



Emergency Access Advisory Committee (EAAAC) Report on TTY Transition

March 2013

TTY Transition

This document is a report to the FCC from the Emergency Access Advisory Committee (EAAC). The committee was assigned the task to review the sustainability of the TTY communication solutions for text communication with people with deafness, hard-of-hearing, deafblindness and speech disabilities. In the task is included to propose solutions if the TTY communication is found to be at risk or by other reasons need to be replaced or paralleled with new services with similar but improved functionality.

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1. Summary

This document starts from the recommendations from FCC committee EAAC in December 2011 regarding possible phase out of the legacy TTY communication, explains the situations, the risks for deteriorating communication quality, and the options to improve functionality by establishing a transition path from TTY to more modern and higher functionality devices in IP networks.

It recommends protocols and functions for the new communication, and how interoperability with the old can be achieved. Finally a timeline is provided.

2. Charter

2.1 Charter from EAAC

The TTY Transition group worked with TTY related goals of the main EAAC charter.

EAAC Provision: Deadlines by which interconnected and non-interconnected VoIP service providers and manufacturers shall achieve the actions . . . where achievable, and for the possible phase out of current-generation TTY technology to the extent that this technology is replaced with more effective and efficient technologies and methods to enable access to 9-1-1 emergency services by individuals with disabilities.

The EAAC submitted a set of recommendations in December 2011. The following recommendations were further worked on by the TTY Transition group:

Recommendation P6.1: No TTY Phase-Out Deadline for PSAP: The EAAC recommends against imposing any deadline for phasing out TTY at the PSAPs until the analog phone system (PSTN) no longer exists, either as the backbone or as peripheral analog legs, unless ALL legs trap and convert TTY to IP real-time text and maintain VCO capability.

Recommendation T6.3: Baudot (TTY) Support: The EAAC recommends that Baudot (TTY) be supported by all PSAPs with VCO and HCO capabilities until there are no more TTYs in use – or until there is a gateway between every TTY user and the PSAP, that converts TTY into the proper real-time text format for VoIP systems supported by the PSAPs including support for VCO/HCO functionality. Because of the risk for deterioration of TTY tones by IP transport, actions to secure the transmission must be made close enough to the TTY so that no TTY-non-supporting network path is between the TTY and the securing point. Best practice guidelines should be developed for such actions.

Recommendation P6.5: Conditional TTY Waiver: The EAAC recommends that the FCC remove the requirement for TTY (analog real-time text) support for new IP-based consumer devices that implement IP-based text communications that include at a minimum real time text or, in an LTE environment, IMS Multimedia Telephony that includes real-time text. The text must be possible to use in parallel with voice on the same call so that VCO equivalence is maintained. The EAAC recognizes real time text provides characteristics that are required by some users in emergency communications (e.g., sent continuously as it is typed and supports captioned telephony).

Recommendation T2.2: Removal of TTY Requirement: The EAAC recommends that the FCC remove the requirement for TTY (analog real-time text) support for new IP-based consumer devices that implement IP-based text communications that include, at a minimum, real time text or, in an LTE environment, IMS Multimedia Telephony that includes real-time text. The text must be possible to use in parallel with voice on the same call so that VCO equivalence is maintained. The EAAC recognizes real time text provides characteristics that are required by some users in emergency communications (e.g., sent continuously as it is typed and supports captioned telephony). (This is same recommendation as Recommendation P6.5: Conditional TTY Waiver.) (See also Recommendation T6.3: Timeline Contingency.)

2.2 Extracted goals

From the charter and background, the following can be extracted as goals of the TTY transition report from EAAC to the FCC.

1. Functions and modern technology

Provide advice to the FCC about modern technologies that can support the same functional needs as the TTY does today and how such technologies could be applied both for user an emergency communication.

2. Transition requirements

Provide advice on how a transition can be achieved from TTY usage to usage of the recommended new technology

3. Interoperability requirements and solutions

Provide advice about to what degree interoperability is needed between new technology and TTYs, as well as between users of new technology, both with users and 911 services, and how such interoperability can be achieved.

4. Modification of regulations

Provide advice on what modifications may be desirable in the TTY-related regulation to support and encourage a transition to modern technologies

5. Timeline

Provide advice on what timelines should be applied on the actions for TTY transition.

3. Definitions and abbreviations

ASCII	American Standard Code for Information Interchange. Originally a character code standard, but in accessible communication used term for text telephony communication in USA using the Bell 103 modem standard and ASCII character code.
CMRS	Commercial Mobile Radio Service; a regulatory classification for mobile telephone service that is provided for profit and makes interconnected service available to the public, usually in the form of mobile phone service.
DTMF	Dual Tone Multi Frequency. Tone coding of numbers used in telephony.
FSK	Frequency Shift Keying (a robust modem technology used in the TIA 825a standard)
GSM	Global System for Mobile Communication

GSMA	GSM Association
HCO	Hearing Carry Over (Audio and text in same call)
IETF	Internet Engineering Task Force
LTE	Long Term Evolution (wireless technology)
NDBEDP	National Deaf-Blind Equipment Distribution Program
NECA	National Exchange Carrier Association, Inc.
NENA	National Emergency Number Association
PSAP	Public Security Answering Point
PSTN	Public Switched Telephone Network
RJ-11	Phone connector standard.
RTT	Real-time text
Real-time text	Text transmitted instantly while it is being typed or created. The recipient can immediately read the sender's text as it is written, without waiting.
SIAT	Swedish Institute of Assistive Technology
TEDP	Telecommunications Equipment Distribution Program
TEDPA	Telecommunications Equipment Distribution Program Association
TRS	Telecommunication Relay Service
Total Conversation	Conversational communication in video, real-time text and voice.
TTY	Text telephone based on the TIA 825A standard for an FSK modem, used in the USA.
TTY replacement	Technology to be supported as an alternative to the TTY and possible replacement of the TTY for similar types of conversational situations as the TTY.
U.S. Access Board	The Access Board is an independent Federal agency devoted to accessibility for people with disabilities. The Board develops and maintains design criteria for the, telecommunications equipment, and for electronic and information technology and many other areas.
VCO	Voice Carry Over (Audio and text in same call) where the caller can switch between voice and text or use text in one direction and voice in the other.
VOLTE	Voice over LTE. A profile within IMS for IP based voice and text communication. Real-time text is included in the specification.
VRS	Video Relay Service
W3C	World Wide Web Consortium

4. User needs in text based emergency 9-1-1 calling

The EAAC user survey [32] provides information about how a number of respondents with accessibility interest views emergency service calling today and in the future. The respondents themselves announced their interest to participate in the survey. Therefore only brief guiding conclusions can be drawn, but no reliable extrapolations to the whole population of USA can be done from the material. Some extracts are

provided here of interest for the judgments in relation to the TTY and other communication methods including text.

The TTY is a technology for text communication combinable with voice in PSTN that has been wide spread. It is now reducing in usage. A possibility to connect TTYs to wireless handsets exists but is reported to have very little use.

The following is the user's view of the TTY and other communication including text as a means for 9-1-1 calling:

Current TTY usage for 9-1-1 calling

The EAAC user survey [32] asks in question #13 what communication the users used for calling 9-1-1 during the last two years.

The response indicates that of the respondents who used means including other modality than voice, 22% used the TTY. This shows that the TTY still plays an important role in 9-1-1 calling.

High percentage of reasons to call 9-1-1 are not fulfilled

Question #14 shows a scaring reality. 25% of the respondents had reasons to call 9-1-1 during the last two years but could not do it. Of these, 30% tried but failed and 70% had no suitable means at the site of the emergency.

Desired variation in modality of 9-1-1 calls

Question #15 shows a quite even distribution among respondents of desired modalities to use for 9-1-1 calls, between text, video, voice, and the combination of text, video and voice together.

From question #16 it is seen that the most favored way of future text communication methods with 9-1-1 among respondents is real-time text. Over 45% of the respondents answered that they wanted that option, while 10% still wanted the TTY as an option (also providing a kind of limited real-time text).

Question #25 indicates what modality mix the respondents want to use with 9-1-1. 40% of the respondents want to have the option to use text both ways. 19% want to have the option to use text one way and voice the other, and 22% want the option to get text captions added to voice communication.

Question #29 shows a very high preference for real-time text over message-wise texting. Of the respondents wanting to use text communication with 9-1-1, only 13% want to use text messaging.

Question #29 also shows that more than 50% of the respondents want to be able to communicate in text both ways simultaneously. Thereby they indicate a strong interest to get away from the functional limitation of the TTY that allows communication only in one direction at a time.

Wireless and wireline solutions are desired

Question #21 shows a high preference for having wireless solutions for calling 9-1-1, but also maintained interest in having a landline options.

Direct communication with 9-1-1 telecommunicator

Question #22 shows a high preference for contacting 9-1-1 directly rather than go through a relay service with no direct contact with the 9-1-1 telecommunicator.

Same device and tool for everyday communication as for 9-1-1 calling.

Question #23 shows that the respondents have an overwhelming desire to use the same communication tool for 9-1-1 as for everyday calling. 82% indicated that option.

Conclusions

When making conclusions, it must be remembered that the method for selection of respondents only allow brief indications. Only by combination with statistics of other sources, reliable guidance can be achieved.

For the conclusions, material has been used from the survey, supported by the EAAC recommendations and by statistics provided in chapter 5 of this document. :

- The wireline TTY is important and takes 20% of the 9-1-1 accessibility calls.
- A TTY replacement that can be wireless is needed and would increase the number of successful calling to 9-1-1 when there is a need.
- A TTY replacement shall do away with the limitations of the TTY; Text and voice shall be possible to use together simultaneously. Text shall be rapid real-time text, with possibility to send text in both directions simultaneously.
- Some users want video included. It is therefore important that solutions offering only real-time text and voice are interoperable with solutions offering video, real-time text and voice.
- The solutions for 9-1-1 calling with real-time text and voice need also be wide-spread and attractive to use for everyday calling.

5. The current situation for TTY and other PSTN usage

5.1 General information on the TTY

TTY is one harmonized technology with strong policy support in USA, implementing a kind of limited real-time text feature in the PSTN with the goal to enable conversations on distance in text and voice. The users are mainly persons who cannot use voice fully in communication because of a disability in hearing or speech. The policy support of the TTY has established a service environment where TTY users can call each other and also use relay services and 9-1-1 emergency services.

PSTN, and especially TTY communication is at threat in the generation shift to Internet protocol technologies. New technologies outperform the TTY functionally in many ways, while the thorough harmonization, the interoperability between users of different carriers, the availability of both voice and text in the same call, the smooth flow of text while it is typed, the access to 9-1-1 emergency services and the consistent access to relay services of the TTY system is not yet established by any other technology.

The usage of TTY is declining, but the users in need of consistent accessible communication then often move to fragmented services with no 9-1-1 access, lacking some of the basic functional features of the TTY, like the smooth real-time text and the ability to use voice in one direction and text in the other, a form of communication very important to elders who can speak but not hear and not type well, especially on small keyboards.

This document is written from the 9-1-1 access point of view, but deals comprehensively with the transition to other accessible technologies, since a main principle is that the communication tool and service that is used for everyday calls should also be the possible to use for 9-1-1 calls in an emergency situation. In fact, it is important that people be able to call 9-1-1 on the devices they use every day and are familiar with, rather than expecting them to think of, find, and figure out a new technology in the middle

of an emergency. Therefore discussion of 9-1-1 and general communication issues are intermingled within the document.

