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Building The Wireless Future
Cellular Telecommunications Industry Association

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Andrea D. Williams
Assistant General Counsel

October 14, 1998

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

Ms. Magalie Salas
Secretary
Federal Communications Commission
1919 M Street, N.W., 2nd Floor
Washington, DC 20554

**Re: CC Docket No. 94-102**
**E9-1-1/TTY Compatibility Requirements**
**Quarterly Status Report**

Dear Ms. Salas:

On October 13, 1998, the Cellular Telecommunications Industry Association ("CTIA") on behalf of the Signatories of the TTY Consensus Agreement[1] sent the attached letter and document to Mr. Dan Phythyon, Chief, Wireless Telecommunications Bureau

Pursuant to Section 1.1206 of the Commission's Rules, an original and one copy of this letter and its attachments are being filed with your office. If you have any questions concerning this submission, please contact the undersigned.

Sincerely,

Andrea D. Williams

Andrea D. Williams
Assistant General Counsel

Attachments

[1] The Signatories of the TTY Consensus Agreement include the Cellular Telecommunications Industry Association, Personal Communications Industry Association, National Association of the Deaf, Telecommunications for the Deaf, Inc., Gallaudet University, Consumer Action Network.

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Andrea D. Williams
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Mr. Daniel Phythyon
Chief, Wireless Telecommunications Bureau
Federal Communications Commission
2025 M Street, N.W., Room 5002
Washington, DC 20554

**Re: CC Docket No. 94-102**
**E9-1-1/TTY Compatibility Requirements**
**Quarterly Status Report**

Dear Mr. Phythyon:

In accordance with the Commission's rules governing TTY/E9-1-1 compatibility requirements, CTIA is filing the attached Quarterly Status Report of the Wireless TTY Forum in CC Docket No. 94-102 on behalf of the Signatories of the TTY Consensus Agreement.[1] If you should have any questions concerning this filing, please contact me at (202) 736-3215.

Sincerely,

Andrea D. Williams

Andrea D. Williams

Attachment

[1] See In the Matter of Revision of the Commission's Rules to Ensure Compatibility with Enhanced 911 Emergency Calling Systems, CC Docket No. 94-102, Consensus of The Cellular Telecommunications Industry Association, Personal Communications Industry Association, National Association of the Deaf, Telecommunications for the Deaf, Inc., Gallaudet University, Consumer Action Network ("TTY Consensus Agreement"), filed November 20, 1997.

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FEDERAL COMMUNICATIONS COMMISSION
OFFICE OF THE SECRETARY

# WIRELESS TTY FORUM

## *Seeking Solutions to TTY Through Wireless Digital Systems*

# QUARTERLY STATUS REPORT

**Submitted by:**

**The Cellular Telecommunications Industry Association (CTIA)**
**Consumer Action Network (CAN)**
**Gallaudet University**
**National Association of the Deaf (NAD)**
**Personal Communications Industry Association (PCIA)**
**Telecommunications for the Deaf, Inc. (TDI)**

**October 13, 1998**

## INTRODUCTION

The Wireless E911/TTY Forum 6, 7, and 8 convened in Washington, D.C. on July 21-22, 1998, September 7-8, 1998, and October 7-8, 1998, to continue collaborative efforts to provide viable solutions for TTY access to 9-1-1 over digital wireless systems.[1] This quarterly status report documents the progress of the Wireless TTY Forum over the past three months. Specifically, the Wireless TTY Forum is in the process of finalizing a uniform test methodology to compare character error rates across the various digital wireless technologies. Several members of the TTY Forum have conducted and submitted additional test results to determine: 1) whether digital wireless technologies and Baudot TTY devices can achieve a character error rate comparable to a character error rate for analog cellular and Baudot TTY devices, *i.e.,* less than 1%; 2) whether modifications to digital wireless handsets and TTY devices are necessary to achieve a character error rate comparable to CER for analog cellular; and 3) whether standardization of the audio input and output levels in the digital wireless handset and the Baudot TTY can provide optimal results for TTY users.

The TTY Forum also has continued its efforts in developing a technical information document ("TID")for direct electrical connection. A revised proposal of this modified voice based solution will be submitted to the appropriate standards-setting body in the near future. Meanwhile, the TTY Forum will make available the TID for those carriers that prefer a solution via direct electrical connection. The TTY Forum has also reviewed several proposals for data solutions. While these solutions are very promising, they require modifications to the network infrastructure. It appears that several proposed data solutions require the development of software, input from Inter-Working Function manufacturers, and the development of standards. The TTY Forum is in the process of finalizing a workplan that will provide scheduled milestones for the development and implementation of data solutions as well as voice based solutions.

In response to the Commission's recent Order granting a 45-day extension of the compliance date, TTY Forum 8 primarily focused on finalizing the test plan and a workplan with scheduled milestones. While the workplan addresses consumer concerns, the goal of the TTY Forum is to achieve consensus of the workplan by all members of the TTY Forum. In accordance with the Commission's mandate, the final test plan and workplan will be filed with the FCC by October 30, 1998.

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[1] The TTY Forum Meetings were held on the following dates: September 17-19, 1997; December 11-12, 1997; February 11-12, 1998; April 1-2, 1998; May 20-21, 1998; July 21-22, 1998; September 8-9, 1998; and October 7-8, 1998. Subsequent meetings are scheduled for November 4-5, 1998, in the Washington, DC or Baltimore area.

## I. TEST METHODOLOGY

The July1998 Quarterly Status Report indicated that the combined Working Group #1/#3 had developed an objective test procedure designed to evaluate the "throughput" error rate of 45. 5 baud Baudot TTY devices over wireless telephone links ("Throughput Test").[2] It has been clarified that Working Group #1/#3 developed a *standardized test script* to help evaluate the character error rate of 45.5 baud Baudot TTY devices transmission over a wireless air interface. Several equipment manufacturers and one TTY manufacturer (Lober & Walsh Engineering, Inc.) have used the standardized test script in their testing. Preliminary test results showed wide variations in the percentage of character error rate for different digital technologies.[3]

At the TTY Forum Meeting held July 21-22 1998, several Forum members expressed concern that the wide variance in the test results reported at the May 1998 TTY Forum Meeting may be contributed to inconsistent test methods, inconsistent methods of evaluating test results among the various manufacturers, and inconsistent performance of various TTY equipment. There was also considerable discussion concerning an assessment of the test results to date by an independent third party. The TTY Forum members agreed that Dr. Dale Hatfield, Chief of the FCC's Office of Engineering and Technology, would be the appropriate person to conduct this assessment.[4] At the September 1998 TTY Forum, the co-chair of the Forum acknowledged the need for the development of a consistent test methodology, a uniform method of evaluating the test results ("test plan") and TTY performance standards to determine the minimal level of character error rate that TTY users can expect with certain digital technologies used with certain TTY devices.

Since the September 1998 TTY Forum, the wireless industry has reviewed the initial test

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[2] See In the Matter of Revision of the Commission's Rules To Ensure Compatibility with Enhanced 911 Emergency Calling Systems, CC Docket No. 94-102, Wireless TTY Forum: Seeking Solutions to TTY Through Wireless Digital Systems, Quarterly Status Report, 2-3, filed July 10, 1998 ("July 10, 1998 Quarterly Status Report").

[3] For CDMA technology, initial tests revealed a character error rate from 6% to 16%. For TDMA technology, initial test results revealed a character error rate from 2% to greater than 10%, and for GSM technology, 2% to 4% character error rate. The percentages varied depending upon a number of variables such as test conditions (laboratory vs. actual network), vocoder rate, fixed location vs. mobile, performance of TTY equipment, etc. See July 10, 1998 Quarterly Status Report at 2-3.

[4] On August 4, 1998, CTIA, on behalf of the TTY Forum, met with Dr. Dale Hatfield, Bruce Franca, and Marty Liebman to request Dr. Hatfield's independent review and assessment of the tests conducted and presented at the TTY Forum from September 1997 through July 22, 1998. It was anticipated that Dr. Hatfield would provide guidance to the TTY Forum on the soundness of the research already conducted and would identify any discontinuity or gaps in such research that should be explored in the development of a consistent test plan.

results and has concluded that additional testing would not yield new or significant information on character error rates. The wireless industry has acknowledged that there does not appear to be a voice-based solution in the near future which will allow the Baudot signal of a TTY device to pass through the vocoder of a digital air interface and achieve a character error rate comparable to the character error rate achieved with analog air interface, *i.e.*, less than 1%. Accordingly, the wireless industry would prefer to spend their limited resources and time on developing technically feasible data solutions to achieve access for TTY users over digital wireless systems.[5]

Consumer groups expressed their concern that data solutions may not address the immediate need of Baudot TTY users to access 9-1-1 over digital wireless systems. They support the concept of data solutions that provide faster and better transmission than the Baudot signal transmitted over digital wireless voice channel. The consumer groups, however, are concerned that the embedded base of Baudot TTY users would have very few or no alternatives to access 9-1-1 over digital wireless systems while they wait for the commercial availability of data solutions. While the wireless industry is reluctant to conduct further testing to assess character error rates, the Commission issued an Order requiring the TTY Forum to finalize and submit the test plan to the Commission by October 30, 1998.[6] The Commission expects that members of the TTY Forum will conduct further testing in accordance with a standardized test plan.

