some of this capability is a part of a totally digital system using the Integrated Digital Services Network (ISDN). ISDN systems could provide many advanced features not yet even thought or just beginning to emerge in (E)9-1-1 systems. This approach could also be telco or service provider independent.

The disadvantage with this approach is that it changes most of what is known about handling (E)9-1-1 calls today. The existing SS7 system would need to be modified to handle the additional tasks, and most of the PSAP equipment in place today would need to be changed. It may be possible to make a transitional change between the two technologies by adding equipment to simulate a tandem selective router until the PSAP equipment is changed. This approach will require considerable effort to bring all of the SS7 participants together to discuss standards, approaches, implementation timetables, and possible costs.

Conclusions

Emerging technologies, like PCS and the changing telephone network, will have a profound effect on (E)9-1-1 systems. Indeed, technology and the market is moving so fast that the time to act is very short (1 to 2 years). There is no solution immediately in hand. The final solution may be something different than any of the options discussed above or it may be a combination of technologies. If PCS is as successful and widespread as it is hoped, most of the existing (E)9-1-1 systems will face a compelling need to adapt within the next few years. It is expected the first of these systems will be online during 1995 with rapid deployment expected primarily in the urban areas. I believe the best long-term solution is to take the SS7 approach, although an interim solution such as the first two alternatives discussed may be required to bridge the gap. In any event, action is needed now. APCO Project 31 and related NENA efforts are working to address some of the technical issues. However, effort, vigilance, and money will be required on the part of every operator of an (E)9-1-1 system to make their system compatible with PCS. I urge all (E)9-1-1 system operators to learn what they can about PCS and emerging network technologies and to watch for service offerings in their areas. APCO Project 31 and NENA are working with the PCS standards groups, but we cannot take responsibility for every individual (E)9-1-1 system in the country. Each manager needs to evaluate the effects of PCS and emerging technologies on their own system before it becomes a crisis.