When discussing a replacement or complement for the TTY, a first step should be to look into what characteristics are important to maintain.

Important capabilities of TTY that should be provided by any replacement technologies include:

- a. The ability for users to contact the emergency service PSAP via the same procedure used by voice callers - e.g. by dialing 9-1-1.
- b. The ability to direct 9-1-1 calls that include text (or where text appears in the call after connection) to PSAP telecommunicators equipped for accessible text communication.
- c. The ability to use the same communication devices and methods for 9-1-1 calls as are used for everyday calls.
- d. The ability to use the same communication devices and methods for relay service calls.
- e. With only minor time delays, text characters must appear on the recipient's display as they are being typed by the sender.
- f. The ability to intermix both voice and text on the same call.
- g. The ability to support all PSAP functions for accessible text calls that are supported for voice calls.

Examples include:

- i. Caller ID.
- ii. Call recording including text and voice.
- iii. Caller location provision.
- iv. Caller location use for call routing to most appropriate PSAP.
- v. Call transfer
- vi. Call back
- vii. Multi-party calls

A guide for handling of accessible emergency calls and especially TTY calls is found in the DOJ information at <http://www.ada.gov/911ta.htm> [20]. Its service principles must be maintained while the technology specific parts may be changed when new technologies are introduced.

5.2. Wireline TTY situation

On wireline phone connections where TTY is used, the following features are available.

- a) Voice with limited narrow-band quality (300-3400 Hz).
- b) TTY for limited real-time-text communication.
 - i. Also referred to as the "TIA-825A" [10] standard, using a 45.45 bit/s half duplex FSK modem and a 5-bit character code, also called Baudot.

A call is set up with general PSTN technology. When answered by a TTY, limited real-time text communication can take place. Characters typed on one of the TTYs appear on its own display and on the other's. When text is not transmitted, voice can be transmitted in an adjacent telephone alternating on using the same line as the TTY.
 - ii. Limitations of TTY (using TIA-825A (Baudot code)) include:

- The maximum transmission rate is about six characters per second, which is slower than many people type.
- Devices are not able to send and receive text at the same time.
- Although users are able to intermix voice and text on same call, *simultaneous* voice and text is not supported.
- Case shift is not supported. So the letter transmission is all seen as either upper case or lower case depending on the terminal display characteristics.
- Only alphanumeric and a few symbols are covered. Many important characters are not supported, such as the "@" symbol.
- Small transmission errors can cause garbling of the reception, which can carry forward for up to 72 characters after the error.
- A common reason for garbled reception (but not the only one) is due to the Baudot presentation protocol having modes. For example, the five-bit code 00001 represents the letter "E" when the TTY is in Letter Mode, and represents the digit "3" when the TTY is in Number Mode. It is not uncommon for the sending TTY and the receiving TTY to temporarily lose mode synchronization, causing the receiving device to display nonsense characters.
- In order to compensate for the risk for garbling by minor communication disturbance, the devices commonly have a feature for manual request to invert the shift on received and displayed characters.

iii. Many TTYs also support a manufacturer-specific proprietary enhanced text protocol with advantages over 45 baud TIA 825A, including a faster transmission rate and the ability to interrupt the typing party with an indication that the other party want to get the turn to type.

Note that, because these more rapid alternative technologies are non-standard proprietary protocols and only work between TTYs of the same manufacturer, PSAPs are not required to support them. The PSAP interfaces are required to follow only open standards.

Devices capable of these more rapid protocols that fail to receive a "handshake" of its same kind will default automatically to 45 baud TIA 825A.

c) DTMF (e.g., "If you are in danger and cannot speak, press 1.")

i. Note that users using a direct connect TTY do not necessarily know how to create the dial tones with their TTY instead of the normal TTY number tones.

d) Captioned telephony phones, providing rapid real-time text together with a phone call on another line by means of a human operated service.

e) "ASCII" text telephone support. Many text relay services and 9-1-1 PSAPs also support text communication with users with computers and low speed modems. The rate of use is not known exactly, but is reported to be much lower than for TTY.

5.3 Wireless TTY situation

Mobile voice channels are not directly suitable for carrying the tones for TTYs successfully. Therefore, methods for reliable transmission of TTY over wireless networks have been created, called Wireless TTY. The implementations have so far required connection of a TTY with a cable to the headset interface of the mobile handset. Different wireless technologies use different ways to encode, transmit and decode TTY tones.

With this arrangement, it is supposed to be possible to have TTY calls between TTYs connected to mobile phones and land-based TTYs.

The setup, requiring a TTY and a mobile phone cabled together is regarded inconvenient for a mobile situation by most users, so this solution is reported to have found very little use. It is difficult to find all the pieces and cords and connect them all successfully in time to receive a call, as well as being cumbersome to carry them all about. It has not been possible to get figures either for the real use of the solution, or for the amount of quality problems that sometimes is said to exist in usage of the Wireless TTY solutions.

There have been indications at the EAAC that there is some use of the wireless TTY solution. The general impression is however that the current wireless TTY solution with the TTY device attached to the wireless handset by a cable is very little used, much less than the regular wireline use. Therefore, transitioning to a TTY replacement technology would cause very little concern for current users as long as the replacement can connect to TTYs at the far (non-mobile) end of the conversations if the calls terminate on the PSTN.

For the GSM and UMTS wireless technologies, the standards allow for solutions completely built-in to the handset, but no such implementations have been made commercially available.

For next generation mobile solution, LTE, the real-time text and TTY interoperability solution builds on IP transmission of text coded text with the same text protocol that is specified for real-time text in NG9-1-1. This solution can qualify for being a model for the technology to replace TTY. The implementations need then be built into the handsets including the user interface in order to gain any interest from users.

5.4 Specific solutions for users with deaf-blindness

The National Deaf-Blind Equipment Distribution Program (NDBEDP) enables low-income individuals who are deaf-blind to access 21st Century communications services.

In this program, launched by the FCC, some of the distributed technology is based on TTY transmission. When transition is planned for TTY users to improved functionality in more modern environments, it is important to include the deaf-blind users of the NDBEDP program in the planning, so that suitable accessible devices are available, and interoperable with what is offered other users.

An advice from the EAAC TTY transition subgroup is therefore that representatives from the NDBEDP get actively involved in implementing TTY transition measures.

5.5. Solutions for captioned telephony in PSTN

There are captioned telephony phones, providing rapid real-time text together with a phone call on another line by means of a human operated service. The text transmission is only from the captioned

telephony service to the user. Therefore the text transmission part of this solution does not put any extra requirements on the PSAP communication technology.

IP based variants exist.

The conditions that the captioned telephony communication is only between the service and the user, and that an IP based alternative exists cause the conclusion that the transition of this type of communication from PSTN to IP can be left to the discretion of the captioned telephony service provider.

5.6 Proprietary solutions linking to standardized TTY

There are systems providing proprietary communications technology within an organization, converting to and from TTY transmission in the outside world. Decisions about TTY support in networks and 9-1-1 influences all users of such systems. If these systems are going to be maintained and interwork smoothly with the TTY replacements and NG9-1-1, it might be desirable to update them with direct links to IP and adaptation to the TTY replacement protocols.

5.7 TTY Statistics

It is sometimes said that the TTY is obsolete and not used anymore. Looking at statistics from for example text relay service usage, it can however be seen that the use has fallen dramatically over the last few years, but the usage is still significant and just over half the level of the text IP-relay usage. Thus, over one third of the text relay traffic is still TTY.

The following are coarse extrapolated approximate figures indicating the size of the TTY population and its usage 2012. An explanation of the sources of this information is found in Appendix A.

Relative use of different TTY implementations: The statistics provided here is mainly based on relay service usage statistics. At that point, calls with wireline TTYs, wireless TTYs and proprietary office TTY solutions look the same, and the statistics does not differentiate between these kinds. The contribution to the statistics from the Wireless TTY solution is however expected to be close to 0.

Approximate number of current users of TTY in USA: 100 000.

An estimate of the number of emergency calls from TTY: 20,000 per year (See Appendix A).

State of public use of TTY: TTY is a formally accepted way for accessible communication in USA.

Services available: TTY users have access to text relay services for calls with hearing people using voice phones. Text relay services translate between text and voice. Text relay services for TTY are available at phone number 711 from the TTY side. It is possible to alternate between text and voice in a relayed call. (This function is called VCO and HCO)

Trend: The rate of use of the TTY is being reduced by approximately 10% per year. This results in half the current volume in 7 years, 1/4th the usage in 14 years etc., unless something changes.

5.7.1 TTY usage compared to other accessible service usage in USA

In order to get an indication of the importance of the TTY, an effort is made here to compare its usage with the usage of other accessible communication solutions.

5.7.1.1 Relay service usage 2010/2011 in USA.

Type	minutes / year	calls / year	Source
Video Relay (VRS)	100 M minutes	25 M calls	NECA 2011
IP-Relay (Text)	50 M minutes	16 M calls	NECA 2011
Captioned Telephony	50 M minutes	16 M calls	NECA 2011
Traditional TTY TRS	28 M minutes	9 M calls	California 2010/11 extrapolated with NECA
Sum	228 M minutes	66 M calls	

Thus TTY based relay calls are about 12% of the total load of relay calls and 36% of the text relay calls.

Trends:

- VRS -unreliable trends (current decrease, likely temporary)
- IP-relay - decreasing
- Captioned Telephony - Increasing a bit more than the decrease in IP-relay.
- Traditional TTY - Decreasing about 10% per year, to half in 7 years, 1/4th in 14 years etc.

Conclusion: TTY traditional relay is still considerable but lowest in volume, and only about 12% of the total relay service call volume and approximately 36% of the text relay calls (See Appendix A)

5.7.1.2 User -to - user calls

Of the call types above, only Videophone and TTY are possible to use for direct user-to-user calls. An estimate from the EAAC survey [32] early 2011 indicates that TTYs are used for as many user-to-user calls as for relay calls. That would mean around 9 M TTY calls per year.

There are indications that videophones are used about 5 times more for user-to-user calls than for VRS relay calls. That would mean around 125 M calls per year in USA.

5.7.1.3 Total calls

The sum of relay calls and user-to-user calls can then be estimated to be:

- TTY: 18 M calls per year
- Videophone: 150 M calls per year
- Captioned telephony 16 M calls per year
- IP text relay 16 M calls per year
- Sum accessible calls 200 M calls per year

The wireline TTY thus seems to be used for about 9% of the accessible calls including other modalities than voice.

Note that these figures are very coarse and only provided to give an approximate view of the current situation with the degree of precision needed for the discussion in this report.

5.8. Reasons for users to keep on using the TTY

It is shown in this document that the number of TTY users is decreasing. The functionality is limited, and the communication problems for TTY are increasing. The wireless TTY solution is said to be close to extinct. Even so the wireline TTY users select to use the TTY for a call around 20 million times per year in USA (See Appendix A). What reasons can the users have to keep on using this communication tool that so often is said to be out aged and should be made obsolete.

Here is a list of possible reasons for a user to keep using the TTY.

