Trunking for Private Switch 9-1-1 Service

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TECHNICAL INFORMATION DOCUMENT

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1   Executive Overview

1.1   Purpose and Scope of Document

This NENA TID defines three distinct alternative trunking configurations to accomplish the provisioning of Private Switch 9-1-1 Service (PS/911) in conjunction with the use of Private Branch Exchange (PBX) telephone systems. For PBX systems that use digital trunks, Primary Rate Interface Integrated Services Digital Network (PRI-ISDN) trunks, the provisioning of PS/911 may be accommodated without the requirement of dedicated trunks for transporting 9-1-1 calls. For PBX systems that use analog trunks (i.e. they are not compatible with PRI and/or PRI trunks are not available from local service providers), the provisioning of PS/911 may be accommodated by using dedicated circuits that operate with the Centralized Automated Message Accounting (CAMA) signaling protocol. There are two CAMA alternatives that can be implemented; connecting the circuit to the Selective Router or connecting the circuit to the PSAP. While this document recommends using the PRI alternative for PBX sites served by PRI trunks, it is recognized that technical issues, tariff issues, or local conditions may determine that the CAMA alternative must be used. This document discusses how these configurations may be implemented, along with the issues and benefits of each alternative.

This document also supports the *NENA PS-ALI Model Legislation* by describing three alternative means of implementing PS/911 that are currently available.

1.2   Benefits

This TID is a guide for vendors and users of PBX systems, local service providers, 9-1-1 network providers, and 9-1-1 agencies to use in determining how to implement PS/911 in an efficient and reliable way.

As additional legislation is adopted that mandates implementation of modifications to multi-line telephone systems (MLTS) in order to improve the capability for identifying the location from which 9-1-1 calls are made, the need for proven methods of meeting such mandates becomes more critical. The most common means of provisioning PS/911 over the past decade has been the use of dedicated CAMA-type circuits that connect a PBX to the 9-1-1 selective router in essentially the same way as a telephone company end office is connected to a selective router. In some areas, this configuration may still be the only viable solution in spite of the overwhelming trend towards digital telecommunications services. The use of dedicated circuits with CAMA signaling seems antiquated in an environment of digital PBXs equipped with digital PRI-ISDN trunks. The combined cost of accommodating analog interfaces for dedicated CAMA-type circuits in digital PBXs, and having to accommodate literally thousands of additional trunk groups terminated on 9-1-1 selective routers and/or end office switches is a significant disadvantage of using the dedicated CAMA-type circuit alternative.

The limitation of the CAMA signaling protocol using 8-digit numbers presents a significant problem in high-growth areas whenever new area codes are created as "overlays" instead of splitting the geographic area served by the old area code. The possibility that a PBX could be assigned ranges of

telephone numbers using more than one area code must be taken into consideration, since the CAMA-type circuits can accommodate only one area code.

PS/911 has been provisioned successfully for sites using PBX systems equipped with PRI-ISDN trunks without having to use dedicated CAMA-type circuits. The 9-1-1 calls are passed to the local service provider's serving central office over the PRI-ISDN trunks like a normal local call and then routed to the 9-1-1 selective router via the 9-1-1 trunk group that connects the central office switch to the 9-1-1 selective router. This represents a clear advantage over the use of dedicated circuits from each PBX to the 9-1-1 selective router.

It must be noted that careful attention must be devoted to ensure the successful operation of PS/911 in this configuration, and that under some circumstances it may not be achievable due to technical issues. This TID covers as many issues as could be identified by the working group, but cannot be assumed to be all-inclusive.

Another benefit of this TID is to aid in promoting public awareness of a potentially detrimental result of using PRI-ISDN trunks that transmit outgoing calling line identification (CLID). One of the features PRI-ISDN trunks offer to PBX users is the ability to send the PBX extension line number as "caller ID" on outgoing calls. Activation of this feature will result in this CLID being sent to the 9-1-1 system on a 9-1-1 call unless specific programming is used in the PBX and/or the central office switch that provides the PRI-ISDN trunks. Whenever a CLID is used in conjunction with a 9-1-1 call, it will result in the display of "No Record Found" (NRF) at the 9-1-1 call-taker position unless a record has been uploaded to the 9-1-1 database for that specific station line number. Some local phone companies that are aware of this effect have uploaded records to the 9-1-1 database for all of the direct inward dialing (DID) numbers assigned in conjunction with PBX trunks, using the address of the network interface for every record. This mitigates the NRF issue by displaying an address, but the address may mislead the 9-1-1 call-taker if it is not accurate because the extension line is an off premises extension (OPX). Since displaying an address for a DID number has the appearance of a PS/911 record, the call-taker would perceive it to be the actual location of the caller. If the extension line is not at an off premises location, however, display of the network interface or main billing address information may aid the PSAP in identifying the caller's location.

Ironically, in situations where the PBX is capable of sending CLID, and the central office successfully passes the CLID to the 9-1-1 system on 9-1-1 calls, the only thing that has to be done to achieve a true PS/911 service enhancement is to upload records to the 9-1-1 database with specific station locations with MSAG-valid addresses as opposed to using the main billing telephone number address for every number.

This TID provides useful information in the event a full PS/911 implementation is desired, whether it is done as a PBX service "enhancement", to meet a state 9-1-1 mandate, or to mitigate 9-1-1 call processing issues discovered by test calls.

In summary, following the guidelines in this TID, the first consideration for implementing PS/911 should be given to using the capability of the PBX's PRI-ISDN trunks whenever possible, and to

using dedicated CAMA-type circuits whenever technical or other issues prevent the successful use of the PRI alternative. However, in most cases, either the PRI-ISDN configuration or one of the two CAMA alternatives should provide a successful PS/911 network solution.