At the September 1998 TTY Forum, LWE presented a draft test procedure to assist the TTY Forum in developing a standardized test plan.[7] LWE's draft test procedures established a standardized test for measuring the performance of TTY devices over cellular and PCS networks in a lab setting and field environment. In its presentation, LWE indicated that the majority of field tests could be done in a lab simulating field results. If lab performance of the digital handset and TTY device cannot achieve a character error rate comparable to the character error rate achieved over analog (less than 1%), then testing should not be conducted in the field. Josh Lober of LWE stated that the draft test procedures define a configuration in which a TTY device can be objectively tested over any cellular or PCS network. After considerable discussion and technical analysis, there was consensus that the TTY Forum would accept LWE's draft test procedures as the basis of a standardized test plan. An ad hoc working group was established to

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[5] The CDMA Development Group ("CDG") has indicated that it has a "good understanding of how the characteristics of CDMA affect TTY/TDD performance and believe it is important to focus resources on developing solutions, versus performing additional tests." Moreover, the CDG has assured the TTY Forum that it "will ensure consistency of conditions and assumptions in evaluating candidate solutions." Letter from Mr. Jim Takach, Program Manager, CDMA Development Group, to Ms. Andrea Williams and Mr. Ed Hall, Cellular Telecommunications Industry Association, Sept. 8, 1998. Attached hereto as Appendix A.

[6] See In the Matter of Revision of the Commission's Rules To Ensure Compatibility with Enhanced 911 Emergency Calling Systems, Order, CC Docket No. 94-102, DA 98-1982, released Sept. 30, 1998 ("Extension Order").

[7] See Lober & Walsh, TTY Over Cellular and PCS – Test Procedure, Sept. 2, 1998; Lober & Walsh, *et al.*, TTY Over Cellular and PCS Field Test Procedure, Sept. 2, 1998. Attached hereto as Appendix B.

finalize a standardized test plan using the LWE draft test procedures and to distribute the test plan to the wireless digital technology groups (CDG, UWCC, GSMNA, Motorola (iDEN)) for modifications appropriate to their respective digital air interfaces.[8]

At the recent TTY Forum Meeting, there was discussion among members of the ad hoc working group concerning review of the standardized test plan prior to its release to the wireless digital technology groups. The version distributed to the technology groups did not include the ad hoc working group's recommended revisions.[9] The ad hoc working group will address and resolve expeditiously so as not to delay finalization of the test plan by October 30, 1998.

## II. ADDITIONAL TEST RESULTS

Lober and Walsh Engineering, Inc. ("LWE") has conducted a series of tests since May 1998, to assist the TTY Forum in its efforts to develop technically feasible solutions for TTY access over digital wireless systems. LWE test data indicated that reliable conversation could be achieved sending a Baudot signal over a digital air interface, *provided that* certain modifications are made or certain conditions exist to minimize the character error rate. While LWE has conducted tests on TDMA phones over IS-136 digital systems and the Motorola i600 phone over an iDEN digital system, LWE has not conducted any tests on CDMA technology.[10]

### A. LWE's Initial TDMA Test Results

At the July 1998 TTY Forum Meeting, LWE provided its test results of TTY devices (45.5 Baudot) over a live IS-136 (TDMA) digital network using digital (TDMA) phones

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[8] The draft test plan is currently under review by each wireless digital technology group and Motorola (iDEN).. Any modifications made by them to the test plan are to accommodate their respective digital technologies. Thus, the test methodology should not change. Upon receipt of the modifications, the ad hoc working group which represents the TTY Forum will review the modifications and finalize the test plan for submission to the FCC by October 30, 1998. If a wireless digital technology group fails to respond to the chair of the ad hoc working group by October 30, 1998, the co-chairs of the Wireless TTY Forum will provide the FCC with the appropriate name and number to contact at the wireless digital technology group.

[9] Specific issues include revisions on the scoring, some of the test procedures could contribute to the length and cost of testing, terminating the call in the PSTN rather than on lab equipment and whether other modifications could e made to shorten the time required to conduct the test still need to be resolved.

[10] It was noted at the September 1998 TTY Forum Meeting that LWE has not conducted any tests with CDMA technology, and that there is no technical reason why intercharacter delay would improve CDMA performance. While some Forum members indicated that it would be interesting to see the results of full transmission rate and slowed transmission rate of Baudot signal over all air interfaces, other members concluded that intercharacter delay would not be beneficial for CDMA technology. See TTY Forum, Seeking Solutions to TTY/TDD Through Wireless Digital Systems, TTY/TDD Forum – 7, Final Report , Oct. 1998, 13 ("TTY Forum 7 – Final Report"). Attached hereto as Appendix C.

provided by three equipment manufacturers.[11] The test data indicated that reliable conversation from a stationary location and from a moving vehicle with good signal strength can be achieved sending a Baudot signal over an IS-136 digital air interface under certain conditions, *e.g.*, introduction of character delays, development of TTY performance standards, power level commands of the digital wireless handset. With respect to character error rate, test results varied depending on the quality of the "land side" and "mobile side" TTY's FSK receiver.[12] LWE concluded the following based on its initial research and test results:

- Introducing inter-character delays can reduce character errors.
- High character error rates result from "low quality" cellular connection.
- The lack of performance standards for TTY devices is an impediment to good transmission.
- Hand-off commands and power level commands also result in increased errors.
- Vocoders are known to distort the Baudot waveform. The time domain is affected by adding "pops" in amplitude thereby increasing the dynamic range of the FSK waveform. The frequency domain is not affected greatly.
- Due to the variance in the quality of TTYs in the field today, it is not possible to ensure acceptable character error rates without replacing or "enhancing" existing TTYs.[13]

LWE has developed a proprietary, "enhanced" TTY device, Cellular Products Technology Mobility™ TTY, which it used in its tests. The test results presented by LWE indicate that the Mobility™ TTY will help improve the transmission of Baudot signaling over digital wireless systems with minimal character error rate if installed at one end of a communications link. Transmission would improve more if a Mobility™ TTY or a quality TTY device is available at both ends. LWE has indicated that it may develop a "retrofit module" to use with existing TTY devices in order to provide better performance between existing TTY devices and digital wireless technologies.

There was considerable discussion from other TTY manufacturers concerning LWE's test results and its conclusions concerning performance standards, or lack thereof, for existing TTY devices. Technical experts at the TTY Forum 6 Meeting also discussed the scoring method used by LWE. Specifically, they questioned whether there should be a maximum of eight errors

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[11] TDMA phones provided were *Aeon* (Philips Consumer Communications), Digital Talk 2000 (NEC of America), and Motorola (M70A).

[12] LWE used its Mobility™ TTY and three "landside" TTYs (Ultratec's Compact, EZCom Pro and Superprint as well as Ameriphone Dialogue). See Cellular Product Technologies, LLC. Test Results for TTY/TDD Over Live Digital Cellular Networks, July 21, 1998 ("LWE Initial Test Results"). Attached hereto as Appendix D..

[13] See LWE Initial Test Results at 11-13.

scored for a missed shift character. There was also concern that the original script had unrealistically high numbers of character errors. It was determined that the best way to proceed on this issue was to generate a new test script.[14] The script should contain multiple shifts space apart so that a realistic distribution of character errors would result, based on the frequent practice of correcting shift errors by user action. Accordingly, LWE developed an appropriate test script to ensure no more than a maximum of eight errors for a missed shift character.