1. The TTY is a robust device capable of surviving 10 years with minimal maintenance. No similar robust products exist for mobile and IP-networks, where the expected lifetime of a product is about 2 years.
2. The user has become used to operating the TTY, and is not interested in learning new devices and new services when the communication needs are sufficiently satisfied with the TTY.
3. The user appreciates the approximately installation-free use of the TTY. It has an acoustic coupling option, so any traditionally shaped phone receiver on a regular telephone network telephone can be used to connect the TTY to the network as well as be used for alternating between voice and text in the call.
4. The user has only phone-line TTY access and is not interested in changing the phone subscription to add Internet.
5. The user has other means for daily communication, but maintains a TTY for the case of emergency at home, when the TTY is the only directly applicable solution.
6. The user has relatives who have only TTY. The TTY is used for communication with them.
7. The user has other means for daily communication, but maintains the TTY for text relay calls with hearing people in authorities and other organizations.
8. The user is deaf-blind and no solution for deaf-blind people are marketed sufficiently other than the TTY based solution with Braille display distributed through the deaf-blind equipment program.
9. The user has a number of old friends who mainly use TTY for communication. Some of them have no Internet so TTY is the only way to reach them.
10. The TTY was provided from the Technology Equipment Distribution Program and the user saw no reason to not accept it.
11. The user prefers alternating between voice and text during the call. No other available communication tool enables that mode.

If products with similar ways of operation, similar robustness, equal interoperability, higher functionality, better mobility and equal capability to be used for direct 9-1-1 calls were available for IP networks, it is likely that the transition from TTY to modern communication methods would be more rapid.

5.9. Reasons to want to cease use of or support for the TTY

Wireline carriers, wireless carriers and 9-1-1 centers may find it desirable to cease support of the TTY because of a number of reasons. Users may find reasons to cease use the TTY. Some of the reasons are listed here:

Reasons for 9-1-1 centers to want to cease support of TTYs:

1. 9-1-1 TTY calls are rare. In some 9-1-1 centers it is months between the calls. It is complicated to maintain the technical capabilities to handle all kinds of TTY calls, when the frequency is so low.
2. It is complicated to maintain PSAP operational competence and preparedness to handle TTY calls with all variants including the ways to alternate between voice and text during the call.
3. TTY calls are often silent from the caller, expecting the called party to answer with TTY. For 9-1-1 centers this implies that a time consuming procedure needs to take place for each incoming silent call, so that it is checked if it is a TTY calling before deciding other treatment on the silent call. This issue is compounded by the infrequency of TTY calls vs. standard silent calls making them easy to confuse.

Possible reasons for wireline carriers to want to cease supporting TTY calls.

1. Modern communication technologies may have problems to support TTY transmission well, especially when planning for IP transport technology.
2. The need to support TTY transmission requires extra testing, extra engineering, and extra specialist support actions for a small and decreasing minority of the subscribers that use the TTY.

Possible reasons for wireless carriers to want to cease supporting calls with TTYs attached to handsets.

1. There seem to be extremely few users of this technology, and there are considerable costs involved in setting up and maintaining the infrastructure for the few calls made.
2. Each new generation wireless technology requires new specifications and new implementations of the handset and network support for the wireless TTY solution. With the few users, it seems to be a lot of resources spent for very little benefit.
3. In certain contexts, providers may get the impression that it would be sufficient to provide the SMS based "text-to-9-1-1" solution until an NG9-1-1 adapted TTY replacement can be provided.

Possible reasons for users to cease or decrease or not begin using the TTY.

1. There is a desire to be able to call on wireless devices and to wireless devices. The TTY support in wireless devices is not convenient to use.
2. The functional limitations of the TTY make it inconvenient to use. It is slower than typing speed, it can only be used in one direction at a time, and it has only capitals or lower case letters, not both. It has limited set of special characters; voice can only be used alternating with text and not simultaneously.
3. The user wanted to mainly use sign language in communication, so when videophones were distributed, the user moved to mainly use videophone and sign language.
4. The user wanted to talk and get captions on the incoming voice so the user moved to mainly use captioned telephony when that service was launched.
5. The IP relay services provide suitable replacement for many of the relay calls that the user used the TTY for.

6. There are many text communication alternatives today making up a patchwork of services through which it may be possible to have direct communication with many people. So, even if they do not have the same ubiquitous possibility to reach all, and do not provide full rapidity and conversational flow as desirable and no possibility to merge voice and text, they are used instead of TTY in many situations because of their widespread use and mobility.

These reasons may explain the observed reduction in TTY usage. They should be compared with the reasons for users to maintain use of the TTY listed in previous section.

NOTE: A desire to decrease support for TTY connection to a mobile handset should not be confused the continued need to support connection to TTYs at the far (non-mobile) end of a call, if it terminates in the PSTN. In both emergency and daily communication, people (using mobile devices) may need to communicate in text to people who are on the PSTN. TTY is the ONLY way for text communication to take place at the PSTN end of the call. So future TTY replacements on mobile phones must be able to continue to connect to and work with TTYs on the PSTN or else there will be no way to communicate in text to people on the PSTN as there is today.

Also, it needs to be remembered that for PSTN wireline networks, there is no text communication technology other than TTY. Eliminating TTY support on PSTN wireline networks would eliminate all text communication to those who only have PSTN wireline networks available to them. (Eliminating all PSTN wireline networks would address this problem but it is unclear how soon that would happen, and until it does TTY support on PSTN is needed.)

6. Theory behind observed transmission problems

TTY transport over packet-switched networks

On many packet-switched telecommunication systems, when attempting to transmit 45.45 baud Baudot TTY signals *as audio tones* – i.e., when attempting to transmit TTY information via the same audio protocols and mechanisms that are used for voice – three common types of transmission impairment *at levels that that tend to be acceptable in voice conversations* can cause the TTY character error rate to rise above acceptable levels. They are:

- (1) Packet loss
 - a. Includes packets that are never delivered and packets that arrive too late to be used.
 - b. A typical audio packet contains a digital audio recording that is 20 milliseconds in length.
 - c. In voice conversations in which the packet loss rate is not extreme, voice-optimized packet loss concealment algorithms are often able to trick the human ear into hearing something that wasn't there – for example, by automatically filling the gap with “comfort noise” or by acoustically interpolating between the packets on either side of the gap.

d. Voice-optimized packet loss concealment algorithms are *not* able to trick a TTY into “hearing” a TTY tone (data bit) that was not received. If any one of the audio packets containing a TTY tone is lost, the receiving TTY will be unable to decode and display that character properly. Some quick math:

i. If a packet size of 20 milliseconds is assumed, the sequence of audio tones *that comprise a single TTY character* spans approximately eight audio packets.

ii. If one assumes that packet loss occurs randomly, as opposed to being clustered or “bursty”, the expected character error rate will be roughly equal to the packet loss rate times eight. This means that one can expect to exceed the one percent character error rate threshold recommended by the FCC when the packet loss rate is only 0.12% – an amount far below what is often regarded as acceptable for voice communication.

(2) Audio compression

a. In order to allow telecommunication transmission pipelines to accommodate a larger number of conversations simultaneously, many systems employ audio compression techniques that reduce the number of bits-per-second required by each audio stream.

b. The audio compression techniques that are commonly used in enterprise VoIP and in wireless systems are voice-optimized. When compared with uncompressed audio (e.g., audio encoded using ITU-T Standard G.711 [15]), the loss of perceived voice quality attributable to these techniques tends to be noticeable but not objectionable. By contrast, because these techniques are voice-optimized, the techniques tend to distort non-voice audio information (such as DTMF and Baudot TTY signals) so badly that the receiving devices are often unable to decipher the information reliably.

(3) Echo cancellation

a. In telecommunication systems, many factors can cause an undesirable reflection of signals from a receiving device back to the transmitting device. A simple example of this problem may be encountered when amplified handsets are employed: Because the sound coming from the handset’s speaker is amplified, the sound can be picked up by the handset’s microphone and then echoed back to the person who is speaking.

b. In telecommunication systems in which the transmission from one person to the other is virtually instantaneous, a person who is speaking into a telephone and receiving these reflected signals will perceive that their own voice sounds a bit louder to them while there are speaking. The effect can be annoying, but generally not something that would interfere with the person’s ability to speak.

- c. In typical IP telecommunication systems, point-to-point transmission times can be hundreds of milliseconds. Under these conditions, people who are speaking will perceive a reflected signal as an obvious echo, time-delayed by an amount that makes it difficult for people to have a conversation.
- d. In order to ensure that voice conversations will not be disrupted by reflected signals, IP telecommunication systems have voice-optimized echo cancellation mechanisms.
- e. In order to cancel echo, without cancelling desirable signals (e.g., a voice user trying to interrupt another voice user), signal characteristics that must be detected and measured by the echo canceller include: (1) the presence of transmitted signals with acoustic characteristics that appear to duplicate the characteristics of the received signal, (2) the difference in amplitude between the original signal and the duplicate signals, and (3) the time delays between the original signal and the duplicate signals. Echo cancellation is achieved by attenuating transmitted signals at levels that align with the measured amplitudes and time delays of what are determined to be echoes.
- f. Voice-optimized echo cancellers may diverge in presence of the relatively long even tones used in TTY communication. In this situation, the manner in which signals are attenuated by the echo canceller will be incorrect, thereby causing TTY transmissions to be inappropriately choked or distorted. An article describing some of these problems is referenced in [33]

Three examples:

- i. Many voice-optimized echo cancellation mechanisms assume that a signal with little acoustic variability is noise (because it cannot be speech), and will therefore try to attenuate or block the signal.
- ii. If there is intermittent, random noise coming from the endpoint that is receiving the TTY signal, the echo canceller might assume that the non-varying TTY signal is noise that should be removed, and that the intermittent, random noise is a signal that should be retained.
- iii. Signal from one end and noise from the other can be taken for cross-talk. Under cross-talk situations, some echo cancellers freeze their operational conditions in a way that can lead to diversion, or even worse, block transmission in one of the directions.

For these reasons, the EAAC advises against methods that transmit TTY information as audio tones within IP networks. Instead, it is recommended that PSTN gateways transcode between traditional audio TTY signals on the PSTN side of the gateway, and real-time *text* packets on the IP side of the gateway.

7. Threats to the quality of experience of TTY calls.

TTY transmission quality is threatened by some development trends in electronic communication. These threats are assessed in this chapter.

7.1 Access network threats

The network connection where the TTY is connected needs to have characteristics suitable for TTY tone transmission.

- Traditional analogue PSTN phone line connections have such suitable characteristics.
- But at an increasing rate such connections are replaced by solutions containing IP based transport of the audio. Then, a risk for deterioration of the TTY tones appears, resulting in reduced or destroyed or irregular TTY transmission quality.

This risk appears especially when a user tries to connect a TTY to the phone jack of an interconnected VoIP connection, but may also possibly appear because changes in the access network behind a PSTN connection.

VoIP operators may have specific settings to apply to connections that the user announces that they intend to use for TTY.

In order to avoid these risks, information must reach TTY users and potential TTY users explaining the risks for reduced TTY communication quality in these situations, and possible actions against such deterioration, if found effective. The TEDPs, the TRS, the TTY resellers and the wireline carriers can share the task to provide this information.

The TTY Transition subgroup recommends that FCC arranges so that an investigation is performed on to what degree VoIP transmission technology in the access network causes bad quality on TTY calls, and to what degree this is known by carriers and service providers offering connection of PSTN equipment. It should also be clarified if there are known remedies. This information can then be the base for requirements to the carriers and service providers to inform users about the suitability of a phone connection for TTY usage.