1.3   Document Terminology

The terminology used in this document has been aligned to designate definitions used within the American National Standard for Telecommunications technical standard T1.628 Emergency Calling Service, issued by the Alliance for Telecommunications Industry Solutions (ATIS).

1.4   Reason for Issue

Recognizing that there are literally hundreds of network configurations that can be identified using different combinations of all variables, this document is intended to be used as a guide/reference by private switch owners/operators who are implementing PS/9-1-1 service.

The three basic alternatives are -

- Dedicated CAMA trunks from the PBX to the Selective Router (SR) tandem

- Dedicated CAMA trunks from the PBX to the serving Central Office (CO) where calls are switched and transported to the SR tandem on the message trunks from that CO to the SR tandem

- PRI-ISDN trunks configured to pass "9-1-1 valid" CLID to the serving CO where calls are switched and transported to the SR tandem on the message trunks from that CO to the SR tandem.

1.5   Reason for Reissue

NENA reserves the right to modify this document. Whenever it is reissued, the reason(s) will be provided in this paragraph.

1.6   Date Compliance

All systems that are associated with the 9-1-1 process shall be designed and engineered to ensure that no detrimental, or other noticeable impact of any kind, will occur as a result of a date/time change up to 30 years subsequent to the manufacture of the system. This shall include embedded application, computer based or any other type application.

To ensure true compliance the manufacturer shall upon request provide verifiable test results to an industry acceptable test plan such as Telcordia GR-2945 or equivalent.

1.7   Anticipated Timeline

Deployment or implementation will take place as required.

1.8   Costs Factors

Cost factors that may be associated with the trunking options discussed in this document are;

- Upgrades to PBXs or adjuncts
- Installation cost for new CAMA or ISDN circuits
- Recurring cost for new CAMA or ISDN circuits
- Implementation, testing and project management

1.9 Cost Recovery Considerations

Normal business practices shall be assumed to be the cost recovery mechanism.

1.10 Acronyms/Abbreviations

This is not a glossary! See NENA 01-002 - NENA Master Glossary of 9-1-1 Terminology located on the NENA web site for a complete listing of terms used in NENA documents.

The following Acronyms are used in this document:	
ALI	Automatic Location Identification
ANI	Automatic Number Identification
CO	Central Office
CAMA	Centralized Automatic Message Accounting
CLEC	Competitive Local Exchange Carrier or Certified Local Exchange Carrier
CLID	Calling Line Identification
CPE	Customer Premises Equipment
DID	Direct Inward Dialing
DN	Directory Number
DTMF	Dual Tone Multi-Frequency
ESN	Emergency Service Number
ISDN	Integrated Services Digital Network
MF	Multi-Frequency
MLTS	Multi-Line Telephone System
MSAG	Master Street Address Guide
NPA	Numbering Plan Area
NPD	Numbering Plan Digit
NRF	No Record Found
PBX	Private Branch Exchange
PRI	Primary Rate ISDN
PSAP	Public Safety Answering Point or Primary Public Safety Answering Point
SR	Selective Routing
SS7	Signaling System 7
TID	Technical Information Document (published by NENA)

2   Generic Requirements for PS/911 Service

This section of the TID describes call processing that is the same regardless whether the PS/911 service configuration utilizes PRI-ISDN trunks or dedicated CAMA-type circuits to transport the 9-1-1 calls.

Basic Assumptions applicable to the service configurations described in this document.

- The local community has enhanced 9-1-1 service

- The E9-1-1 service includes ANI, ALI, and Selective Routing features

- The E9-1-1 service utilizes a centralized ALI database system. (Where local, decentralized ALI database services are used, special consideration must be given to how PS/911 may be accommodated)

- Every station line associated with a PBX must have the ability to dial 9-1-1. It is incumbent on the owner/operator of a PBX to test the ability to dial 9-1-1 and assess the need for a PS/911 service enhancement. Please refer to the description of testing 9-1-1 calls from PBX station lines in Section 5.0 of this TID.

- All station lines associated with the PBX, including off-premises extensions and lines served by sub-tending remote switch modules, are located within the service area of the 9-1-1 selective router that serves the location of the main PBX.

    NOTE: In cases where there are station lines located outside the area served by the 9-1-1 selective router that serves the location of the main PBX, a configuration using multiple CAMA-type circuits connecting the PBX to more than one 9-1-1 selective router may be feasible if the PBX can be programmed to accurately route 9-1-1 calls to different outgoing trunk groups.

2.1   PS/911 Call Processing in the PBX

The processing of a 9-1-1 call that originates from a PBX station line begins with the PBX's recognition of the dialed digits (i.e. 9-9-1-1 and 9-1-1) as an emergency call. The subsequent processing steps are critical to a successful PS/911 service:

- Recognition of station lines that are assigned full 10-digit, NANP-valid DID numbers and station lines that are "intercom-only" stations (i.e. phones which may be restricted from placing outbound calls and/or receiving incoming calls, except to or from other PBX extensions) or non-assigned stations (e.g. outdial lines).

- Programming in the PBX must ensure that station lines that are not assigned full 10-digit numbers are associated with an active 10-digit, NANP-valid number that will be transmitted by the PBX as CLID when a 9-1-1 call is made from a non-DID station line.

- Programming in the PBX must route 9-1-1 calls to the switch ports associated with the PRI-ISDN outdial trunks or the dedicated 9-1-1 CAMA-type circuits, depending on the chosen PS/911 trunk configuration.