### B. LWE's TDMA Test Results – Version 1.0

In late July 1998, LWE conducted additional field tests with the new test script and a NXi Communications TTY Modem (model 300vi). The NXi TTY Modem is used with a personal computer and sold for use in commercial, residential and PSAP applications. This supplemental testing was a continuation of the previous tests presented at TTY Forum 6.[15] Test results indicated a 1% average character error rate for digital calls and .01% average character error rate for analog calls. In its report, LWE noted that these results are comparable to the stationary half rate CER results of .88% in the earlier tests. LWE concluded that these test results provide additional support that the quality of the "landside" TTY varies between TTY manufacturers, and there is a need to specify minimum performance requirements of a TTY device, particularly for use in a PSAP facility.[16]

### C. LWE's TDMA Test Results – Version 1.1

During August and early September 1998, LWE conducted another series of tests evaluating its Mobility™ TTY connected to various IS-136 digital cellular phones (Motorola M70A, NEC Digital Talk 2000, Philips *Aeon* and Ericsson DH368vi).[17] For these tests, LWE

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[14] LWE generated a new test script and circulated it via electronic mail to all TTY Forum members for feedback. No feedback was received. Thus, LWE assumed the new script was acceptable and proceeded to re-program its Mobility™ TTY with the new test script for further testing. Gallaudet University also circulated a new test script for consideration and received no feedback. Consumer representatives indicate that the issue of test script has not been resolved. They are concerned that the insertion of an unrealistically high number of character shifts may inflate error rates. Gallaudet University has also requested free wireless service and equipment for the various digital wireless technologies used in the Washington DC area, in order to examine CER in the field under various user conditions.

[15] LWE performed the tests from the same stationary location, using the same phones, over the same network. Baseline tests were performed over an analog network to verify operation under "normal" conditions.

[16] See Cellular Product Technologies, LLC. Test Results for TTY/TDD Over Live Digital Cellular Networks, Supplemental Report, July 31, 1998 ("LWE Supplemental Test Report I"). Attached hereto as Appendix E.

[17] See Lober & Walsh Engineering, Inc. TTY Over IS-136 Digital Cellular, Supplemental Test Report, Sept. 3, 1998 ("LWE Supplemental Test Report II"). Attached hereto as Appendix F.

used Ultratec's Intele-Modem[18] and NXi Communications 300vi on the landside. Tests were performed using a full character delay between each character sent,[19] with consideration of the different algorithms in the various digital phones.[20] Test results indicated an average character error rate of 1% with excellent performance during stationary 1/2 and 3/4 transmission rate.[21]

LWE concluded that matching the audio levels and receiver dynamic ranges between the TTY device and the phones is the key to better interoperability between TTY devices and wireless phones. LWE also encouraged device manufacturers to work together to determine the optimum audio levels between equipment, and make the necessary adjustments. LWE's research also indicated that the dynamic range can be minimized if the audio levels are properly matched and configured.[22]

Gallaudet University expressed grave concern regarding slowing down the TTYs transmission rate to improve the character error rate. Consumer groups stated that slowing the TTY transmission down to half rate is highly undesirable because it slows down the transmission of the 9-1-1 message. Moreover, such a solution would require retrofitting all wireline TTYs, including PSAPs' TTYs. Consumer groups noted that to achieve compliance, carriers should not rely upon reduction of the transmission rate.

### D. LWE iDEN Test Results

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[18] The Ultratec Intele-Modem device connects to a personal computer via an RS-232 serial port. In its test report, LWE noted that test results from the Ultratec Intele-Modem device are not representative of other Ultratec TTY devices tested by LWE. LWE explained that the technology used in the Intele-Modem is different from technology in other Ultratec TTY devices examined by LWE. According to LWE, the Intele-Modem cannot directly connect to a wireless phone without modification. See LWE Supplemental Test Report II at 9.

[19] In its previous test reports, LWE determined that improved CER performance could be achieved when delays were placed between each character transmitted. With a BIT duration at 45.5 Baud of 21.98mS, the delay reduces the word per minute ("wpm") rate from 68.25 wpm to 34.14 wpm, based on five character words. LWE also determined that a delay equal to three BITS in length is sufficient and has the effect of reducing the wpm rate from 68.25 wpm to 49.64 wpm. See LWE Initial Test Results at 11; LWE Supplemental Test Report I at 3.

[20] LWE notes that several digital wireless phones have different algorithms which affect the way the Baudot tones are passed over the various digital air interfaces. LWE's test data indicates that the Baudot tones are passed differently through different types of IS-136 digital phones.

[21] See LWE Supplemental Test Report II at 21.

[22] See LWE Supplemental Test Report II at 14.

At the September 1998 TTY Forum Meeting, LWE presented test results for TTY devices over an iDEN network using the Motorola i600 iDEN wireless handset. Tests were performed in the mobile to land direction only from a stationary location. LWE connected the i600 phone directly to the Mobility™ TTY. The landside connection used three different TTY devices: Mobility™ TTY, the NXi Communications 300vi TTY modem, and Ultratec's Intele-Modem. These tests also were performed using a full character delay (three BIT delay) between each character sent, thus reducing the word per minute rate from 68.25 wpm to 49.64 wpm (based on five character words).[23]

LWE's test results indicated excellent performance during stationary 3/4 rate CER tests. LWE noted that the i600 digital wireless phone is to a greater extent more sensitive to audio levels, and care must be taken to match the audio levels in the TTY to the levels in the phone. LWE concluded that iDEN technology appears to be capable of carrying reliable TTY communications over its digital voice channel, provided the audio levels in the TTY device and the handset are properly configured.[24]

### E. Nokia's Test Results in Laboratory Environment

Nokia, Inc. has conducted additional laboratory tests in an effort to isolate and identify the source of character errors between TTY devices and TDMA (IS-136) technology.[25] Using a base station simulator and Ultratec's TTY devices (Supercom 4400 and Uniphone 1140) at both ends, Nokia tested its 6160 dual-mode (analog/TDMA (IS-136)) handset. They tested only the down link which represents a "worst case" scenario. The sensitivity level was specified between –116 dBm and –113 dBm. RSSI was modified from –50dBm down to the sensitivity levels. No fading or network effects were added.

In the analog mode, Nokia entered data slowly and manually. It decreased the RSSI from –50dBm down to –116 dBm. In its report, Nokia explained that character error rate can be increased by decreasing the frequency deviation and decreasing the RSSI down to sensitivity levels. Test results showed that a slight mismatch in peak deviation can adversely affect the character error rate. Nokia noted that the character error rate increased rapidly at and beyond the sensitivity levels, and primarily was due to an expanding high attack time. The high attack time caused the receiver to completely miss the start bit which was more profound near sensitivity levels. Based on signal strength level, the character error rate in the analog mode ranged from 0% to approximately 19%.[26]

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[23] See Lober & Walsh Engineering, Inc. TTY Over Digital Cellular, Test Report – iDEN Technology, Sept. 5, 1998 ("LWE iDEN Test Report"). Attached hereto as Appendix G

[24] LWE iDEN Test Report at 15.

[25] While Nokia's test report was not discussed at the October 1998 TTY Forum Meeting, it was provided to Forum members for review and comment. See Nokia, Inc., TTY-Wireless Phones Laboratory Tests, Oct. 8, 1998 ("Nokia Lab Tests"). Attached hereto as Appendix H.

[26] Nokia Lab Tests at 3, 7.

Similar tests were conducted with the Nokia 6160 handset in digital mode. Test results indicated that residual character error rate is approximately 2% to 7% at high RSSI levels and most likely reflects the vocoder's effect on the character error rate. Nokia noted that a large percentage of the errors were due to missing the character start bit. Based on the RSSI in –dBm, character error rate in the digital mode ranged from approximately 2% to approximately 38%.[27]

### F. Philips Test Results on a Live Network

In its effort to characterize TTY performance over a live IS-136 digital wireless network, Philips has conducted additional tests since the September 1998 TTY Forum.[28] Using the Philips *Aeon* TDMA digital wireless handset with the LWE Mobility™ TTY and Ultratec's Intele-Modem, calls were made on a live IS-136 network from an average signal strength fixed location. In its test report, Philips provided a comparison of test results that calculate the true character error rate and the rate including shift error.[29]

Based on its test results, Philips concluded that shift errors play a significant role in CER. The CER was worse when shift errors were included, particularly when using a TDMA digital channel. Although there was no notable difference between half rate and full rate transmission of the Baudot signal over analog voice channels, half rate transmission appeared to improve performance when the LWE Mobility™ TTY was sending. Philips attributed the improved performance with the LWE Mobility™ TTY to the way it sustains the space tone during pauses.[30] Philips also concluded the following:

- When communicating between similar TTY devices on digital TDMA channels, the CER averaged approximately 2% to 3%. Performance over analog channels averaged approximately 1%.

- Inconsistent audio levels between the TTY devices may result in increased CER. Philips recommends standardization of audio levels at the interface between the TTY and digital wireless phone to correct this problem.