7.2 PSTN Core network threats

The PSTN network for telephony is approaching end of life. PSTN-like services will continue for some time, but the core networks are moving to use IP as the internal technology. This means that users, still having regular PSTN RJ-11 jacks and plain old telephone equipment, in an increasing rate will have their calls go through IP based transmission even if also the other endpoint in the call has a similar PSTN technology access.

Knowing the extreme sensitivity of audio carried TTY tones in IP networks, where the requirement is that any echo canceller must not malfunction in presence of TTY tones, and no more packet loss than 0.12% must occur, there is an apparent risk that IP replacements of the PSTN core network will not always meet these requirements, and therefore introduce irregular deterioration of TTY call quality.

The TTY Transition subgroup recommends that FCC arranges so that an investigation is performed on to what degree IP transmission technology in the core network causes bad quality on TTY calls, and to what degree this is known by carriers and service providers using core network carrying traffic for PSTN devices, and if there are remedies. This information can then be the base for requirements to the carriers and service providers to inform users about the suitability of a phone connection for TTY usage.

8. Known standards and technical methods intended to transport TTY reliably through IP networks.

There has been some efforts to standardize transport between PSTN based TTYs in a reliable way through IP network segments.

ITU-T Recommendation V.151 [19] This is a standard for transmission of TTY and other text telephone standard signals over segments of IP networks. This standard is intended to be implemented in gateways between PSTN and IP. Devices following this standard demodulate TTY tones, and convert them into text coding sent in IP packets. At the egress side the text is again converted to TTY tones.

- Implementations exist in large gateways, with slight proprietary additions making it required to have the same make of gateway at both ends of the communication.
- The standard is not intended for communication between a PSTN based TTY and an IP based terminal.
- Echo canceller concerns still apply and are not covered by the V.151 standard.

TIA 1001 [11] This is a standard applicable to USA only, because it covers only TTY communication and not the other text telephone transmission standards used in other countries. The method is similar to the one used by V.151. This standard is therefore also only applicable to calls between PSTN based TTYs.

ITU-T Recommendation J.161 [17] This is a standard specified for transmission of IP communication in cable TV networks. It requires good transmission for TTY tones and also a possibility to use IP based real time text communication.

IETF RFC 4734 [6] This standard is for detection of tones from e.g. TTYs. It may also be possible to transfer some tones through IP networks with this standard, but the main idea is to detect and indicate e.g. TTY, and then move to use of one of the other standards for the transmission of real-time text.

3GPP TS 23.126 [22] The standards for TTY transmission through GSM and UMTS wireless networks also contain a description on how to handle an all-IP wireless IMS network by IP based real-time text transmission, called GTT-IP. Even if it is foreseen that most implementations would make the user interface for text communication built-in to the handset, it is possible to use it also with conversion to a TTY attached to the handset.

Advice is also sometimes provided for trying to establish network conditions suitable for the transport of TTY through IP without the standards above. There is no guarantee for success.

The main parts of such advice are:

1. Use a large static jitter buffer for reception after IP transmission.

2. Do not use voice error concealment.
3. Use G.711 [15] encoding.
4. Do not use silence detection and comfort noise generation.
5. Use a G.168 [14] line echo canceller that is tested for good performance with TTY tones as specified in G.168 Test 14 in the actual network conditions. Echo cancellers have less risk to cause problems if they are set to disable non-linear processing, do no clipping on double-talk detection and make sure that no G.164 and G.165 functionality are active simultaneously with G.168.
6. Use this way of transmission only in controlled network environments.

Applicability and deployment of these methods for legacy TTY transmission over IP network segments.

All the methods specified above in this section only aims at reliable transfer of TTY signals over IP network segments. They thus have the opportunity to prevent the experience of bad quality when crossing IP networks between legacy TTY terminals, if implemented in both ends of such a connection. They do not help for connections between TTY and IP based text capable terminals, and have therefore no real place in a TTY transition plan.

A general protocol suitable for gateway operation including TTY and real-time text is:

ITU-T Recommendation H.248.2 Gateway control protocol: Facsimile, text conversation and call discrimination packages [16].

Brief descriptions on interoperability between TTY and IP based real-time text can be found in **IETF RFC 5194** [7].

9. TTY Replacement

9.1 Features desired by the users

The EAAC user survey [32] provides good insight in features and functionality that users find important and desirable to bring into the TTY replacement. The most relevant features are extracted in chapter 4. This chapter describes the feasible functions and features and recommends ways to implement them.

9.2 Achievable functionality in IP based implementations

A solution that can replace the functions of the TTY and enable users to move to IP networks should provide the functionality that is appreciated by the TTY users but eliminate its most apparent limitations.

The following functionality should be provided:

1. Provide smooth, rapid transmission and display of real-time text so that text is transmitted not more than one second after character submission and without any extra action than typing the characters, or submitting them in some other way, e.g. through speech-to-text.

2. Allow international and national interoperability so that calls can be made with other service providers or devices. Use agreed interworking standards between providers even if providers may use different technologies internally. Less functionality does not meet the functional equivalence goals.
3. Make use of any international characters possible with both capital and lower case characters.
4. Provide transmission speed of text above the most rapid typing speed and speed of input of voice-to-text applications. (at least 30 characters per second)
5. Use a technical method that supports a character error level of not more than 0.2% in network conditions that are possible to use for voice calls.
6. Use a method that can indicate where text may have been lost.
7. Allow simultaneous speech and text in calls without requiring user actions for alternating between speech and text.
 - a. To allow people (especially elders) who can speak but not hear or hear clearly and who often cannot type well or at all, to speak to 9-1-1 but get text back from 9-1-1 center.
 - b. To allow 9-1-1 centers (or callers) to mix text with speech when noise makes it hard to understand specific words or instructions
 - c. To allow captioned telephony (where the caller receives both voice and text captions back from 9-1-1 center coupled to text caption relay)
 - d. To enable 9-1-1 services to perceive the background audio from the place of the emergency situation (while texting is going on) in order to assess the situation rapidly.
8. Support at least 'erase of last character' and 'insertion of line break' as edit functions.
9. Provide possibility to have calls with TTYs, using calling with the destination phone numbers between the devices of each environment.
 - a. TTYs are only able to dial numbers, and are expected to reside in PSTN networks using phone numbers as identification.
10. Provide possibility to have calls directly with legacy PSAPs who communicate in TTY mode.
11. IP-based TTY replacement (voice and real-time text) is able to interoperate with IP-based total-conversation devices (voice, real-time-text and video)
12. Enable multi-party calls, with mixing and distribution of both text and audio in the call to other parties.
13. Enable creation of text based IP-relay services for this type of device, and let calling be based on direct dialing the destination.
14. Initiate the media in a call with a negotiation protocol, so that each side can detect if real-time text and other media will be supported in the call.
15. Make generation of DTMF tones possible in the audio channel.
16. Arrange visual indication of audio strength in the audio channel.
17. Provide alerting on incoming calls in accessible ways, selectable between visual, tactile and audible means.

18. Provide functionality common for telephony users, e.g. answering machine functionality in real-time text and audio.

9.3 Standards and technologies in IP networks suitable for TTY replacement

The functional requirements specified above can be met in IP networks through application of existing standards and provide a good replacement for the TTY. The protocols can be used for interoperability between service providers as well as for communication with terminals within each service provider's network.

The recommendation is to use the following specification as the primary set of standards for interoperability between SIP based accessible communication providers and for replacement for the TTY.

9.3.1 For native SIP

For Native SIP protocol environments that can be used in over-the-top services on wireless networks and in broadband networks the protocol set is:

- IETF RFCs 3261 SIP [4] for call control
- ITU-T Recommendation T.140 [18] for real-time text presentation and IETF RFC 4103 [5] for real-time text transport.
- Suitable audio and wide-band audio codecs commonly used in the implementation environment and supported by NG9-1-1 PSAPS, e.g. the narrow-band codec ITU-T G.711 [15] to assure interoperability and a wide band codec included in NG9-1-1.

This case is also described in RFC 5194 [7].

9.3.2 For IMS used in wireless LTE networks and fixed broadband networks

For IMS, the protocol set is similarly:

- IETF RFC 3261 SIP for call control as contained in the IMS Multimedia Telephony service.
- 3GPP TS 26.114 IMS Multimedia Telephony Codec Considerations for media, including:
 - ITU-T Recommendation T.140 for real-time text presentation and IETF RFC 4103 for real-time text transport.
 - AMR and AMR-WB audio.

This set of protocols is collected in a profile defined by the GSM Association, and called GSMA PRD IR.92 "IMS Profile for Voice and SMS" [1]. The real-time text part is described in IR.92 Annex B.

9.3.3 For XMPP

Work is in progress with a standard for real-time text based on the XMPP protocol, called XEP-0301 In-band real-time text [27]. If the standardization process is successfully completed, it can be a base for TTY replacement in the XMPP environment properly complemented with audio (with preference for wide-band audio codec). The native way for adding audio in the XMPP environment is by use of XMPP extension XEP-0166 Jingle [25] and XEP-0167 Jingle RTP Sessions [26].

9.3.4 Use of other real-time text protocols

Other real-time text protocols than the above may be used within each service provider's network and between service providers, as long as the functional goals are met and the protocol set described above is supported as a fallback for cases when other protocols are not agreed.

It is preferable that terminals also use the same set of protocols as is used between the service providers. That approach creates the best opportunity for an efficient market of components supporting the TTY replacement.

An example of a possible future protocol environment for implementation of calls with real-time text and voice is in web-based technologies. Standards work is currently going on in this area, called IETF RTCWEB and W3C WebRTC. Specifications on how to handle real-time text in this environment and how to combine it with audio (and video) as well as arrange interoperability with other environments and NG9-1-1 is urgent.

9.3.5 Routing and addressing by number

Routing mechanisms based on IETF RFC6116 ENUM [8] can be used for addressing based on numbers in the international number plan. Other addressing formats may be used within each platform for implementation.

9.3.6 Example from another region

When designing a system for TTY replacement, it may be of guidance to look at how the situation is handled in other countries. Therefore it is described here how this was done in Sweden.

Sweden has a telecommunications equipment distribution program for accessible communication with some similarities with the TEDP in USA. County council departments procure accessible communication devices and services based on a joint procurement requirements specification developed by the Swedish Institute of Assistive Technology, SIAT [31].

Earlier, PSTN textphones (same idea as TTYs, but with different modem technology) dominated the procurements, but since around 2003, SIP based Total Conversation devices and softphones dominate accessible communication procurement in Sweden.

The procurement specification has a SHALL-requirement for interoperability between Total Conversation devices and PSTN textphones, so that the real-time text and voice functionality of Total Conversation devices is used also for calls with PSTN textphones and IP based textphones.

Earlier, Total Conversation terminals having dual network connections, one for PSTN text telephony, and one for IP connections were common. Lately, it has instead become more common to provide access to calls with PSTN textphones through gateways included in the Total Conversation services.

Also lately (2012), it has become common to not procure PSTN textphones anymore, but instead buy IP based textphones. Both Total Conversation devices and IP based textphones have SHALL requirements for interoperability through SIP for call control, IETF RFC 4103 for real-time text and common audio codecs for audio. Both softphones, hardware based products and mobile solutions occur among the IP based textphones and the Total Conversation devices.

Direct access to 112 emergency services is currently provided through the interoperability with PSTN text telephony. The 112 PSAPs have access for PSTN text telephony and receive real-time text calls from both the PSTN textphones, the IP based textphones and the Total Conversation devices.