- When using the PRI-ISDN trunk configuration, the PBX must transmit specific CLID in the call setup message according to the standards referenced in Section 3.0 of this document.

- When using the dedicated CAMA-type circuit configuration, the PBX must transmit 8-digit ANI following the CAMA signaling protocol described in Section 4.1 of this document.

When using the dedicated CAMA-type circuit configuration, the PBX must also be programmed to route 9-1-1 calls over regular PBX trunks should the dedicated CAMA-type circuits be unavailable due to "out of service" or "traffic-busy" conditions. (Note that in this configuration, calls not routed over dedicated CAMA-type circuits will not deliver the PS/911 enhancements. In most cases only the main billing telephone number and the service address are displayed to the 9-1-1 call-taker.)

2.2   PS/911 Call Processing in the 9-1-1 Selective Router using CAMA-type Circuits

The processing of 9-1-1 calls by the 9-1-1 Selective Router should be the same regardless of whether the call was delivered to the 9-1-1 Selective Router via message trunks serving a Central Office Switch or via dedicated CAMA-type circuits that connect a PBX directly to the 9-1-1 Selective Router.

The call processing steps for calls using CAMA-type circuits are:

- Programming is written in the 9-1-1 Selective Router for each incoming trunk group. This programming includes assigning a single numbering plan digit (NPD) that is used to identify the area code that applies to the 7-digit number in the ANI transmitted by the PBX.

- The 9-1-1 Selective Router uses the NPD + 7-digit ANI to identify the 10-digit number that is used to search the selective routing database for the emergency service number (ESN) that is used for routing the call to the appropriate 9-1-1 trunk group serving the public-safety answering point (PSAP).

- The 9-1-1 Selective Router also uses the NPD to format the 8-digit ANI that is transmitted over PSAP trunks that use standard MF signaling protocol or to format the full 10-digit ANI that is transmitted over PSAP trunks that use enhanced MF signaling or to PSAPs that use ISDN.

- A default ESN is assigned to each incoming trunk group to enable the 9-1-1 Selective Router to complete calls in the event of ANI failures. When using the dedicated CAMA-type circuit configuration, a default ESN can be assigned to ensure calls are routed to the PSAP that serves the location of the PBX. (This can be more precise than the default ESN assigned to the CAMA-type trunks associated with a local service provider central office, which may accommodate a central office switch that provides local telephone service to an area that overlaps multiple PSAP jurisdictions.)

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- All call control features of the Selective Router, such as Fixed Transfer, Selective Transfer, Manual Transfer, Alternate Routing, Speed Dial, Forced Disconnect, etc. work the same on 9-1-1 calls from PS/911 sites as other 9-1-1 calls.

2.3 PS/911 Database Requirements

In addition to successfully delivering ANI to the PSAP, the PS/911 service enhancement requires the creation and maintenance of database records in the appropriate 9-1-1 database management system. Each and every telephone number that may be transmitted as CLID on a 9-1-1 call from a PS/911 site must be uploaded to the 9-1-1 database management system in accordance with the NENA Recommended Standard 02-010 or a locally approved alternative. Database considerations are described in detail in the Private Switch PS/911 Standards Document written by the NENA Database Standards Subcommittee.

2.4 Questions to Ask Yourself When Implementing E-911

There are many factors that must be examined when deciding how to best implement E-911 in a PBX environment. Below is a list of some questions that will help in this determination;

1. Does the PBX support Direct Inward Dialing (DID)?

- If not, DID numbers will still be needed to implement CLID, but they will not be usable for callback. The main number and PBX station (extension) number must be placed in the ALI record.

2. Will CLID be implemented for all individual stations or for logical groups of stations?

- When sharing a CLID among stations, one must be designated for callback.

    Note: On systems where DID is not supported, the PBX owner must understand that a human or automated attendant would be required to support callback to facilitate locating an emergency call from the PBX on a 24X7 basis.

3. If the PBX supports DID, are all the stations DID-enabled?

- If so, the DID numbers can be used for CLID and unique callback. This is the ideal scenario from a 9-1-1 perspective.

4. If all the stations are not DID, then decide which alternative is most suitable:
- Upgrade all non-DID stations to DID?
- Acquire DID numbers to support CLID on an individual station basis for non-DID stations, with indication on the ALI record as to callback capability?
- Implement a lesser number of DID numbers for CLID, with logical groups of stations sharing a single CLID?

- Implement DID service to a designated station in each logical group (to enable direct callback), or support callback to that group of stations through the main number and human or automated attendant?

2.5   Other Considerations

Some PBX environments present more complex challenges. The PS/911 service may not be able to accommodate off premises extension lines, for instance, if the extension lines are terminated at locations outside the geographic area served by the 9-1-1 selective router. In very large PBX system configurations, there may be multiple PBX switches and/or remote modules that are networked to serve multiple locations with a common numbering plan using DID numbers out of the same NPA/NXX. These unique situations must be dealt with on a case by case basis with the participation of the PBX vendor, the dial-tone provider, the 9-1-1 network and database provider(s), and the local 9-1-1 agency.

3 Implementing PS/911 for PBX Systems equipped with PRI-ISDN Trunks

A PBX equipped with PRI-ISDN trunks may, or may not, normally deliver station level ANI to a PSAP when the originating station line dials 9-9-1-1 or 9-1-1. For any PBX that has not implemented a PS/911 enhancement, the billing telephone number (BTN) should be sent as the ANI whenever the serving central office of the PRI trunks routes the call to the 9-1-1 Selective Router via the dedicated 9-1-1 trunks serving that central office. The 9-1-1 Selective Router uses the ANI to query the selective routing database for the ESN that determines which PSAP will receive the call, and the PSAP CPE uses the ANI it receives from the Selective Router to query the ALI database for the associated ALI record. This record will identify the name and main service address of the PBX owner/operator and may include specific location data.