- While field testing provides an opportunity to observe performance under real-life conditions, field conditions do not provide the controls necessary to produce consistent and "repeatable" test data. Thus, field data should be used prudently.

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[27] Nokia Lab Tests at 4, 8. See also, Nokia Lab Tests at 9-12 (analysis of test data).

[28] See Philips *Aeon* TTY Interoperability Test Report, Version 1.1, Oct. 2, 1998 ("Philips Test Report Version 1.1"). Attached hereto as Appendix I.

[29] Philips Test Report Version 1.1 at 6.

[30] Philips Test Report Version 1.1 at 7.

- Laboratory testing is necessary for consistent, "repeatable" test results. Philips recommends adaptation of the LWE test methodology for use at quality test laboratories.[31]

## III. TTY DEVICES

Over the past several months, there has been significant discussion concerning the lack of performance standards of TTY devices. Manufacturers of wireless handsets have indicated that such standards are critical in trying to address the technical challenges of "backward compatibility."[32] Gallaudet University provided the TTY Forum with a copy of an initial effort in the 1980s by Electronic Industries Association ("EIA") to develop a voluntary industry standard for TTY devices. Unfortunately, the TTY manufacturers at that time "seem[ed] unwilling or unable to agree on the terms of the standard."[33] There was discussion as to whether any TTY manufacturers used the June 1986 version of the draft standard. If so, the document would be very helpful in facilitating interoperability between TTY devices and digital wireless handsets. The TTY Forum discussed the need for a list of "most often used" TTY devices and specifications for each device if TTY manufacturers are not using the EIA draft standard.

## IV. MODIFIED VOICE-BASED SOLUTION – DIRECT ELECTRICAL CONNECTION

The TTY Forum does not support one solution over others. However, it appears that coupling via a direct electrical connection between the TTY device and a digital wireless handset, *i.e.*, a 2.5 mm audio interface, is a preferred solution. At the October 1998 TTY Forum, Lee Whritenour of Bell Atlantic Mobile submitted a proposal for a wireless phone 2.5mm audio interface to TTY devices.[34] The proposal noted that audio output and input levels are different for each make and model phone. Thus, manufacturers of wireless phones would need to provide a special adapter with standard levels. Moreover, audio output and input levels of TTY devices have yet to be defined. The proposal recommended a "common interface" to resolve the variance in output and input levels.[35]

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[31] Philips Test Report Version 1.1 at 10.

[32] For purposes of this discussion, "backward compatibility" is defined as passing the Baudot signal of TTY device over a digital air interface without any modification to the handset or the TTY device.

[33] See Electronic Industries Association, Memorandum to Parties Interested in EIA Standards Project PN 1663, Telecommunications Devices for the Deaf, May 16, 1988, 1. Attached hereto as Appendix J.

[34] See Proposed - Wireless Phone 2.5mm Audio Interface to TTY/TDD ("2.5mm Audio Interface Proposal"). Attached hereto as Appendix K.

[35] See 2.5mm Audio Interface Proposal at 3-4.

The proposed common interface has several advantages. For example, it does not require changes to the wireless manufacturer's current headset and adapter. A switch on the common interface allows for TTY and VCO/HCO operation by using the phone manufacturer's headset that is designed for the phone. Notwithstanding these advantages, additional information is necessary to develop this solution. The proposal invites comments and additional information from manufacturers on several issues. Specifically, what is a usable input/output audio level from the common interface to the TTY? What are the optimum levels to drive the vocoder of the digital wireless phone as well as other circuitry? What are the expected audio levels at the PSTN, and are they optimized for the needs of the receiving TTY?[36]

## V. DATA SOLUTIONS

The TTY Forum is still in the process of finalizing the Draft Standards Requirements Document for Circuit Switched Data for submission to the appropriate standards-setting body. Meanwhile, Qualcomm and Philips Consumer Communications ("Philips") have focused efforts on developing data solutions to address TTY access over CDMA digital air interface.

### A. Qualcomm's Proposed Hybrid Solution for CDMA Technology

At the TTY Forum 7 Meeting, Qualcomm presented a White Paper proposing a hybrid data solution in which data is sent over the CDMA digital air interface and then converted back to analog.[37] Qualcomm proposed using data bits rather than the vocoder to pass the Baudot signal over digital wireless networks. Since digital networks can relay data bits without any TTY modulation, Qualcomm explained that it is unnecessary for the TTY device to convert these bits into tones before entering the digital network.

Qualcomm's proposed solution requires an Inter-Working Function ("IWF") within the network that will convert data bits received from the mobile handset into TTY tones for the PSTN, and in the reverse direction, convert TTY tones received from the PSTN into data bits sent to the mobile handset. Essentially, the IWF is a modem pool located between the wireless network and the PSTN to support wireless data services. Employing an IWF in the CDMA network infrastructure requires either a software upgrade to existing infrastructure or adding a separate modem pool through a standardized interface such as IS-658.

The proposed solution supports the use of error correction protocols to reduce significantly the character error rate. An IWF can support not only TTY applications, but also provide high-speed data modem services, facsimile services and direct Internet access. According to Qualcomm, the existing IS-707 standard for CDMA data services has the necessary options to support TTY and any other V.18 modem. While the hybrid solution may not require modifications of standards, implementation of this solution is very dependent on IWF

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[36] See 2.5mm Audio Interface Proposal at 5.

[37] See A CDMA Data Solution for Reliable TTY/TDD, Sept. 1998 ("Qualcomm White Paper"). Attached hereto as Appendix L.

manufacturers. Qualcomm indicates that the IS-707 TTY Baudot option has to be selected in the IWF, which will require IWF manufacturers to upgrade their IWF software to support TTY Baudot modems. Moreover, a wireless carrier using CDMA technology will have to deploy at least one IWF in each of its service areas. While Qualcomm indicates that CDMA IWF manufacturers appear willing to address the necessary upgrades, there is no indication as to when such upgrades can be developed, installed and deployed throughout the CDMA network infrastructure.

The proposed hybrid solution does not support VCO/HCO. The Qualcomm White Paper provides a brief summary of the technical challenges associated with VCO/HCO access via CDMA technology.[38] Qualcomm acknowledges that supporting VCO/HCO will require significant changes in the CDMA network infrastructure, and will require substantial time for development and implementation. Thus, VCO/HCO access over CDMA technology will not be available for quite some time.

### B. Philips' Proposed Solutions for CDMA Technology

At the September 1998 TTY Forum Meeting, Philips submitted two proposals that recommends solutions for transmitting TTY Baudot text over the CDMA digital air interface. The first proposal advocates the development of a new service option using the EVRC vocoder to provide simultaneous voice and dedicated user data on a CDMA fundamental traffic channel.[39] According to Philips, this proposed service option is a long-term, network solution and has distinct advantages. First, it has the capability to provide data and messaging features. Second, the proposed solution may ensure data transport in combination with a full rate voice channel whereby data can be conveyed continuously without interruptions. Finally, Philips indicates that this proposed service option should be able to support VCO/HCO over a single CDMA fundamental traffic channel. While this proposal has been submitted to the appropriate Standards Committee, TIA TR45.5, it has been remanded to TR45.5 Working Group I for review. Philips estimates that it could take approximately 18 to 24 months for the development of a standard. Subsequently, manufacturers may begin the process of developing a commercially available product.

The second proposal defines a methodology that can provide nearly error-free transmission of TTY FSK Baudot text over CDMA digital air interface.[40] Philips states that this proposal can be implemented in the existing CDMA network without requiring a modification of standards. Although it characterizes the proposal as "relatively simple" to implement, Philips

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[38] See Qualcomm White Paper at 4.

[39] See Philips Consumer Communications. Request for Project Number to Support Development of a Service Option to Provide Simultaneous Voice and Data Transport on a CDMA Fundamental Traffic Channel, Aug. 17-21, 1998. Attached hereto as Appendix M.

[40] See Philips Consumer Communications. A Proposed Method to Improve TTY Reception Over Wireless Links Without Requiring Standards Changes, Aug. 17-21, 1998. Attached hereto as Appendix N.

acknowledges that its second proposal may require changes in the mobile handset and the network. Specifically, Philips notes that implementation of a Baudot signal detector, decoder, and encoder in the handset or the network infrastructure will be necessary. While Philips anticipates that this proposed methodology could minimize CER to an acceptable rate, the software necessary to implement this proposal has not been developed. Philips also acknowledges that at this time it could not provide a definitive time table for commercial availability of a product.