The conclusion is that Sweden is on the way with the textphone replacement evolution and the main mechanism is a joint procurement specification with strict interoperability requirements between the old and the new.

9.4 Access to NG9-1-1

The protocols described above for user and service provider usage are also fully in line with the NG9-1-1 specifications. The media chapters in the NG9-1-1 related specifications IETF RFC 6443 [9] and NENA i3 technical specification [3] both specify use of IETF RFC 4103 [5] for real-time text support.

NENA i3 Technical Specification 08-003 [3] specifies that all PSAP positions shall be capable of handling real-time text in IP-based SIP calls according to RFC 4103 [5], together with corresponding specifications for audio and video and text messages. For TTY access, this specification indicates two options, either conversion between TTY and RFC 4103 at the border of the PSAP, or handling IP carried audio based TTY coding in the PSAP work stations. NENA i3 also refers to IETF RFC 5194 [7] for the real-time text communication and TTY interoperability.

The Internet Engineering Task Force IETF specifies in RFC 6443 "Framework for Emergency Calling Using Internet Multimedia" [9] that SIP calls with real-time text as specified in IETF RFC 4103 [5] shall be supported together with corresponding specifications for audio and video and text messages.

The NG9-1-1 implementations should be developed so that:

- Real-time text with good real-time flow is implemented in the PSAPs.
- Full support of simultaneous real-time text with voice and video included.
- Recording of all media in the call is supported.
- Support for multi-party calls, and call transfer is included for all media.
- Support for invocation of assisting services with text and voice is included.
- Guidance for selection of text transmission method in callbacks is provided.
- Guidance for supporting the differences in functionality between TTY, TTY replacement and text messaging is provided.

The IMS IP Multimedia Subsystem, an environment for IP based services specifies also that RFC 4103 shall be supported for emergency calls. This is specified in 3GPP TS 22.101 [21] by referring to the IP based variant of Global Text Telephony GTT implemented by IMS Multimedia Telephony 3GPP TS 26.114. [23] and contained in the profile GSMA PRD ir.92 [1] including its Annex B.

Work is underway for multimedia emergency services in the Multimedia Emergency Services (MMES) work in 3GPP. The MMES requirements are specified in section 10 of 3GPP TS 22.101 V11.3.0 (2011-09), 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Service Aspects; Service Principles (Release 11) [21]

For emergency service access, the procedures for location information provision and call routing described in IETF RFCs 6442 and 6443 must be implemented by the terminal and the service it is used in.

As long as no IMS addition is published for NENA i3 emergency service access, the service must follow the specification in IETF RFC 6443. The basic functionality of IMS emergency calling is specified in 3GPP TS 22.101 in line with the specification above. ATIS has current work in progress for North American IMS based emergency calls that is expected to complete in 2013.

Since the proposed TTY replacement is interoperable with Total Conversation, the advice expressed in ETSI TR 103 170 Total Conversation Access to Emergency Services [30] which has been validated in Europe may provide the template needed for planning PSAP access for the TTY replacement and should be considered and evaluated on North American networks due to similarity of equipment.

9.5 Access to legacy 9-1-1 and transition from legacy to NG9-1-1

During a period both NG9-1-1 ready PSAPs and legacy PSAPs will exist. Users of the TTY replacement must not be left without access to emergency services when the geographically most appropriate PSAP is a legacy PSAP that handles only legacy TTY as text protocol.

There are at least three possible solutions.

1. The TTY replacement service providers are required to provide TTY interworking, for the calls between TTY replacement and legacy PSAPs.
2. The NG9-1-1 introduction is made so that NG capable PSAPs take TTY replacement calls on behalf of legacy PSAPs.
3. An emergency call transport network is arranged for handling the protocol harmonization, routing, adaptation to the kind of PSAP to receive the call, and any needed invocation of assisting services. This network can be made as an extension on the transport network described in the text-to-9-1-1 report.

There are severe limitations with TTY functionality compared to real-time text that will cause limited usability in interoperation between the TTY replacement and legacy PSAPs. The most apparent will likely be the lack of simultaneity of text in both directions and of text and voice. Users and PSAPs will need application support to obey the turn-taking habits that are needed for successful TTY communication.

However, organization of PSAPs working on behalf of other PSAPs may cause organizational complexity that will be hard to overcome. One of these complexities is to keep track of the expected load from TTY replacement calls in the NG9-1-1 PSAP. Another complexity is that if this is selected to be the only supported method, then all legacy PSAPs need to have an agreement with an NG9-1-1 PSAP, and that it will be impossible to start deploying the TTY replacement before NG9-1-1 PSAPs are implemented.

EAAC recommends that the third method for handling the transition period until full NG9-1-1 deployment are enabled should be examined with highest priority, and that therefore TTY replacement providers are required to cooperate in establishing the transport network for routing, adaptation and assisting service invocation of emergency calls.

The EAAC also suggests that a feasibility study is performed to show if it is realistic to provide TTY interoperability with legacy PSAPs with support for overcoming the functional differences between TTY and TTY replacement.

9.6 Methods for interoperability between TTY and IP based solutions

The most convenient method for interoperability between the TTY and the IP based solutions would allow the TTY user to dial a number and reach the IP user and communicate in real-time text and voice. Equally, the IP user would dial the number of the TTY user, get connected and communicate.

Gateways in the border between the networks would convert between the transmission and coding forms for real-time text and voice in the two environments.

It is feasible to produce the required type of gateway action between TTY calls and IP based calls with IP-based real-time text and voice. However, there are apparent obstacles against providing the described simplicity in reality. The problem concentrates around how to get the required gateway functionality included in the call where it is needed.

1. The TTY gateway is needed at the point of conversion to IP. If the call is allowed to first be converted to IP and then to RTT somewhere within the IP network then the path where the TTY audio is transported over IP is a risky path. Audio may be more or less corrupted, and thereby text corrupted.

2. The TTY users are used to moving their equipment between different PSTN connections. The total number of VoIP gateways in homes, office networks and carrier networks is too high for it to be realistic to require all VoIP gateways to implement TTY gateway functionality. This is because the VoIP networks had some years without regulation, and then the VoIP gateways were deployed without TTY gateway functionality. A TTY call cannot be distinguished from a voice call by any other way than to detect the typical TTY modem signal timing and frequencies. When answering a call, it is even needed to prompt the connection with an answering phrase in text in order to cause the calling party to send characters so that a possibly connected TTY is detected. This makes it slow and resource consuming to detect TTY signals in VoIP gateways. On the IP side, the opportunities are better. Capability for real-time text is indicated in session set-up, and requirement for text can be indicated.

Because of this, the TTY owners cannot anymore expect to be able to connect their TTY at any phone connection point, but rather keep it at a connection where it has proven to achieve suitable transmission quality.

3. Interconnected VoIP services have phone numbers so they should be possible to call and be called if used for a TTY replacement.

4. The users of the TTY replacement may not be interested to pay extra fees that may be needed by the service provider to finance the provision of TTY interoperability if the functionality is put on the TTY replacement side.

Routing and conversion requirements

PSTN calls to the phone number of the IP based TTY replacement terminal shall be routed through a VoIP gateway with capabilities for conversion between TTY and the TTY replacement. When no text transmission is going on, voice should be allowed to pass through. The calls to and from the TTY replacement user may be detected by the service provider to require TTY conversion, so that functionality can be activated only for calls to and from TTY replacement users.

Calls from the IP based terminal to a PSTN number shall be routed through transcoding equipment for conversion between TTY replacement and the TTY.

The transcoder shall monitor the connection passively. As long as no text flows in either direction, audio should be allowed to pass through. When text from either side is detected, it shall be converted between TTY audio coding in the audio channel and the TTY replacement coding of text in a text channel. Text transmission towards the TTY should only be sent when no text is received from the TTY.

Handling differences in speed, simultaneity and character sets between the solutions.

The conversion mechanism needs to adjust for limitations in TTY communication. TTY handles only one direction of text at a time, cannot handle voice while text is transmitted, is slower than many users type, supports a limited character set and creates a risk of corruption of up to 72 characters in sequence after a single character error. These limitations must not hamper a TTY replacement technology when communicating with other IP based communication tools. An indication of the limitations should be provided to the user of the TTY replacement technology during sessions with TTYs. The conversion equipment needs to guide users to stay within the limitations so as to maintain TTY compatibility. For example, the conversion equipment should store text on the way towards the TTY while the TTY user is transmitting and make other efforts to span the functionality gap between TTY and TTY replacement.

The conversion equipment should also protect the user of the TTY replacement from receiving TTY tones at high volume.

9.6.1 Alternative solutions for interoperability between TTY and TTY replacements.

There are a few alternatives for the possibility to have calls between TTY and TTY replacements.

- a. Require all VoIP gateways both residential and carrier and office located to introduce support for a standard for reliable TTY transmission through IP network segments for communication between TTYs, and conversion between TTY and a TTY replacement protocol for communication between TTY and IP networks. Even if this is what current regulation requires, it does not look feasible. Too many VoIP gateways in homes, offices and networks are already deployed without these features for it to be realistic to require this upgrade.
- b. Define small single user gateways for TTYs, which are used locally for connecting TTYs to the VoIP network and use the TTY replacement protocols. Promote deployment of these single user gateways for moving TTYs to VoIP subscriptions. For locations with both PSTN and IP connection, the gateway can select the proper network for each call and activate conversion only on IP calls. For connection only to VoIP networks, let these gateways (against advice elsewhere in this report) use best effort audio transmission of TTY signals when they have calls with legacy TTYs. This solution is mainly of interest for users who want to keep their traditional TTY equipment.
- c. Define gateways for conversion between TTY and TTY replacement that are deployed by service providers of the TTY replacement. When calls are made between PSTN and a user provisioned to have TTY replacement, then the gateway functionality is activated seamlessly through routing analysis in the network. NG9-1-1 calls would need to be regarded as going to a user with registered interest in TTY calls.
- d. Gateways can be arranged for two-step dialing between the two environments. First a call is made to the gateway where the gateway asks by text communication what number or address the call is going to be made to. When the call is completed, the gateway functionality is activated. An organization already involved in TTY communication, e.g. the TRS services, could be assigned the task to set up this kind of gateways. . Relay operators would not be involved. The call would go

through completely automated without any human intervention. It is just suggested that the same entities (relay operators) would maintain these automated gateways. This must be regarded a last resort solution if the more automatic gateway alternatives are not selected. Two-step dialing through gateways has functional limitations that make it less attractive. One is that electronic phonebooks cannot be used for the destinations of the calls. In addition it will be neigh on impossible and impractically expensive to contact all the TTY users and teach them to dial two numbers now to make a call when they used to only have to dial one.

- e. Ignore the need for interoperability and promote the view that persons interested in communication with TTYs and TTY replacements should have devices and network access for both types of communication. This involves providing all TTY users with an IP line, or requiring that they purchase one on their own. It also causes problems for areas where landline IP is not available even if the National Broadband Plan is addressing the issue of broadband IP coverage everywhere, but it may also be a long time before the last PSTN line is vanquished.

Recommendation: The TTY Transition subgroup of EAAC recommends FCC to further explore all alternatives regarding market interest and costs involved. Without deeper analysis, alternatives b and c together seems to be the most attractive solution.

9.7 Other session control protocols than SIP

If another session control protocol than SIP is used within a service, it must be specified by the organization responsible for specifications for the environment how Real-Time text shall be implemented in that environment and how NG9-1-1 calls shall be handled.