It must be noted, however, that certain programming in the PBX and/or in the serving central office that provides the PRI trunks can potentially adversely affect the processing of a 9-1-1 call. In cases where a PBX is programmed to send calling line identification (CLID) on outgoing calls to enable outgoing caller identification, there is a possibility that the CLID would be transmitted as ANI on a 9-1-1 call. Whenever this occurs, the SR tandem may not route the call to the correct PSAP, and the ALI display will read "No Record Found" when the call is answered at the PSAP. These are the end results if ALI records have not been uploaded into the 9-1-1 database management system for every number the PBX might transmit as CLID.

THE NEED TO TEST THE ABILITY TO PLACE 9-1-1 CALLS FROM EVERY PBX THAT USES PRI-ISDN TRUNKS CANNOT BE OVER EMPHASIZED. See section 5.0 of this TID for recommended testing procedures.

3.1 Considerations for Successfully Transmitting Calling Station ANI with PRI Trunks

The Generic Requirements for PS/911 Service found in Section 2.0 of this TID apply to all trunking alternatives, including the PRI-ISDN alternative. This section discusses how to configure the PRI – ISDN trunks to successfully transmit CLID to the serving central office and have the CLID transmitted as ANI when the serving central office routes the 9-1-1 call to the 9-1-1 Selective Router.

There are several issues to consider when utilizing PRI-ISDN trunks in lieu of dedicated CAMA-type circuits to transport 9-1-1 calls for PS/911. The following questions should be answered while evaluating whether or not the PRI-ISDN alternative is an option or a best practice.

The PBX owner/operator must consider the type of lines providing service within the PBX. Does the PBX have non-Direct Inward Dial (non-DID) lines behind the PBX? If the answer is "yes", then the PBX owner/operator must take the necessary steps to either map the non-DIDs to specific DIDs for ANI on a 9-1-1 call or convert the non-DID lines to DIDs. If the PBX does not have the non-DID mapping capability then an adjunct station translation box may be acquired and added to the PBX to ensure the correct DID is passed.

Example: Non-DID numbers cannot form an outgoing number like DID numbers from a PBX. It is not valid to make a 7-digit number by prefixing the DN with the NXX. For example: A PBX has an NXX of 972 and a DID range of 1000-1999. An extension within this DID range, e.g. 1010, will form a calling number of 972-1010, which is valid and unique. However a non-DID telephone e.g.

DN 2500, would form a calling number of 972-2500. Because this is outside the DID range of 1000-1999, this number will most likely misroute because it could be allocated to a different subscriber or not be in the system at all. Thus special arrangements need to be made for non-DID telephones within the PBX

Does the PBX user desire to transmit assigned DID numbers as outgoing station level CLID on local calls and 9-1-1 calls? In some cases, such as law enforcement agencies, the PBX user does not want to transmit outgoing caller ID on local calls. In order to successfully use the PRI-ISDN trunks for PS/911, it must be determined whether the PBX or the central office is the most effective point at which to control the processing of the CLID. If the PBX is capable of distinguishing 9-1-1 as the dialed number and can be programmed to transmit the CLID on calls to 9-1-1 but not on other outgoing calls, the central office switch can be programmed to allow the CLID received from the PBX to pass as ANI on a 9-1-1 call. If the PBX cannot be programmed to allow the transmission of CLID on 9-1-1 calls while suppressing it on other outgoing calls, it must be determined whether or not the central office switch can be optioned to perform this function.

The PS/911 Trunking Working Group identified three options that were available on some central office switches. Option 1 is to pass CLID for Caller ID but pass the BTN of the PRI-ISDN trunk group as ANI on 9-1-1.   Option 2 is to pass the CLID received from a PBX as ANI on 9-1-1 calls and also as caller ID on other outgoing calls. Option 3 is to pass BTN for Caller ID but pass CLID on 9-1-1 calls. TELEPHONE COMPANIES AND PBX USERS ARE ADVISED TO CONSULT WITH THEIR LOCAL TELEPHONE PROVIDER, SWITCH VENDORS AND MANUFACTURERS TO CONFIRM THE CAPABILITY OF THE EQUIPMENT THEY USE.

3.2   PRI-ISDN Signaling Protocols

Because there are various ways to pass information between a PBX and the serving central office on a PRI-ISDN trunk, it is essential to achieving proper switch translations that the telephone company identifies what Protocol is used by the PBX. For this discussion we will categorize the Protocol as either NI2 or non-NI2, but the specific protocol must be communicated to the Telephone Company to obtain proper translations at the end office.

The capability and compatibility of the local service telephone company central office switch and its translations is a major issue. It is impractical if not impossible for this TID to list every switch manufacturer and the specific translations required by each. Instead the PS/911 Trunking Working Group has developed a series of questions, which should help determine the capability of central office switches in handling the signaling protocols that support PS/911 service.

- Does the end office support PRI? If the PBX currently has analog trunks, it must be determined whether PRI-ISDN trunks can be obtained. Even some digital serving central offices may not be configured to provide PRI-ISDN trunks. The local telephone service provider would be able to answer this question.

- Each telephone company end office operates on software. The switch vendor publishes a document listing the features of each particular release and manuals outlining the proper

programming techniques to code translations for each type of line or trunk. The telephone company must confirm with the switch vendor to determine if there is a specific E9-1-1 feature required for the software release loaded to support the passing of station level ANI over PRI on a 9-1-1 call. If the answer is "yes" it is also important to research and determine if the feature only works with certain protocols.