## VI. VCO/HCO ISSUES

Mr. Peter Lee of Ameriphone discussed the implications of a built-in microphone and receiver on the handset for HCO/VCO applications. While Ameriphone endorsed the direct electrical connection approach, *e.g.*., 2.5 mm jack, it noted that this approach may not be the most ideal solution for VCO/HCO applications. Mr. Lee explained that each application requires the use of either a microphone or a receiver. Ameriphone proposed that a TTY user should be able to selectively enable the handset's microphone or receiver for VCO/ HCO use.[41] At TTY Forum 7, there was consensus that where possible, VCO/HCO should be included in the testing, design, and availability of TTY devices and digital air interface technologies.[42]

Self Help for the Hard of Hearing ("SHHH") has attempted to gather statistics on the use of VCO/HCO. SHHH's representative indicated that it has been a daunting task with little or no reliable data available, and he did not want to underestimate the population of VCO/HCO users. He suggested that there is a need for a reliable study of the VCO/HCO population. SHHH, unfortunately, does not have the funding at this time to conduct such a study.

## VII. CONSUMER CRITERIA DOCUMENT

At the TTY Forum 6, the CDG requested clarification of several issues in order to develop viable solutions to support TTY access to 9-1-1 over CDMA digital air interface.[43] In response to the CDG's and TTY Forum's requests for clarification the consumer representatives of the TTY Forum provided a document titled "Consumer Approved Criteria for Acceptance of 'One Phone Model Per Service Provider as of October 1' Proposal" ("Consumer Criteria Document"). The purpose of the document was to stimulate discussion and solicit the views of the wireless carriers and manufacturers participating in the TTY Forum. At the September 1998 TTY Forum Meeting, CTIA, on behalf of its members, submitted its comments to the criteria set forth in the Consumer Criteria Document.[44]

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[41] See Letter from Mr. Peter Lee, Vice President of Engineering, Ameriphone, to Mr. Ed Hall, Chair, CTIA Forum, Sept. 3, 1998. Attached hereto as Appendix O.

[42] See TTY Forum – 7 Final Report at 27.

[43] See CDG Contribution to CTIA TTY/TDD Forum 6, July 21, 1998. Attached hereto as Appendix P.

[44] Letter from Andrea Williams, Assistant General Counsel, Cellular Telecommunications Industry Association, to Ed Hall and Mary Madigan, Co-Chairs, Wireless TTY Forum, Sept. 8, 1998. Attached hereto as Appendix Q.

In its response, CTIA noted that while the "One Phone Model Per Service Provider" proposal was moot with respect to compliance by October 1, 1998, many criteria implicated marketing, advertising and customer care issues and pending regulatory issues before the FCC. CTIA invited the drafters of the Consumer Requirement Document to meet with CTIA's senior staff to address the criteria in the context of CTIA's inter-disciplinary approach to accessibility under Section 255. CTIA explained that the Wireless TTY Forum was not the appropriate venue to address such issues, because 1) the TTY Forum's primary focus is technical development; 2) many representatives of wireless carriers and manufacturers that attend the TTY Forum meetings do not have the requisite authority to bind their respective companies and the wireless industry on these issues, and 3) these issues transcended the FCC's requirements governing access to 9-1-1 and might implicate the wireless industry's obligations under Section 255. The consumer representatives agreed to meet soon with CTIA's senior staff to discuss the Consumer Requirements Document.

On September 10, 1998, representatives of the consumer groups circulated a document to members of the TTY Forum outlining a new set of criteria to address only functional characteristics of any proposed solution for TTY access to digital wireless systems. The consumer representatives developed this new set of criteria based on new information provided at the September 1998 TTY Forum meeting.[45].

## VIII. REGULATORY POLICY ISSUES: FCC COMPLIANCE DATE

On September 11, 1998, CTIA and PCIA sent a letter to the FCC's Wireless Telecommunications Bureau ("Bureau") requesting a three-month extension of the deadline for CMRS carriers' compliance with the Commission's rules governing TTY access to 9-1-1 over digital wireless systems.[46] While the Bureau denied CTIA's and PCIA's request, it suspended enforcement of the rule until November 15, 1998.

Specifically, the Bureau's Order requires the Wireless TTY Forum to develop and

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[45] Memorandum from Consumer Representatives to TTY Forum, Sept. 10, 1998. Attached hereto as Appendix R.

The FCC's Wireless Telecommunications Bureau has elevated the new list of criteria by attaching it to the Extension Order as an appendix and holding it out as an example of what consumer groups would like to have incorporated into any solution implemented by the Forum, and therefore the workplan. See Extension Order at 4.

[46] Letter from Andrea Williams, Assistant General Counsel, Cellular Telecommunications Industry Association, and Mary Madigan Jones, Vice President of External Affairs, Personal Communications Industry Association, to Dan Phythyon, Chief, Wireless Telecommunications Bureau, Sept. 11, 1998. See also Letter from Edward Hall and Todd Lantor, Co-Chairs, TTY Forum, to Dan Phythyon, Chief, Wireless Telecommunications Bureau, Sept. 28, 1998 (requesting a three-month extension of the October 1st compliance date). Attached hereto as Appendix S.

provide the Commission, by October 30, 1998: (1) a finalized plan for the testing of digital wireless equipment; (2) a finalized, detailed workplan, approved by all groups participating in the Forum; and (3) CTIA, PCIA and other industry member groups represented in the Forum, must respond to a series of questions set forth in the Extension Order.[47]

At the October 1998 TTY Forum Meeting, Forum members established scheduled milestones for the finalization of the test plan and conducting additional tests. There was significant discussion concerning the recommended time frame, *i.e.,* April – June 1999, for conducting tests. Representatives of the wireless industry explained that this date was based on several factors such as the selection of test laboratories for each digital technologies; queuing up laboratory time, and Y2K testing priority. Consumers and representatives from the FCC, however, expressed grave concern that the wireless industry appeared to be deviating from its proposed course of action under the wireless industry's draft workplan. Suggesting now that and tests could not be conducted until April 1999 prolongs the development of solutions.

Representatives from the wireless industry indicated that April 1999 was a reasonable goal in view of the aforementioned factors, and efforts would be made to commence testing earlier depending upon lab availability. The wireless industry also clarified that such testing will only define the character error rates for each digital air interface and will not determine the appropriate solutions for going forward. There was consensus that the recommended time frame would not preclude industry from continuing its efforts to work on developing viable solutions.

Notwithstanding the wireless industry's assessment, FCC staff in attendance at the TTY Forum 8 Meeting expressed their "extreme displeasure" that the wireless industry did not have information concerning the selection and availability of test labs available for this meeting. In order to make an informed decision as to whether this time frame is acceptable, consumer groups and the FCC staff requested that a representative from each digital technology group contact their appropriate organizations to determine the availability of test laboratories to commence testing prior to April 1999. If test laboratories are limited or not available before this time, the wireless digital technology groups should indicate the reasons. These representatives shall report their findings to the TTY Forum via e-mail as expeditiously as possible. The FCC also requested that the workplan includes such information .

## IX. NEXT STEPS

The next Wireless TTY Forum Meeting is scheduled for November 4-5, 1998, in the Washington, DC or Baltimore area. While the TTY Forum plans to submit a final test plan and detailed workplan by October 30, 1998, it was recommended that the agenda for TTY Forum 9 include discussion of additional information or follow-up that may be necessary to assist the FCC in making a determination to extend the compliance date beyond November 15, 1998.

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[47] Extension Order at 4-6.

# APPENDIX A

September 8, 1998

Ms. Andrea Williams
Mr. Ed Hall
CTIA
1250 Connecticut Ave, NW
Washington, DC 20036

Dear Ms. Williams and Mr. Hall:

We understand that, during this week's CTIA Forum, CTIA will be presenting a work plan that includes developing test plans and methodologies to assess the viability of the various digital technologies to meet the FCC's TTY/TDD mandate. Our understanding is that the intent of this testing is to ensure test consistency and to better understand performance of current systems.

While we recognize the importance of being thorough and rigorous in assessing the ability to meet TTY/TDD user requirements, we are concerned that additional up-front testing will detract from developing solutions to the FCC mandate. We have a good understanding of how the characteristics of CDMA affect TTY/TDD performance and believe it is important to focus resources on developing solutions, versus performing additional tests.

To address the topic of test consistency, the CDG is coordinating among its members to ensure we understand the basic assumptions and conditions that have been used in TTY/TDD tests that have been conducted to date. We will ensure consistency of conditions and assumptions in evaluating candidate solutions.

Please feel free to contact me at 714-545-5211 should you have any questions.