For interconnected VoIP services, it must be specified how real-time text is negotiated and how other aspects of interoperability with SIP environments are handled.

For the rare case that NENA i3 technical specification is extended for a session control environment with real-time text, this new way to interact with NG9-1-1 may be used for emergency service sessions with real-time text according to the target session control environment.

In most cases however, conversion to the protocols already supported by NENA i3 must take place in the connected service. This is valid both for session control, media handling, multi-party call handling, call transfer, additional information, location information and routing.

One protocol environment that is mentioned as possible for a future extension for next generation emergency calling in both IETF RFC 6443 and NENA i3 technical specification is the XMPP protocol. This is a wide spread protocol for instant messaging. Since work is in progress with a specification of real-time text in that environment, called XEP-0301 [27], this may become a possible alternative way for TTY replacement calls. However, as long as no extension for XMPP is ready for NENA i3 NG9-1-1 access, all emergency calls must be provided using SIP [4] through external conversion by the service provider. Whatever solution is selected, standardization needs to be forceful in this area if any use of XMPP at all for emergency calling shall be made possible.

9.8 Solution proposals for interoperability between different IP based solutions.

It is recommended that interoperability between communication providers be handled as follows:

- If two IP based communication environments have interoperability for voice calls, they should also provide interoperability for text simultaneously with voice in these same calls.
- If at least one of the providers is using SIP as the call control protocol, at least real-time text according to IETF RFC 4103 is to be provided as an interoperability protocol for text and used as the TTY replacement if the service providers have no mutual agreement to use another interoperability protocol for real-time text.
- If none of the environments use SIP as call control protocol, an interoperability protocol for real-time text needs to be specified by the providers.

Any differences between the real-time text presentation standards used need to be catered for in a best effort way. There may be differences in supported character sets, editing features, scope of erasures and corrections, use of emoticons, indications of errors, multi-party handling etc., that may not be possible to translate exactly between the environments.

10. Non real-time text alternatives; Applicability and functionality.

Lacking convenient mobility, functionality and mainstream availability of TTY communication, many users in need of text-supported communication have decreased or ceased use of the TTY. A multitude of other solutions are used instead.

Many of these systems are based on transmission of completed text messages, in contrast with the continuous flow of characters used by the TTY and real-time text technologies.

Also, many users prefer to move from TTY communication to use of video communication for sign language, sometimes in combination with real-time text or text messaging.

In these moves, the users currently sacrifice some functionality in order to achieve mobility, higher functionality and connectivity with the people they want to contact.

The typical sacrificed functions are:

1. No direct 9-1-1 access, instead needing to text to hearing friends to ask them to call 9-1-1, or finding other inferior solutions.
2. No direct communication with anyone in the International Number Plan, instead using a number of communication tools and services, and needing to keep track of who is user of what service in order to maintain a functioning human communication network.
3. No immediate communication in real-time text, instead needing to collect typed text in messages, causing delays and risk for crossed dialogue.
4. No communication with the users who are using only TTY for their text based communication, because interoperability between TTY and new services has not been implemented.

The patchwork of services making up the communications functions includes:

1. Proprietary Instant Messaging services, for transmission of text messages, nowadays usually possible to combine with audio and video, but only working within its closed user group.
2. Standardized Instant Messaging services, mainly based on the IETF XMPP standard, sometimes providing combination Instant Messaging with audio and video.
3. Short Message Service SMS in the mobile phone systems, offering a way to send text messages to other mobile phones. There is ongoing Joint ATIS & TIA work to standardize a solution for SMS to 9-1-1.
4. IP-relay. Text relay services based on IP technology enabling conversion between voice telephony and text communication, often in the form of real-time text. This type of service provides numbers in the North American Number Plan to the text users for communication with hearing users. 9-1-1 calls are allowed and end up as voice calls in the PSAPs. Most of the IP Relay services use real-time text communication, while some use messaging.
5. Video phones, Video Relay Services and Total Conversation Services, provide possibility to mainly use sign language instead of text for the communication. This option is preferred by many users because of the more rapid flow and ease of communication that can be achieved with sign language compared to typing the conversation. However it is another mode of communication and further handled in other parts of the EAAC reports. A considerable number of users are not sign language users and there are situations when video communication is not feasible, technically, economically or by the situation of the user. Therefore sign language users many times are also text communication users and rely on provision of modern text communication facilities.
6. IP based captioned telephony services. The captioned telephony services adding real-time text to voice phone calls are available in IP technology and can be used in 9-1-1 calls for users who prefer to talk, but need to read a rapidly created real-time text representation of the answers from the voice phone user.

10.1 The gap between mainstream provision and accessibility

As long as the mainstream provision of services does not meet accessibility requirements, there will be a gap between these types. Only when the mainstream services are made accessible, this gap will be closed.

As long as the gap exists, some users will select to use the accessible services, some will select to use the mainstream services, and some will use a patchwork of accessible and mainstream services to fulfill their communication needs.

Real-time text is a feature that has potential to become a mainstream improvement of text messaging services because of its more rapid delivery of text during typing and the resulting better experience of contact and efficiency of the communication. The real-time text feature has however not yet received widespread acceptance in mainstream services. Therefore a gap exists between text messaging services and real-time text.

When a service with real-time text and voice is offered as a replacement for TTY, it is important for its success that it gets many users, good functionality and good interoperability with other services. Thoughts should be given as to what degree the already existing mainstream text messaging services will be sufficient or not as replacement of the TTY. Many TTY users are also users of such services.

The following facts speak for a conclusion that text-messaging services would or would not be sufficient as TTY replacement.

Would be sufficient:

- a. Many Instant Messaging services are today combined with voice and video options.
- b. It is possible to exchange information in text through the service.
- c. The most popular services have many users.
- d. Two text-messaging standards are specified for NG9-1-1 emergency calling by both IETF and NENA (SIP MESSAGE and MSRP).

Would not be sufficient:

- e. Earlier efforts to create interoperability between TTY and text messaging have failed because the TTY user expects more rapid action and has a tendency to disconnect thinking that there is an error when no text shows up in a long time while the message user composes a message. Automatic user guidance by text to avoid this is possible, but not really feasible because it dilutes the real conversational text output on the TTY.
- f. It is true that two SIP-based text message protocols are specified in the IETF and NENA i3 specifications for next generation emergency services, but enterprise use of SIP-based instant message is declining in popularity, there are very few consumer services using these two protocols, and there is no trend towards use of SIP-based instant messaging protocols for emergency services.
- g. Most text messaging services use proprietary methods for messaging, and would need to establish translation mechanisms to use the standards for the emergency calls.
- h. The waiting time during composition of messages can be experienced to be very stressful for both the sender and the recipient, especially in an emergency situation. The real-time text flow corresponds much better to a natural efficient dialogue between humans.
- i. The slowness of messaging is also especially stressful and causing inferior access if used in relay services and in participation in conferences by transcription services.
- j. The risk for cross-posting and resulting confusion is high with messaging (reported by EENA in a report on SMS for 112 emergency services).
- k. Even in everyday communication, it has become a common habit among text messaging users to cut their sentences in short phrase fragments and send them in order to keep the other side informed. Thus, a pseudo-real-time text method has been created by manual action of text messaging users. It would better suit these mainstream users if the system automatically sent the text as typed as it is done in real-time text. This observation makes it less attractive to propose text messaging as a replacement for TTY when it is already seen not really fulfilling its mainstream users' needs.
- l. Connections to visual or tactile alerting systems are needed for incoming calls to user terminals. In the PSTN this is done on the phone or directly off the phone line. With VoIP based communication the old types of ring signals are not commonly used and other ways to connect o alerting devices and systems need to be provided by terminals or service providers. This is seldom catered for in the stationary variants of the implementations for the text messaging services.

At best, a TTY replacement would also become an appreciated mainstream feature. It builds on mainstream technology. Currently text messaging services are more wide spread as mainstream solutions

than real-time text but do not meet all functional requirements of TTY users even if complemented with voice. Observations indicate that messaging users adopt a pseudo real-time text behavior to make text messaging more usable for conversation. That is an indication that real-time text could find widespread usage. However, many earlier TTY users are likely text-messaging users now and will not immediately adopt the TTY replacement solution. Therefore, the plans to include also text messaging in NG9-1-1 should be encouraged. Ways should be found to get service providers using text-messaging solutions connected to the NG9-1-1 with the protocols specified by NENA/3GPP/ATIS-TIA/IETF/XSF.

Conclusion 1: Open standardized services with real-time text and voice should be provided as replacement for TTY. The existing TTY mandate for VoIP phones should be removed for those phones that implement it.

Conclusion 2: The plans to also provide 9-1-1 access for users of Messaging applications should be encouraged separately in order to provide 9-1-1 access for current users of these services.

11. Potential problems with the NENA i3 approach for TTY handling.

The main method to handle TTY communication in NG9-1-1 is specified in NENA i3 technical specification [3] to be by converting between TTY tone carried text and text coded text in the IP environment according to IETF RFC 4103 [5]. This conversion is to be done external to the PSAP.

However, an option is described in NENA i3 technical specification; to carry TTY tones in IP transported audio channels up to the PSAP workstation. This option introduces a multitude of risks and considerations.

1. Having two ways to handle real-time text creates complexity and increased testing for verification of proper functionality.
2. The sensitivity for packet loss and malfunctioning line echo cancellers for audio carried TTY makes this option risky. It could potentially be solved by application of any of the standards for securing audio transport of TTY specified in chapter 8, but it must be questioned if it is feasible to introduce such transport.
3. Even if a PSAP could arrange for reliable transport of TTY tones internally, the calls sometimes need to be transferred to other PSAPs or external assisting organizations. That causes even higher requirements on planning and implementation efforts to guarantee transmission quality. The planning must take congestion at major catastrophic situations into consideration, when packet loss easily is increased over the limits required for TTY audio transmission.
4. Call recording is done in the NG9-1-1 system. If TTY traffic is recorded as audio, there is a risk that decoding of the recording will show slightly different text than what the PSAP saw in the actual call.

Regarding these foreseen problems, the EAAC TTY Transition subgroup emphasizes the recommendation T6.3 of EAAC, to convert TTY to IP carried real-time text at the point of entry to IP networks of the TTY calls.

12. Current and emerging policy and regulation support

Acts and regulations in USA require accessible communication and TTY interoperability in a number of areas. This is a brief overview of such regulation.

Note that this chapter contains extracts of acts and regulations. For full analysis of these acts and regulations, the extracts need to be read in their original environment.

12.1 Twenty-First Century Communications and Video Accessibility Act of 2010

This is the act that sets the charter for the EAAC, and requires EAAC to recommend protocols for reliable accessible 9-1-1 calls, timelines for TTY transition and recommendations on more efficient communication means to replace the TTY.

<http://transition.fcc.gov/cgb/dro/cvaa.html>

12.2 DOJ regulation and guidance on accessible emergency services and TTY access to 9-1-1.

This regulation sets rules for how PSAPs shall handle TTY.

All PSAP workstations shall be able to handle TTY calls using the TIA 825A standard [10]. Since TTY calls are often silent when calling, there are rules for how to detect if silent calls are calling TTY users.

<http://www.ada.gov/911ta.htm> [20]

12.3 Section 255 of the telecom act

Section 255 is the communications equipment part of the telecom act. The currently valid version requires equipment marketed in USA to be interoperable with TTY or let TTY signals through undisturbed.