- Central office switches are connected to 9-1-1 Selective Routers with dedicated 9-1-1 trunks. These dedicated trunks may use MF or SS7 signaling. The telephone companies involved, the dial tone provider, and the provider of the Selective Router, must determine what specifications to follow in order to successfully transmit station level ANI from the central office to the Selective Router.   For instance, a dedicated SS7 trunk group may use the trunk type of IT, whereas a dedicated trunk group with MF signaling may be classified as OP-type or ES-type trunks.

- It is becoming a common practice for a PBX to transmit station level ANI over PRI-ISDN trunks to support the delivery of Caller Line Identification (CLID) on outgoing calls. It is important to understand how this feature could have an adverse impact on 9-1-1 calls. If the serving central office does not support separate translations for CLID on non-emergency calls and CLID on 9-1-1 calls, there is a degradation of the 9-1-1 system if an ALI record for the station level ANI has not been pre-loaded into the 9-1-1 database. Precisely how the serving central office switch handles CLID on emergency calls versus regular local calls is a question the dial tone provider must answer.

- Software within the central office switch is also used to facilitate proper billing of the customer for long distance calls. The telephone company must be certain to evaluate any modifications in the serving central office switch to accommodate PS/911 using PRI-ISDN trunks to assess any impact the modifications may have on tables used by billing systems.

4 Implementing PS/911 Using Dedicated 9-1-1 Circuits With CAMA Signaling

4.1 Specifications for Dedicated CAMA Type Trunks for PS/911 Service

It is recommended that the dedicated CAMA-type circuits associated with a PS/911 service terminate at the 9-1-1 Selective Router. Alternative configurations to serve individual PS/911 sites include using dedicated CAMA-type circuits that terminate at the serving central office of the PBX, dedicated CAMA-type circuits that terminate at a designated Central Office switch (other than the serving CO of the PBX), or dedicated CAMA-type circuits that terminate in the 9-1-1 CPE at the PSAP that serves the PS/911 site. These alternatives are discussed elsewhere in this Technical Reference in Section 4.2.

It is recommended that a minimum of two (2) CAMA-type circuits be installed for PS/911 service. These circuits may be connected directly to the PBX or may be connected to an adjunct device positioned between the PBX and the 9-1-1 Selective Router. The use of an adjunct device is indicated when the PBX lacks the ability to perform the necessary CAMA signaling protocol, or when the PBX lacks the ability to translate non-DID station lines with pre-determined DID numbers to transmit as ANI when 9-1-1 calls are made from non-DID station lines.

ANI, in this case, refers to the ability of the PBX to pass station identification to the public switched network. The calling party's station identification, for purposes of 9-1-1 emergency telephone calls, would be translated by the PBX to be the seven-digit DID number associated with that station. This DID number would be passed via multifrequency tones (MF) along the voice path of the PBX outgoing CAMA-type circuit to the 9-1-1 Selective Router. Along with the calling party's telephone number, the PBX must send an ANI information digit. Traditional signaling requires a one (1) digit information digit, while expanded signaling requires two (2) digits. [Most existing E9-1-1 Networks are utilizing traditional signaling, a single digit, at this time.] The information digit will be either a zero (0) or a two (2). Zero (0) indicates a successful automatic identification and the calling party's seven (7) digit telephone number will follow. A two (2) indicates an ANI failure at the PBX, and no additional digits will be sent.

The format of the ANI signal is   KP-I-NXX-XXXX-ST

Where: KP   indicates a KP (Key Pulse) signal
            I   information digit
            NXX   the prefix of the telephone number (exchange)
            XXXX   the caller's PBX station number
            ST   indicates a ST (Start Pulse)
         (the hyphens are inserted for clarity only and are not transmitted)

All of this information is sent via Multifrequency (MF) Pulsing. MF Pulsing is a method of communicating call set-up information over telephone trunks by various combinations of two out of six frequencies in the voice band. Each combination of two frequencies is sent as a pulse of tone intended to represent a digit or a control signal such as the KP or ST. The signals are transmitted over the regular talking (voice) path of each trunk circuit. MF receivers detect the pulses and

transfer the digit information to switching control equipment and/or data collection systems. MF signals are not the same as DTMF signals. They are combinations of different frequency tones. The six MF frequencies are 700, 900, 1100, 1300, 1500, and 1700 Hz. The frequency combinations and the digits or control codes they represent are depicted in Figure 1 below.

MF tone transmitters used in E9-1-1 Networks are arranged for a pulse duration or inter-digital periods of 60 ± 5 milliseconds (ms) each (a rate of approximately 8.3 digits per second). The MF pulsing rates may be 58 to 75 ms for the ST (start pulse), signal, digit pulses, and inter-digital intervals. The KP (key pulse) control signal duration is 90 to 120 ms. It is considered good practice for this signal to be sent near 120 ms to provide margin against transmission impairments such as delay distortion.

MF tone transmitters should be arranged so that, under normal conditions, the two tones are applied to the trunk simultaneously and neither tone is transmitted if either tone source should fail. The start and end of the two tones must be within 1 ms of each other.