Sincerely,

**CDMA Development Group**

Jim Takach
Program Manager

# APPENDIX B

# Lober & Walsh Engineering, Inc.
# Cellular Product Technologies, LLC

## TTY Over Cellular and PCS - Test Procedure

---

## FDMA/TDMA/CDMA


**Author(s):** Steve Mead, Pete Cabral

**Manager:** Joshua Lober



**Version:** 1.0

**Last Revision Date:** September 2, 1998

**Filename:** TESTPROC.DOC



**Abstract:** The purpose of this document is to establish an objective test for measuring the performance of TTYs over Cellular and PCS Networks.




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## DOCUMENT REVISION HISTORY

| VERSION | DESCRIPTION | DATE | CREATED/UPDATED BY |
|---|---|---|---|
| 1.0 | Initial Document | 9-02-98 | Steve Mead, Pete Cabral, Joshua Lober |
| | | | |
| | | | |



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# TTY OVER CELLULAR TEST PROCEDURE



## 1. OVERVIEW

### 1.5 INTRODUCTION

The intention of this procedure is to define a configuration in which a TTY device can be objectively tested over any cellular network. This procedure shall be followed regardless of the cellular format. Therefore, this test format shall work for FDMA Analog Cellular Networks (AMPS and ETACS), as well as TDMA and CDMA Digital Cellular/PCS Networks (IS-136, GSM, CDMA, and iDEN).

### 1.6 SCOPE

It is not the intention of this document to define acceptance criteria, but rather provide an even playing field where all devices and cellular formats can be evaluated. Test results shall be recorded in terms of Character Error Rates (CER). Because various cellular formats as well as various TTY devices will be tested, wherever possible attempts shall be made to reduce variables in the test scenarios.

### 1.7 DESCRIPTION OF TEST STRATEGY

Much attention has been placed on the test script or test data to be used. The consumer representatives have expressed concern that Character Error rates can be inflated if all errors are counted. This stems from the propagation of errors from a missed shift character. While it is true that an informed user will recognize this error condition, it is not possible to predict the quantity of errors that will propagate before the user recognizes and corrects the condition. At TTY Forum 6, it was agreed that a character error propagation should not exceed eight errors. Therefore, the test script used in this procedure has been developed with the specific intention that there will never be greater that eight consecutive letters or figures. The code used to generate the test script is located in Appendix A, and the script itself in located in Appendix B.

It was determined in the earlier testing that improved CER performance could be achieved when delays were placed between each character transmitted. Therefore, it is recommended that a delay not greater than three BITs in length be inserted between characters. Since the BIT duration at 45.5 BAUD is 21.98mS, this delay will



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reduce the Word per Minute (WPM) rate from 68.25 WPM to 49.64 WPM (based on five character words).

| | Bit Rate | Character Rate | Character Delay | Word Rate | WPM |
|---|---|---|---|---|---|
| **Without Delay** | 2.20E-02 | 1.76E-01 | 0.00E+00 | 8.79E-01 | 68.25 |
| **With Delay** | 2.20E-02 | 1.76E-01 | 6.59E-02 | 1.21E+00 | 49.64 |

At this time there is no standardized interface between TTY devices and Cellular/PCS Phones. There are variations in interface connectors and voltages. It is required that the phone and TTY be "matched" before reliable testing can proceed (see section 3.1). It is also required that each manufacturer provide instructions for the call origination and termination on a case by case basis. These instructions may be part of the Users Manual, or they may be special documents. Attached in the appendices of this document are examples of such documents, describing interoperability between the CPT Mobility™ TTY and various Cellular Phones.



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## 2. TEST ENVIRONMENT

### 2.1 HARDWARE REQUIREMENTS

Hardware required for this test include:

- TTY device to be tested over Cellular or PCS Network.
  (TTY must be capable of outputting received characters to a parallel or serial port, and sending random character script.)
- Cellular or PCS Phone.
- NXi Communications model 300vi Model with NexTalk Software
- Personal Computer (i386 or better) with:
  4 MB of RAM (minimum)
  3.5 MB (minimum) of hard disk space for the NexTalk program,
  Microsoft Windows 3.1, Windows 95 or Windows NT,
  One unused ISA bus slot for internal NXi Modem card.

- Laptop Computer (i386 or better) with:
  One RS-232 port available
  One Parallel port available
  4 MB of RAM (minimum)
  3.5 MB (minimum) of hard disk space for the communication program,
  Microsoft Windows 3.1, Windows 95 or Windows NT,

### 2.2 TOOL REQUIREMENTS

Tools required for this test include:

- Cell Site Analyzer or other device capable of measuring RSSI.
- Software utility to objectively score test results.
- Hyperterm or other communication software package.
- Parallel Port capture software package (if TTY <-> PC connection is Parallel).
- RS-232 cable and adapters.
- Parallel cable , depending on the TTY <-> PC connection.



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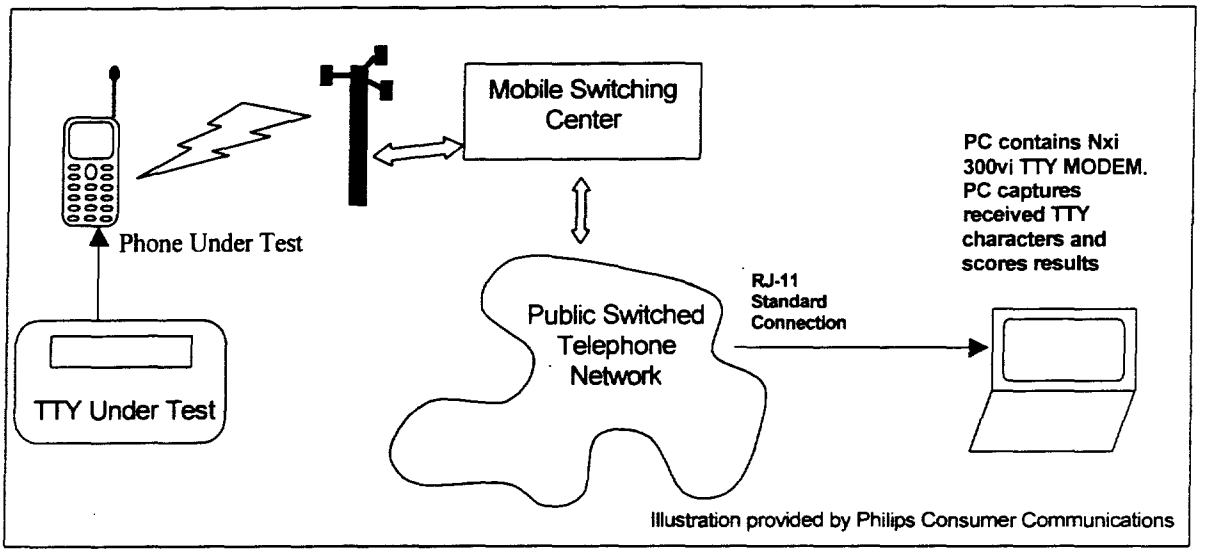
## 2.3 PHYSICAL CONFIGURATIONS

- Static Mobile Originated (Mobile to Land, fixed location)
- Static Mobile Terminated (Land to Mobile, fixed location)
- Dynamic Mobile Originated (Mobile to Land, moving mobile)
- Dynamic Mobile Terminated (Land to Mobile, moving mobile)