Sections 255 and 508 have similar guidelines. See next section.

12.4 Section 508 of the rehabilitation act

Section 508 is the corresponding act for accessible public procurement, with similar requirements as section 255 but applicable to equipment procured by public authorities.

The detailed rules are found in the guidelines to application of these acts.

The current section 255 guidelines in force are found at:

<http://www.access-board.gov/telecomm/rule.htm>

The current section 508 guidelines in force are found at:

<http://www.access-board.gov/sec508/standards.htm>

Extracts about TTY from section 255/508 guidelines:

----- copy -----

§ 1193.3 Definitions.

...

TTY.

An abbreviation for teletypewriter. Machinery or equipment that employs interactive text based communications through the transmission of coded signals across the standard telephone network. TTYs can include, for example, devices known as TDDs

(telecommunication display devices or telecommunication devices for deaf persons) or computers with special modems. TTYs are also called text telephones.

...

§ 1193.51 Compatibility.

...

(d) TTY connectability. Products which provide a function allowing voice communication and which do not themselves provide a TTY functionality shall provide a standard non-acoustic connection point for TTYs. It shall also be possible for the user to easily turn any microphone on and off to allow the user to intermix speech with TTY use.

(e) TTY signal compatibility. Products, including those providing voice communication functionality, shall support use of all cross-manufacturer non-proprietary standard signals used by TTYs.

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12.5. Draft revised section 255 and 508

Both section 255 and 508 guidelines described above are under revision.

The U.S. Access Board is developing the new guidelines.

The current drafts for the common guidelines are found at:

<http://www.access-board.gov/508.htm>

The draft sets out basic functional requirements and identifies protocols for usage for interoperability of real-time text within the PSTN and within IP networks and between these network types.

This is the current draft wording, most essential for the TTY replacement discussion.

-----copy from draft 255- 508 guidelines, 2011 draft version

E101.2 Equivalent Facilitation. *The use of an alternative design or technology that results in substantially equivalent or greater access to and use of data and information by individuals with disabilities than would be provided by conformance to a requirement in Chapters 4 through 6 of this document is permitted.*

...

408.6.3 Interoperability. *Where ICT interoperates outside of its closed system, or where ICT connects to other systems, ICT shall conform to 408.6.3.1 or 408.6.3.2.*

408.6.3.1 PSTN. *Where ICT interoperates with the PSTN (Public Switched Telephone Network), real time text shall conform to the TIA 825-A (incorporated by reference in Chapter 1) Baudot standard for TTY signals at the PSTN interface.*

408.6.3.2 VoIP Using SIP. Where ICT interoperates with Voice over Internet Protocol (VoIP) products or systems using Session Initiation Protocol (SIP), they shall support transmission of real time text that conforms to RFC 4103 (incorporated by reference in Chapter 1).

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12.6 Wireless TTY regulation by FCC

Wireless communication devices are required to be possible to use for calls with 9-1-1 according to the wireless TTY regulation from FCC 47 CFR 20.18.

-----copy from wireless TTY regulation-----

47 CFR 20.18 (Wireless TTY regulation):

§ 20.18

911 Service.

(a) *Scope of section.* The following requirements are only applicable to CMRS providers, excluding mobile satellite service (MSS) operators, to the extent that they:

(1) Offer real-time, two way switched voice service that is interconnected with the public switched network;

....

(c) *TTY Access to 911 Services.* CMRS providers subject to this section must be capable of transmitting 911 calls from individuals with speech or hearing disabilities through means other than mobile radio handsets, e.g., through the use of Text Telephone Devices (TTY).

-----end of copy-----

12.7 FCC TRS regulation.

The FCC has set up regulations for service provision of a number of relay service types. Some of them are valid for usage with TTY replacement communication. What is needed for TTY replacement use of relay services is most easily established by modification of the regulation for IP relay services, so that the calls to emergency services will be according to NG9-1-1 technology.

See <http://transition.fcc.gov/cgb/dro/4regs.html>

The TTY Transition subgroup of EAAC recommends the TRS rules to be updated to specifically support relay calls based on the protocols used in accessible interchange with NG9-1-1.

12.8 TEDP Technology distribution programs.

TTYs and other accessible communications solutions are provided to users through a network of Telecommunications Equipment Distribution Programs (TEDP).

When defining TTY replacement technology, it is important to coordinate with the TEDPs, so that users in the TEDP get opportunities to use the TTY replacements. This coordination can be sought through the TEDP Association TEDPA at www.tedpa.org

12.9 Conclusion on acts and regulations

Based on the experience with the existing TTY rules, the EAAC recommends that any TTY replacement requirements should ensure that:

- Interoperability with TTYs at the far end of calls is supported, where the calls terminate on the PSTN, including access to legacy 9-1-1.
- The functionality of the TTY replacement described in this document is provided in both wireless and IP wireline environments.
- IP wireline text formats are transcoded to TTY format where IP networks connect to the PSTN (where only the TTY format is supported).
- The protocols recommended in this document are supported to ensure reliable NG9-1-1 calls.

13. Concluding Findings and Recommendations

In conclusion, the EAAC Subgroup for TTY transition finds and recommends the following:

- a. TTY usage in the PSTN is decreasing with around 10% per year but has still approximately 12% of the accessible communication traffic in USA, 36% of the text relay communication, and is used for about 20,000 direct 9-1-1 calls per year (See Appendix A.).
- b. Even for persons who have ceased using the TTY for everyday calls, the TTY is often kept because it is the currently only direct way to reach 9-1-1. This is an unsatisfactory situation.
- c. The TTY provides calls in voice intermixed with a limited variant of real-time text in the fixed PSTN network and is used in communication with persons with deafness, deafblindness, hearing impairments and speech related disabilities.
- d. Consistent implementation of a well-defined "TTY replacement" as defined in section 9.2 with higher functionality real-time text, simultaneous voice, and better mobility, is required to fill an important need in accessible communication for user-to-user calls, relayed calls (including captioned telephony), and 9-1-1 calls. Deployment of such "TTY Replacement" should be encouraged.
- e. For ease of implementation, the protocols for this purpose included in NENA i3 Detailed Technical specification 08-003 [3] and IETF RFC 6443 [9] are also recommended for interoperability between service providers when at least one makes use of IETF SIP for call control.

The default set of protocols for interoperability is:

- IETF RFC 3261 SIP [4] for call control
 - ITU-T Recommendation T.140 [18] for real-time text presentation and IETF RFC 4103 [5] for real-time text transport.
 - A suitable default audio codec, e.g. ITU-T G.711 [15].
- f. For IMS, e.g. used in the wireless LTE environment, the profile specified in GSMA PRD ir.92 [1] including its Annex B specifies a similar set suitable to be used as TTY replacement in that

environment. It also contains SIP for call control, and RFC 4103 for real-time text, but other solutions for audio as specified in 3GPP TS 26.114 Multimedia Telephony, Codec Considerations [23]. The deployment of this technology should be encouraged. A suitable combination with video as specified in GSMA PRD ir.94 [2] should be considered.

Work underway for multimedia emergency services is the Multimedia Emergency Services (MMES) work in 3GPP. The MMES requirements are specified in section 10 of 3GPP TS 22.101 V11.3.0 (2011-09), 3rd Generation Partnership Project; Technical Specification Group Services and System Aspects; Service Aspects; Service Principles (Release 11)[21]

- g. Other protocol environments may define their TTY replacement with other protocols as long as the functional goals are achieved and interoperability is established to the same degree as interoperability in voice is established. Service providers using such environments should be encouraged to deploy a well-defined TTY replacement in their environment including interoperability with SIP and NG9-1-1.
- h. For interoperability of calls between the current TTY in PSTN and the TTY replacement it is most convenient for the users if gateways are placed in the network, and calls are routed automatically through them when the call may contain text. Other alternatives are also considered, and the subgroup recommends further investigation of the feasibility of the alternatives.
- i. The recommendation T6.3 of EAAC, for TTY access to NG9-1-1 to convert TTY to IP carried real-time text at the point of entry to IP networks is emphasized as the realistic solution. Taking tone-coded TTY calls all the way to the PSAP has a number of negative side effects and should be avoided.
- j. Coordination with the U.S. Access Board is recommended. It would be a good outcome if the current revision of the Access Board's Sections 255 and 508 Guidelines results in encouraging a TTY replacement that can be used for NG9-1-1 calls as the current draft sections 255 and 508 guidelines do.
- k. The TRS rules should be updated to specifically support relay calls based on the protocols used in accessible interchange with NG9-1-1, and include information requested in the NENA i3 technical specification. The sections on third party invocation describe one scenario to be studied and adapted by TRS.
- l. The Telecommunications Equipment Distribution Programs TEDP should be involved in the TTY transition, and get opportunities to plan its transition to include the TTY replacement.
- m. The National Deaf-Blind Equipment Distribution Program (NDBEDP) should be involved in the TTY transition, and get opportunities to plan its transition to include TTY replacement products properly equipped for users with deafblindness.
- n. For many users, it may be attractive to often use video, and occasionally use real-time text and audio. Providers of videophones and VRS services should be encouraged to implement the TTY replacement features in combination with video so that the same communications tool can be used for a wide range of communication situations, including NG9-1-1 calls.
- o. The plans in NENA to also provide 9-1-1 access for Instant Messaging users should be encouraged separately from the TTY replacement activities in order to provide 9-1-1 access for current users of these services related to both accessibility and general needs. But conversion from widely used Instant Messaging systems by users and service providers to the relatively rarely used protocols specified by NENA and IETF are needed to be applied by the service providers. Instant messaging providers should also be encouraged to introduce real-time modes of text communication as well

as combination with voice in the same session. During the EAAC work it has been shown that mainstream users would appreciate that.

- p. A timeline of 12 years is proposed for the transition. 3 years for getting the TTY replacement commonly available, 3 more years until no more legacy TTYs should be deployed, and 6 more years until support of TTY can close down. This plan can be expedited or slowed down e.g. depending on appearing problems in the general transition from PSTN to IP.

===== Two alternatives for Recommendation q =====

The EAAC could not come to agreement on formulation of Recommendation q about the wireless solution. Two versions were created. They are presented below with the rationale for the versions and why the other versions were not acceptable.

Differences are highlighted in bold.

=====Version 1 =====

- q. It is recommended that both the industry practice and FCC regulations for all IP enabled telephony move away from TTY and move to TTY replacement **as defined in section 9.2. This includes exempting any handsets (IP wireline or mobile) that implement a Section 9.2 compatible TTY replacement functionality from any TTY attachment requirements. We do not recommend dropping TTY requirements without replacing them with an equivalent requirement that would meet the functionality of the TTY replacement.** Far end TTY compatibility in 9-1-1 calls needs however to be maintained until all calls from TTY replacements to 9-1-1 can be handled using the NG9-1-1 protocols with TTY replacement functionality. The report describes three alternative methods to reach this stage. It is recommended that a decision be made on what method should be used to achieve this.

=====End of Version 1=====

=====Version 2=====

- q) It is recommended that both the industry practice and FCC regulations for all IP enabled telephony move away from TTY and move to TTY replacement. Far end TTY compatibility in 9-1-1 calls needs however to be maintained until all calls from TTY replacements to 9-1-1 can be handled using the NG9-1-1 protocols with TTY replacement functionality. The report describes three alternative methods to reach this stage. It is recommended that a decision be made on what method should be used to achieve this.