Figure 1

FREQUENCIES in Hz	SIGNALS			
	DIGIT AND CONTROL	EXPANDED INBAND	CCITT SYSTEM 5	TSPS EQUAL ACCESS
700 + 900	1			
700 + 1100	2	Coin Collect		
700 + 1300	4			
700 + 1500	7			
700 + 1700		Ringback	Code 11	ST3P (St''')
900 + 1100	3			
900 + 1300	5			
900 + 1500	8	Operator Released		
900 + 1700			Code 12	STP(ST')
1100 + 1300	6			
1100 + 1500	9			
1100 + 1700	KP	Coin Return	SF1	
1300 + 1500	0	Operator Attached		
1300 + 1700			KP2	ST2P (St'')
1500 + 1700	ST	Coin Collect Operator Released		ST

4.2 Signaling Protocol for Calls Routed Via 9-1-1 Switch

Circuits from a PBX that connect to the E9-1-1 Network via a switch utilize controlled outpulsing protocol. With controlled outpulsing, the originating PBX seizes the 9-1-1 trunk and sends a connect signal to the 9-1-1 switch. These circuits will normally signal on-hook toward each end

when in the idle state. On receipt of a connect signal, the 9-1-1 switch will initiate a request for a register to collect the called digits (911, or 11 in this case) and does not immediately return an off-hook signal to the PBX. An idle condition on-hook signal to the PBX is maintained until the register is attached at the 9-1-1 switch, when a wink-start signal is sent by the 9-1-1 switch. The wink-start signal is an off-hook signal that must meet the following requirements:

- The off-hook must be a minimum of 140 ms and a maximum of 290 ms in duration.
- The off-hook to on-hook transition must not occur until 210 ms after the connect signal is received.

The nominal wink-start signal is about 150 ms after the seizure from a 9-1-1 switch. It is desirable to minimize post-dialing delay by sending the on-hook transition as soon as possible after the above requirements are met.
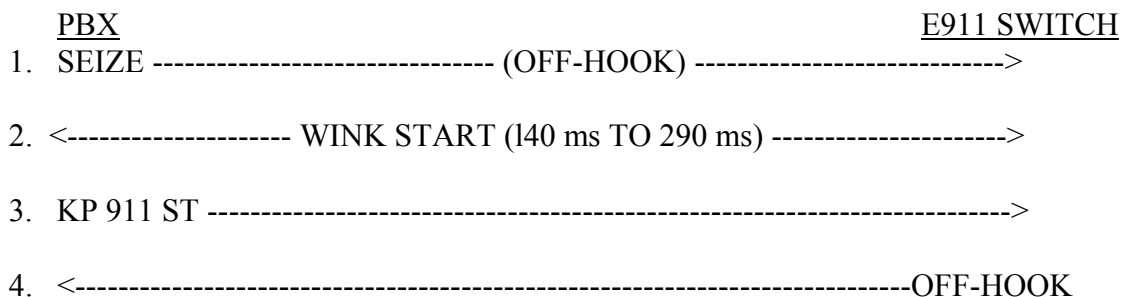
The PBX will be expected to send the digits "911" or "1 1" to the 911 switch as the called number when an emergency service call is initiated. The called number will be sent (using MF pulsing) in the following format:

<div align="center">

KP-9 1 1-ST, KP-1 1-ST or KP-1-ST
(the hyphen is shown for clarity only, it is not transmitted)

</div>

The 9-1-1 switch will then return a steady off-hook which tells the PBX to forward the ANI information in the format previously discussed. The ANI request signal (off-hook) is also used as a supervisory signal which persists until after the calling party disconnects or until 11 to 13 seconds after the called party disconnect is received by the 9-1-1 switch. There is no minimum requirement for a delay between the receipt of the off-hook start dial by the PBX and its sending of the KP pulse of the ANI information. However, it is good practice to have a minimum delay of 50 ms between these two signals to permit the transients associated with the off-hook start-dial signal to dissipate before the first MF pulse is sent.

4.3   Signaling Sequence For CAMA Type Trunks Connected To The 9-1-1 Switch

After a PBX station user dials 911:

PBX   E911 SWITCH
1. SEIZE -------------------------------- (OFF-HOOK) ---------------------------->

2. <--------------------- WINK START (l40 ms TO 290 ms) --------------------->

3. KP 911 ST -->

4. <--OFF-HOOK

5. KP I NXXXXXX ST (ANI) --->

6. <---------------------------- TALKING PATH CONNECTED ----------------->

Calling party goes on-hook

7. PBX DISCONNECTS ------------------- (ON-HOOK) ---------------------->

8. <------------------------------- 911 SWITCH DISCONNECTS -------- ON-HOOK

When the calling party disconnects first, the PBX sends an on-hook signal to the 9-1-1 switch and may release the trunk after an on-hook is received from the 9-1-1 switch. When the 9-1-1 switch receives the on-hook, the 9-1-1 connection is released and an on-hook sent to the PBX.

If the PSAP call taker disconnects first, the PSAP equipment sends an on-hook to the 9-1-1 switch. The switch begins a 1.2 second flash timing, which completes in this case. The 9-1-1 switch sends an on-hook to the PBX and begins a 4 to 5 second timing for an on-hook from the PBX. When the on-hook is received or the time-out occurs, the 9-1-1 switch disconnects the call connections, sends on-hook to the PSAP and idles the 911 circuit to the PBX.

When CAMA-type circuits are installed, the following details must also be specified:

*   Are circuits to be engineered as 2-wire or 4-wire circuits? (determined by the E9-1-1 network provider or the CPE vendor)
*   Is E & M signaling needed? (as determined by the CPE vendor)

4.4   Alternative CAMA Trunking Configurations

4.4.1   CAMA-Type Circuits Connecting the PBX to a Central Office Switch

As an alternative to installing CAMA type trunks terminated at the 9-1-1 Selective Router, the CAMA type trunks may be installed terminated at the PBX's Serving Central Office or any designated CO switch with tandem feature capability. In this configuration, the 9-1-1 call must be switched at the CO switch so that it is transported to the 9-1-1 Selective Router on the dedicated 9-1-1 trunks that connect the CO switch to the 9-1-1 Selective router.