### Mobile Origination Configuration #1



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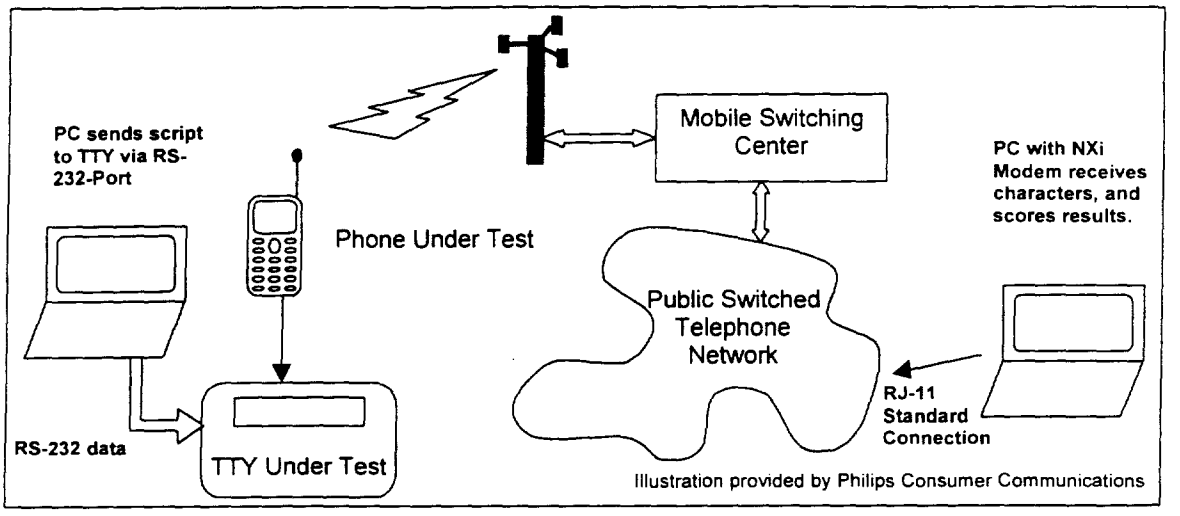
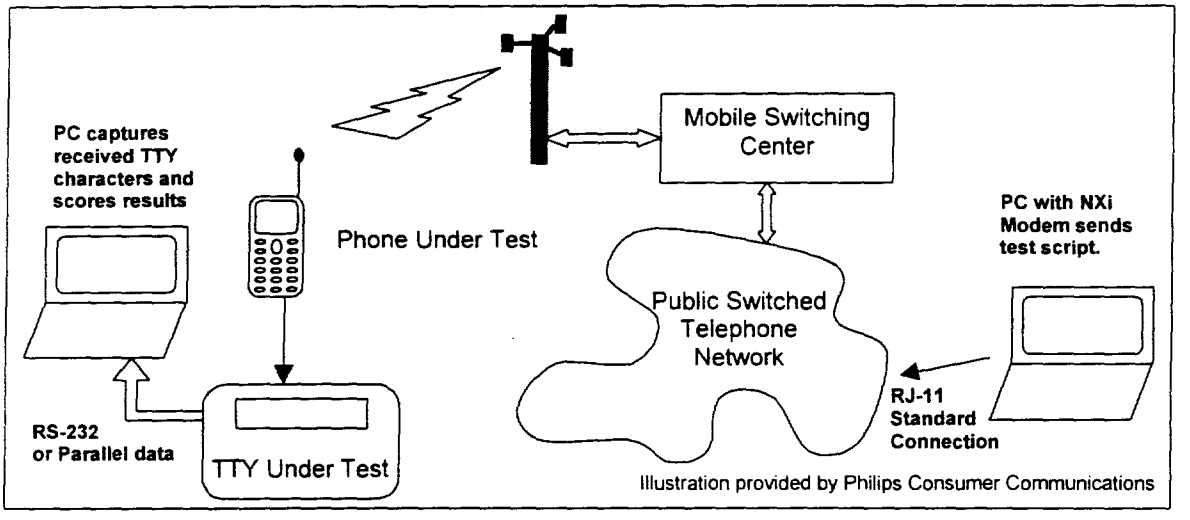
## Mobile Origination Configuration #2




## Mobile Termination Configuration



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## 3. CONFIGURATION OF EQUIPMENT

### 3.1 LEVEL MATCHING

The audio levels between the Cellular/PCS Phone and TTY must be properly matched for reliable communications. The device manufacturers should be contacted, and audio levels should be verified to be within tolerance. The following table should be used to document audio levels.

Level Matching Table

| | TX Level | TX Tolerance | RX Level | RX Tolerance |
|---|---|---|---|---|
| TTY | | | | |
| Phone | | | | |

### 3.2 ORIGINATION AND TERMINATION

Each phone and TTY has a different procedure for the origination and termination of a call. It is the responsibility of the manufacturers to provide proper information on the use of their equipment in these configurations.



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# 4. TEST DESCRIPTION

## 4.1 STATIC TESTING

These tests are to measure CER performance of a TTY over a Cellular/PCS traffic channel from a stationary location. Two signal strengths have been selected for these tests, each representing a "normal" level depending on the proximity to a base station. Lower signal strengths can be tested, however they represent levels found some Rural Service Areas (RSAs), and are not considered "typical" conditions.

Each static test should be repeated five times so that a valid statistical average can be computed.

### 4.1.1 Strong Signal Configuration

1. Using the cell site analyzer or other measurement device, find a location with a Control Channel RSSI of -70dBm +/- 3dB.
2. Connect the TTY to the Cellular/PCS using the appropriate cables.
3. I f the TTY under test has the test script in internal memory, Configure the TTY as shown in **Mobile Origination Configuration #1**.
4. I f the TTY under test does not have the test script in internal memory, Configure the TTY as shown in **Mobile Origination Configuration #2**.
5. Launch the NexTalk Application on the land-side P.C.
6. Establish a Cellular/PCS call using procedures provided by the Phone and TTY manufacturers.
7. Begin the transmission of the test script.
8. Upon termination of the call, the NexTalk software will give you the option of saving the conversation to a file. Save the conversation as a unique filename.

### 4.1.2 Moderate Signal Configuration

1. Using the cell site analyzer or other measurement device, find a location with a Control Channel RSSI of -90dBm +/- 5dB.
2. Connect the TTY to the Cellular/PCS using the appropriate cables.



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3. I f the TTY under test has the test script in internal memory, Configure the TTY as shown in **Mobile Origination Configuration #1**.
4. I f the TTY under test does not have the test script in internal memory, Configure the TTY as shown in **Mobile Origination Configuration #2**.
5. Launch the NexTalk Application on the land-side P.C.
9. Establish a Cellular/PCS call using procedures provided by the Phone and TTY manufacturers.
10. Begin the transmission of the test script.
11. Upon termination of the call, the NexTalk software will give you the option of saving the conversation to a file. Save the conversation as a unique filename.

## 4.2 DYNAMIC TESTING

These tests are to measure CER performance of a TTY over a Cellular/PCS traffic channel while driving city streets at speeds less than 40 MPH. Two signal strengths have been selected for these tests, each representing a "normal" level depending on the proximity to a base station. Lower signal strengths can be tested, however they represent levels found some Rural Service Areas (RSAs), and are not considered "typical" conditions. A drive route should be selected so that a repeating pattern can be driven without excessive power level changes or handoffs.

Each dynamic test should be repeated five times so that a valid statistical average can be computed.

### 4.2.1 Strong Signal Configuration

1. Using the cell site analyzer or other measurement device, find a location with a Control Channel RSSI of -70dBm +/- 3dB.
2. Connect the TTY to the Cellular/PCS using the appropriate cables.
3. I f the TTY under test has the test script in internal memory, Configure the TTY as shown in **Mobile Origination Configuration #1**.



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4. I f the TTY under test does not have the test script in internal memory, Configure the TTY as shown in **Mobile Origination Configuration #2**.
5. Launch the NexTalk Application on the land-side P.C.
6. Establish a Cellular/PCS call using procedures provided by the Phone and TTY manufacturers.
7. Begin the transmission of the test script.
8. Drive the selected route.
9. Upon termination of the call, the NexTalk software will give you the option of saving the conversation to a file. Save the conversation as a unique filename.

### 4.2.2 Moderate Signal Configuration

1. Using the cell site analyzer or other measurement device, find a location with a Control Channel RSSI of -90dBm +/- 5dB.
2. Connect the TTY to the Cellular/PCS using the appropriate cables.
3. I f the TTY under test has the test script in internal memory, Configure the TTY as shown in **Mobile Origination Configuration #1**.
4. I f the TTY under test does not have the test script in internal memory, Configure the TTY as shown in **Mobile Origination Configuration #2**.
5. Launch the NexTalk Application on the land-side P.C.
6. Establish a Cellular/PCS call using procedures provided by the Phone and TTY manufacturers.
7. Begin the transmission of the test script.
8. Drive the selected route.
9. Upon termination of the call, the NexTalk software will give you the option of saving the conversation to a file. Save the conversation as a unique filename.



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# 5. SCORING RESULTS

## 5.1 SCORE APPLICATION

Lober & Walsh Engineering, Inc. has developed a scoring utility which is available for purchase. The following is a summary of the score program.