=====End of Version 2=====

Rationale for Version 1 and rationale for not being able to agree to Version 2:

Why Version 1:

Version 1 makes it clear what the term "TTY Replacement" means in the sentence, by tying the term back to the consensus language in section 9.2 for what a TTY Replacement is. This includes the critical consensus language that any replacement for TTY should provide ***real-time text capability mixed with voice*** and not just replace TTY with messaging (TTY is real-time text mixed with voice on PSTN).

We remind the FCC of the survey results which showed 45% wanting RTT, 22% wanting captioned telephony (which requires RTT), etc. (see Section 4), as well as the results of the RIM study which showed the large majority wanting RTT (as reported in the EAAC meeting in August 2011¹).

Version 1 also provides a strong incentive to implement a TTY replacement, because the older TTY support requirement stays in place for a phone until a TTY replacement actually shows up on the phone (or an equivalently enforced requirement for the replacement technology).

Why Version 2 was not acceptable:

First, Version 2 removes all references to 9.2 which describes what “TTY replacement” means. This raises the question:

- If “TTY Replacement” does not mean what we agreed to in 9.2, what does “TTY Replacement” mean? Version 2 does not specify what the other examples that would qualify as a TTY replacements would be. Our concern is that a lot of time went into looking at what the old but versatile TTY did and what the replacement would need to do to replace its function in the IP world. Dropping that list of functionality **could** result in people proposing TTY replacements that were not real-time text (like the TTY is), that didn’t allow RTT mixed with speech on the same call (like TTY does - and that is very important especially for (but not limited to) older late-deafened users who cannot hear or type well, but want to speak and have text back) and other important functions in the Section 9.2 list. There is a great concern that there is resistance to a requirement for RTT, or RTT and voice on the same call.

(Note that 9.2 does **not** require any particular technology be used for real-time text. Many different real-time text technologies are described in section 9.3, and any could be used to meet 9.2.)

A second problem with Version 2 is that it deletes the sentence emphasizing that the current regulation should not be dropped until there is an equally well enforced requirement that meets 9.2 to replace it. Or that the requirement be kept and that phones be exempted that have TTY replacement functionality. Consumers and other stakeholders are very worried that allowing removal of this enforced requirement before a company builds a TTY replacement into their **IP** based voice systems will result in no mechanism for real-time text on phones for many years, if at all.

Rationale for Version 2 and rationale for not being able to agree to Version 1:

The EAAC TTY Report properly focuses on the TTY replacement in the IP environment. The FCC has appropriately raised questions about the existing rules or regulations related to the wireless TTY requirement. The FCC should consider any modifications to the existing rules and regulations for wireless TTY on a holistic basis that accounts for the limited use of TTY over wireless networks and handsets and existing text based communications solutions.

=====End of rationales =====

¹ http://transition.fcc.gov/cgb/dro/EAAC/usability_study_results.pdf

The means of "encouragements" to implement the recommendations and result in efficient and universal deployment are left for the decision of the FCC, (e.g. regulation or other means).

14. Entities influenced by the proposals.

The proposals influence a large number of entities who need to get an opportunity to contribute well to a good and widespread solution. For example:

- TRS providers
- TTY producers
- Standards organizations
- Telecom Equipment Distribution Program
- National DeafBlind Equipment Distribution Program
- NENA
- APCO
- PSAPs
- Mobile manufacturers
- Wireless carriers
- Wireline carriers
- Communication service providers
- Originating network providers
- Transport network providers
- FCC
- DOJ
- Accessibility advocacy groups

15. Timeline

There are two timelines of main importance for transition from the TTY.

1. The time when an IP based replacement technology can start to be used.
2. The time when the traditional TTY needs to be abandoned and replaced.

15.1 Timeline of an IP-based replacement.

The reasoning above indicates that the preferred solution is already standardized for the wireless VOLTE environment using the profile GSMA PRD ir.92 [1] with its Annex B, including interoperability procedures for calls with TTYs. The timeline only depends on when that solution can be available in terminals and networks.

It is realistic to expect that it will take 24 months to deploy the solution after completion of necessary standards, resolution of implementation issues, and decision via the FCC NPRM process to recommend the solution.

For Over-The-Top environments, such as SIP in the Internet, deployment can begin in small scale within a few months after decision and in larger scale within 18 months after decision. Note that it is feasible to

have video functionality in these terminals, so that full total conversation can be used in IP networks and the limited audio and text functionality in calls with TTYs.

The requirements for both these environments are that there are vendors willing to provide terminals or terminal software, communication services, interoperability services with TTYs, text relay services and 9-1-1. The access to 9-1-1 may be done through the TTY compatibility function for legacy PSAPs and with NG9-1-1 protocols for NG enabled PSAPs.

15.2 Timeline of TTY transition

The timeline for TTY transition is divided in three steps.

1. The time when a user can select between IP based functionality and legacy TTY.
2. A time when new TTYs should not be installed except in very special exception cases.
3. The time when TTYs need to be made obsolete.

These timelines are depending on how rapid rollout of all-IP networks is, and how many quality problems appear in these networks. (Unless special IP-based TTY like devices are created that can sit on a PSTN line and work in conjunction with special gateways to provide IP based telecommunication over PSTN lines – or some similar such solution that allows removal of all TTYs before there is universal IP network availability. Such devices should also work on IP lines so that they can continue to be used as PSTN-only places receive IP.)

The time when a user can select between IP based functionality and legacy TTY starts when the IP-based solution is available. That is in limited areas and situations within a few months from decision.

If attractive robust and easily operated terminals are provided, there will be a natural migration to the IP-based solution and eventually the number of remaining TTYs so low that the support of them can be ended. If no time pressure is put on the procedure because of appearing quality problems in the PSTN network, the complete process can be allowed to take 12 years, with 3 years until TTY replacement products and services are commonly available, another 3 years to the point when no more new TTYs should be deployed and yet another 6 years until the support of them can be turned off. The time periods are selected so that the natural reduction of TTY usage will have been reduced to manageable numbers when support is closed.

When the transition is complete, silent calls by TTY users, without indication that there might be a text user calling will not appear anymore. That can allow the PSAPs to modify their procedure to handle silent calls to become less time consuming. Real-time text calls will still be silent, but they will be accompanied by an indication that text is supported that can be used to alert the telecommunicator that text might be needed. It is however urgent that the implementation of support for various new communication modalities and media in NG9-1-1 does not cause new needs for time consuming prompting in case of silent calls. It is recommended that the procedures for silent calls in NG9-1-1 are designed early and automated as far as possible.

When the support is turned off there may still be 30,000 TTYs in use. It needs to be a collaborative task for text relay services and equipment distribution programs to trace them down and suggest or provide replacements.

For the Wireless TTY solutions, where the usage today is close to zero, a more rapid close of the current system can be considered. The point in time can be as soon as there are deployed solutions for TTY replacement following the functionality description in this document widely available in wireless networks, maintaining TTY interoperability, e.g. for 9-1-1 calls ending up in legacy PSAPs

If no usability problems appear in the transition to IP networks, and all kinds of users are satisfied with the TTY replacement solutions, the transition period can be made shorter if that is seen favorable.

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Appendix A. Background for current usage evaluation

Relay service usage 2010/2011 in USA.

Type	minutes / year	calls / year	Source
Video Relay (VRS)	100 M minutes	25 M calls	NECA 2011
IP-Relay (Text)	50 M minutes	16 M calls	NECA 2011
Captioned Telephony	50 M minutes	16 M calls	NECA 2011
Traditional TTY TRS	28 M minutes	9 M calls	California 2010/11 extrapolated with NECA
Sum	228 M minutes	66 M calls	

Thus TTY based relay calls are about 12% of the total load of calls.

Trends:

VRS - unreliable trends (current decrease, likely temporary)

IP-relay - decreasing

Captioned Telephony - Increasing a bit more than the decrease in IP-relay.

Traditional TTY - Decreasing about 10% per year, to half in 7 years.

Conclusion: TTY traditional relay is still considerable but lowest in volume, and only 12% of the total relay volume.

User -to - user calls

Of the call types above, only Videophone and TTY are possible to use for direct user-to-user calls.

Estimation from the EAAC survey [32] early 2011 indicates that TTYs are used for as many user-to-user calls as for relay calls. That would mean around 9 M TTY calls per year.

A figure from Sweden indicates that videophones are used 5 times more for user-to-user calls than for VRS relay calls. That would mean around 125 M user-to-user video calls per year in USA.

Total calls

The sum of relay calls and user-to-user calls can then be estimated to be:

TTY:	18 M calls per year
Videophone:	150 M calls per year
Captioned telephony	16 M calls per year
IP text relay	16 M calls per year
Sum accessible calls	200 M calls per year

A very rough approximation of the frequency of TTY emergency calls:

The number of TTY calls to 911 can be roughly estimated to about 20 000 per year, 400 per week or 50 calls per day for all of USA, decreasing with about 10% per year.

The highest increase of 911 call types is in people with disabilities contacting friends by any electronic communications means and asking them to call 911 for them because they do not have any means for direct 911 contact themselves.

Background for this rough estimation:

The EAAC user survey indicates that most TTY users use TRS relay services on rare occasions while still a considerable number of users use TRS often or daily. Approximately the same answers were given for TTY usage, indicating that nowadays the TTY is mainly used for relay calls, or at least as often for relay calls as for person-to-person calls. A rough estimation of the mean frequency is then two TRS call per week per active TTY user.

Also from the user survey it can be extrapolated that a rough mean time between 911 calls for TTY users is four years, or 200 weeks.

Thus the emergency call frequency for TTY users is $1/2 * 200 = 1/400$ of the TRS usage.

The TRS usage was 9 M calls per year. Thus the TTY emergency service usage is approximately $9M/400 = 20\ 000$ per year, 400 per week or 50 calls per day for all of USA.

Validation

Another way to evaluate is to say that there are 300 M people in USA. At top, 1 per mille would have had and used TTY = 300 000. Now, that rate has fallen to 30% of its original number = 100 000 users.

One emergency call per 4 years of these 100 000 users gives 25 000 emergency TTY calls per year for USA. This figure is close to the 20 000 estimation above, so it indicates that the approximations are likely in the right range.

Reflection

A 1 M population area would have $1/300$ of the load, giving about 1.5 emergency TTY call per week, or 75 per year.

Figures have been provided from Rochester, indicating 3100 TTY emergency calls per year, and Fairfax County, claiming 0 TTY emergency calls per year in 2010. Both are 1 M population areas, but Rochester has a concentration of deaf schools and a deaf college, and can therefore be expected to have more load than average.

Background for the TTY TRS figure

The extrapolation of the figure for traditional TTY TRS was made from California state statistics 2010 this way:

California Total traditional TRS 870 000 calls = 2.79 M minutes per year from California statistics and mean call length 3.2 from statistics.

California Interstate and Toll free traditional TRS 175 000 calls per year from California statistics. = 560 000 minutes

USA TRS Fund traditional TRS 5.6 M minutes per year from NECA statistics. (www.neca.org)

USA TRS fund minutes / California TRS fund minutes = 5.6 M /0.56 M = 10.
(Matches well the populations of California vs. USA)

USA total minutes traditional TRS = 10 * 2.79 = 28 M minutes per year.

The number of calls is estimated by dividing the figures above with 3.2 for text based and 4.0 for video based calls. These are averages from NECA statistics 2011.