The benefits of these alternatives are:

*   Reduces the number of CAMA-type circuits that must be terminated at the 9-1-1 Selective Router.

*   Typically reduces the distance the CAMA-type circuits must go. (Assumes that the Serving CO of the PBX or other designated CO switch is not the same switch as the 9-1-1 Selective Router)

*   The use of a limited number of designated CO switches, with each switch serving a geographic region, achieves additional concentration benefits.

One Nation 9-1-1 One Number

The potential disadvantages of these alternatives are:

- The additional switching step(s) increase call set up time.

- Cost – the serving CO switch would have to perform "tandem" switching, which would most likely increase operating costs of the local service provider. This is significantly mitigated when using a designated CO switch to serve a geographic region.

- Complexity – the programming of the CO switch to perform "tandem" switching would add complexity, especially when there is more than one outgoing 9-1-1 trunk group from the CO switch to one or more 9-1-1 Selective Routers, as is common for CLECs.

- Complexity and compatibility – in situations where the dedicated 9-1-1 trunks that connect the CO switch to the 9-1-1 Selective Router use SS7 signaling, it would require the CO switch to perform a protocol conversion in order to switch 9-1-1 calls that come into the switch from CAMA-type trunks to the outgoing SS7 trunks.

- Inhibits the ability to identify the originating point of a 9-1-1 call in cases of ANI failure. The pseudo ANI received at the PSAP will only identify the ESCO code of the serving CO switch, whereas the pseudo ANI received on ANI failures on calls where the CAMA-type trunks connect the PBX to the 9-1-1 Selective Router identify the specific PS/911 site.

4.4.2   CAMA-type Circuits Connecting the PBX Directly to the PSAP

Under certain circumstances, it may be necessary to connect the PBX directly to a PSAP using dedicated CAMA-type circuits.

Possible applications for this alternative include:

- The ability to implement a PS/911 service arrangement for a PBX in an area not served by an enhanced 9-1-1 service network and/or a centralized ALI database.

- The flexibility to customize a PS/911 database residing at the PSAP to accommodate unique PS/911 sites such as military bases, large industrial plants, and nuclear power plants.

4.4.3   Signaling Protocol For Calls Routed Directly To The PSAP

Since, in this instance, the PBX is connected directly to the PSAP through the 9-1-1 CAMA-type circuit, the PBX has only to seize the trunk by sending an off-hook signal when a caller dials 9-1-1.

The ANI has one format change when the PBX is connected directly to the PSAP. The information digit becomes the Number Plan Digit (NPD). This is a single digit which represents the area code of the PBX caller's telephone number. Values of this digit range from 0 to 3. The number your PBX will be required to send can be obtained from the 9-1-1 Service Customer.

The format of the ANI signal is: KP-NPD-NXX-XXXX-ST

Where: KP   indicates a KP (Key Pulse) signal

NPD   numbering plan digit representing the area code of the PBX caller   who
originated the 9-1-1 call (ranges from 0 to 3)

NXX   the prefix of the telephone number (exchange)

XXXX the caller's PBX station number

ST   indicates a SP (Start Pulse)

(the hyphens are inserted for clarity only and are not transmitted)

The NPD and ANI (NXX-XXXX) digits are preceded by a KP of 115 to 125 ms duration, and followed by an ST digit of 55 to 65 ms duration.

When the PSAP receives the complete ANI information, the PSAP equipment will signal the call takers and return audible ringing to the calling PBX party. Upon answer, the PSAP will disconnect audible ringing, connect the call to the answering attendant, display the ANI at the answering position, and return an off-hook signal to the PBX indicating that the call has been answered.

When the PSAP call taker disconnects the call, the PSAP sends an on-hook (disconnect) signal to the PBX. The on-hook duration must be greater than the flash timing period (1 .2 seconds). The PBX should return on-hook within 4 to 5 seconds or a time-out occurs.

When the PBX station disconnects first, the PBX should send the on-hook (disconnect) signal to the PSAP. The PSAP will idle the 9-1-1 trunk to the PBX.

4.4.4   Signaling Sequence For CAMA Type Trunks Connected To The PSAP

After a PBX station user dials 911:

```
        PBX                                              E911 PSAP
1.      SEIZE ----------------------------------- (OFF-HOOK) --------------------->

2.      <------------------- WINK START (l40 ms TO 290 ms) -------------------->

3.      KP NPD NXXXXXXX ST (ANI) ---------------------------------------------->

4.      <------------------------------------------------------------------- OFF-HOOK

5.      <--------------------------- TALKING PATH CONNECTED -------------->
```

Calling party goes on-hook

```
6.      PBX DISCONNECTS ------------------- (ON-HOOK) --------------------->

7.      <--------------------------- 911 PSAP DISCONNECTS --------------- ON-HOOK
```

5 Testing 9-1-1 Call Processing For PBX Systems

5.1 Testing of all PBX systems, whether or not the PS/911 enhancement has been implemented

It is recommended that every PBX vendor that installs and maintains PBX systems, as well as local service providers that provide PBX trunks, test the ability to dial 9-1-1 from the station lines associated with PBX systems at the time the systems and/or new PBX trunks are installed or upgraded.

THE IMPORTANCE OF TESTING IS EVEN GREATER WHENEVER A PBX IS SERVED BY PRI-ISDN TRUNKS. This is due to the fact that the feature interaction of the digital trunk signaling messages (which often include outgoing Calling Line Identification) with 9-1-1 ANI signaling protocols can result in DID numbers being sent as ANI on 9-1-1 calls. This condition can exist without the PBX owner/operator being aware until an actual 9-1-1 call is made and one of two adverse effects occurs:

- there is an ANI failure that potentially causes the call to route to the wrong PSAP with no ANI or ALI displayed at the call-taker position

- the PSAP receives a DID number for which no 9-1-1 ALI record has been created, resulting in "No Record Found" in the ALI display at the call-taker position

Discovery of adverse conditions during testing should lead the PBX owner/operator to obtain a detailed assessment of the cause(s) by the PBX vendor and the dial tone provider. This assessment should include consideration of implementing the PS/911 enhancements described in this TID.

5.2 Testing Methods and Procedures

In developing a test regimen, there are considerations that apply to all non-emergency calls placed to 9-1-1. Guidelines are offered here to ensure a test call does not jeopardize the accessibility of the 9-1-1 system to anyone who may have an actual emergency.

5.2.1 Ground Rules for 9-1-1 Test Calls

Rule Number 1: Never dial 9-1-1 as a test call and just hang-up once the call is answered. The 9-1-1 communication center has an automatic display of the telephone number and location identification display. On hang-up calls, because the nature of the call is unknown, resources will be allocated to call the number back to determine if there is an emergency. In some cases, hang-up or no response calls may result in emergency response personnel being dispatched. This reduces the number of people available to answer and/or respond to true emergency calls, and in some jurisdictions may result in fines being assessed to the party who made the 9-1-1 hang-up call.

Rule Number 2: Always contact the local 911 Communication Center, which is typically the local Police Department, via their non-emergency number and ask to speak to the 9-1-1 communications supervisor to request permission to place a 9-1-1 test call. Ask to coordinate test calls during their non-peak calling hours. Many centers allow test calls between 9:00 a.m. and 11:00 a.m., 1:30 p.m. to 3:30 p.m., 7:00 p.m. to 9:00 p.m., and 3:00 a.m. to 5:00 a.m.

Rule Number 3: Before making the test call note the telephone number and address information of the telephone to be tested, and determine which Public Safety Answering Point (PSAP) should answer the test call.

5.2.2   Test Call Checklist

A test call should be made from at least one station line from each identifiable category of station lines working on the PBX. These could include any combination of the categories listed here, depending on the configuration and size of the PBX and the user organization:

- A single-line phone with a DID number.

- A single-line phone with a non-DID number.

- A multi-line phone with more than one station lines, all of which have full DID numbers.

- A multi-line phone with more than one station lines, some of which have DID numbers and others do not.

- An attendant console.

- A station line located off-premises (OPX station).

- Each of the above categories may be classified as restricted from placing outgoing calls. Be sure to test the ability of such station lines to dial 9-9-1-1.

- Any other special class of service used in the PBX configuration.

A test call should be made by dialing X + 9-1-1 (where X is usually '9') as well as 9-1-1. Document the results and assess the implications.

When making test calls from a PBX site after implementing the PS/911 enhancement using two (2) dedicated CAMA-type circuits, it will be necessary to place at least three (3) test calls in order to test the overflow routing of the third call.

Make sure that it is understood prior to placing test calls exactly what is supposed to happen on a call from each category of station lines, and in particular what is supposed to happen on the overflow routing. Otherwise, it will not be immediately clear whether the test call succeeded or failed.

5.2.3   Placing a 9-1-1 Test Call

Dial 9-9-1-1 or 9-1-1. As soon as the 9-1-1 call is answered, immediately state "this is a test call, no emergency." Then ask the call-taker to verify the telephone number and address that displays. Some PSAPs will tell you the information, while others may only confirm what you tell them, thus the requirement to know the telephone number and address in advance. If the call was answered at the correct PSAP and both the ANI and ALI display correctly, the test is a success.

Document the test results. The test call fails unless the information elements listed below are accurately and completely displayed.

One Nation   9-1-1   One Number

- The telephone number that displayed as ANI at the 9-1-1 answering position.

- The ALI record displayed includes the correct name, address, community name, and class of service code.

- Note any error message the 9-1-1 operator may have received, such as the pseudo-ANI that displays in the event of ANI failure.

- Ask the call taker whether 9-1-1 calls requesting Fire or EMS response are normally transferred to a secondary 9-1-1 center. If the answer is yes, ask the call taker to execute the transfer(s) as a part of the test call and ensure that the ALI record is displayed correctly at the secondary 9-1-1 center.

- The date and time of the test call.

- The name of the PSAP that answered the call.

It is key to note if the station level ANI displayed but the error message "Record Not Found" displayed. If you are testing a PS/911 enhancement, this usually means that the database record(s) was (were) not successfully uploaded to the 9-1-1 database management system. If you are making test calls from a PBX that has not implemented the PS/911 enhancement, this means that there is a problem with the programming of the PBX, the signaling protocol of the PRI-ISDN trunks, the programming of the CO switch, and/or the signaling protocol of the trunks connecting the CO switch to the 9-1-1 Selective Router.

6   References

TR-TSY-000350	Bellcore, E9-1-1 Public Safety Answering Point: Interface Between a 1/1AESS Switch and Customer Premises Equipment	Issue 1, 1987
n/a	*Technical Standards: 9-1-1 CAMA Trunking and Database Update for Private Switch ALI*, distributed by the Texas Commission on State Emergency Communications, April, 1993.	April, 1993
ANSI T1.411-2001	Network-to-Customer Installation Interfaces - Analog Voicegrade Enhanced 911 Switched Access Using Network-Provided Reverse-Battery Signaling (Revision and consolidation of T1.411-1995 and T1.411a-1996)	

7   Exhibits

7.1   Trunk Configuration Diagrams