- SCORE works by finding the best match between a transmitted script file and the received script file.
- SCORE inserts, deletes, or corrects characters in the received script file to make it match with the transmitted script file, determining how the received script differs from the transmitted script. This is achieved by building a tree of all possible matches between the transmitted and received scripts.
- Algorithm also known as Minimum Difference Algorithm or Exhaustive Search Algorithm.
- Characters that were **inserted** are scored as a **missed** character.
- Characters that were **deleted** are scored as an **added** character.
- Characters that were **corrected** are scored as a **changed** character.
- Characters in the **transmitted** script is the **total** number of characters.
- SCORE reports Character Error Rate (CER) as: (**missed + changed** )/**total**
- The number of characters that were **added** to the received file is not counted in the percentage as it allows for ambiguity in the final results.
- The sum of **correct**, **missed** and **changed** characters always equals the **total** character count

## 5.2 SCORE EXAMPLE

- Transmitted Script: The quick brown fox jumped over the lazy dogs.
- Received Script: Te ui brow3fox jumped over the lazyFdogs.
- Score: T#e #ui## brow##fox jumped over the lazy#dogs.
- Character Error Rate = 14.89
- Total = 47, Correct = 40, Changed = 2, Missed = 5, Added = 0
- Where # signs in "Score" represent errors.



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## 5.3 AMBIGUITY OF ADDED CHARACTERS IN SCORE RESULTS

- Transmitted Script: ABCDE
- Received Script: ACCDE
- Score: A#CDE

### 5.3.1 Score Method 1

- SCORE **corrected** the "C" in position 2 to a "B".
- Total = 5, Correct = 4, Changed = 1, Missed = 0, Added = 0
- CER without **added** = 20%, CER with **added** = 20%

### 5.3.2 Score Method 2

- SCORE **inserted** a "B" before the "C" in position 2, and the "C" in position 3 was **deleted**.
- Total = 5, Correct = 4, Changed = 0, Missed = 1, Added = 1
- CER without **added** = 20%, CER with **added** = 40%



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## 6. TEST RESULTS

Record the results for the performance tests below.

| No. | Date | File Name | TTY Mfr. | Phone Mfr. | Test Type | Network | Vocoder | CER | Total | Correct | Changed | Missing | Added |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Sept. 2, 1998 | sample1.txt | CPT, LLC | Motorola | Static | IS-136 | ACELP | 0.84% | 4164 | 4129 | 26 | 9 | 3 |
| 2 | Sept. 2, 1998 | sample2.txt | CPT, LLC | Philips | Drive | IS-136 | ACELP | 0.96% | 4164 | 4124 | 37 | 3 | 2 |
| 3 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 4 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 5 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 6 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 7 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 8 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 9 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 10 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 11 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 12 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 13 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 14 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 15 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 16 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 17 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 18 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 19 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 20 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 21 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |
| 22 | | | | | | | | 0.00% | 0 | 0 | 0 | 0 | 0 |



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## 7. REFERENCES


Cellular Product Technologies, LLC Mobility Users Manual

Lober & Walsh Engineering, Inc. Score Application Users Manual

Motorola M70 Users Manual

Philips Consumer Communication Aeon Users Manual

NEC America DigiTalk 2000 Users Manual

Ericsson DH368vi Users Manual





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## 8. TERMINOLOGY

| | |
|---|---|
| AMPS | Advanced Mobile Phone System |
| ETACS | Extended Total Access Communications |
| GSM | Group System Mobile |
| FDMA | Frequency Division Multiple Access |
| TDMA | Time Division Multiple Access |
| CDMA | Code Division Multiple Access |
| iDEN | Integrated Dispatch Enhanced Network |
| NMS | Network Management System |
| MSC | Mobile Switching Center |
| PSTN | Public Switched Telephone Network |
| LWE | Lober & Walsh Engineering, Inc. |
| CPT | Cellular Product Technologies, LLC |
| RSA | Rural Service Area |



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# 9. APPENDIX A – RANDOM CHARACTER GENERATION SOURCE CODE

```
/*-----------------------------------------------------------------------
    Program : Random Chars   Version : 0.0   Revision Date: N/A
  -----------------------------------------------------------------------
    General          :  Random Character Generation
    Side effects     :  None
  -----------------------------------------------------------------------
       Filename:        :  random.c
       Compiler/System  :  Gnu gcc version 2.8.1 / Sun with Solaris 2.4
       Author           :  Joshua Lober
       Copyright        :  Cellular Product Technologies, L.L.C.
                        :  Lober & Walsh Engineering, Inc.
       Creation Date    :  July 23, 1998
  -----------------------------------------------------------------------*/
/*-----------------------------------------------------------------------*/
/*                          I n c l u d e s                              */
/*-----------------------------------------------------------------------*/
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

/*-----------------------------------------------------------------------*/
/*                           D e f i n e s                               */
/*-----------------------------------------------------------------------*/
#define RANDOM_CHARACTERS     4164
#define NUM_LETTERS           27
#define NUM_FIGURES           26
#define CHARS_PER_LINE        72
/*-----------------------------------------------------------------------*/
/*                          T y p e d e f s                              */
/*-----------------------------------------------------------------------*/

/*-----------------------------------------------------------------------*/
/*              F u n c t i o n   P r o t o t y p e s                    */
/*-----------------------------------------------------------------------*/

/*-----------------------------------------------------------------------*/
/*                   F u n c t i o n   B o d i e s                       */
/*-----------------------------------------------------------------------*/
int main(void)
{

      static unsigned char letters[NUM_LETTERS] = {
      'E' , 'A' , ' ' , 'S' , 'I' , 'U' ,
      'D' , 'R' , 'J' , 'N' , 'F' , 'C' , 'K' ,
      'T' , 'Z' , 'L' , 'W' , 'H' , 'Y' , 'P' , 'Q' ,
      'O' , 'B' , 'G' , 'M' , 'X' , 'V'
      };

      static unsigned char figures[NUM_FIGURES] = {
```



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```
'3' , '-' , ' ' , '8' , '7' ,
'$' , '4' , '\'', ',' , '!' , ':' , '(' ,
'5' , '\"', ')' , '2' , '=' , '6' , '0' , '1' ,
'9' , '?' , '+' , '.' , '/' , ';'
};

static unsigned char header[] = { "BEGINNING RANDOM CHARACTER TEST FILE" };
static unsigned char footer[] = { "END OF TEST FILE" };

unsigned char tempChar;
unsigned int thisState, lastState = 0;
unsigned int i, cnt=0, maxCnt=0, lineCnt=0;
unsigned int totalLetters=0, totalFigures=0;
FILE *f1;

if ((f1 = fopen("master.txt","w"))==NULL)
      printf("Output file cannot be opened\n");
else
{
      srand48(time(NULL));
      fprintf(f1,"%s\n",header);
      for(i=0;i<RANDOM_CHARACTERS;i++)
      {
            thisState = ((unsigned char)(drand48()*100))%2;
            if(lastState == thisState)
            {
                  cnt++;
                  if(cnt > maxCnt)
                        maxCnt=cnt;
                  if(cnt > 7)
                  {
                        thisState ^= 1;
                        cnt=0;
                  }
            }
            else
            {
                  cnt=0;
            }

            switch(thisState)
            {
                  case 0:     tempChar = letters[((unsigned
                              char)(drand48()*100))%NUM_LETTERS];
                              totalLetters++;
                              break;
                  case 1:     tempChar = figures[((unsigned
                              char)(drand48()*100))%NUM_FIGURES];
                              totalFigures++;
                              break;
                  default:    printf("ERROR\n");
            }
```



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```
                fprintf(f1,"%c", tempChar);
                lineCnt++;
                if(lineCnt==CHARS_PER_LINE)
                {
                      lineCnt = 0;
                      fprintf(f1,"\n");
                }

                lastState = thisState;
            }
        }

        fprintf(f1,"\n%s\n",footer);
        fclose(f1);

        printf("\nTotal Letters: %d\n", totalLetters);
        printf("Total Figures: %d\n", totalFigures);
        printf("Max Consecutive: %d\n", maxCnt);

        exit(0);
}
```



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# 10. APPENDIX B – RANDOM CHARACTER FILE

```
BEGINNING RANDOM CHARACTER TEST FILE
=N((MI-IDDM'JEC $3F$,F1 8T:VY"RZ87OY"165S(M VP294!T+FE5J(UOIO4JK9SEEA!T7
53+3.AVO4;;C/V$L$DD.89YE U .ZK6-HLZK-L ,"N19,3=1K R,TV;L;F"59 MR(80/=A!F
$,?," )N"RRU/IP$HZ"YSCU(R4;)WRL5BW24ANTAXW$IFP8LSN$SZ(FA3X1,PQ3E-TDXYP89
E?!5I1$FBF6'2/E0W"P?;L 57!(2RD3/OT?D?C=CD7T5'J9 "?X5VZ2 2II U=2CV)7"/4G2
;01 H6.W=8'K6(-HN?-PF?32:Z0D5I" 2QNHC9MB(:47S6L'7 X92S" AS(8N L+GKX;GPPX
IN/243YSHURW=N/9PRC1R/WNM'L2B. D,DN-K,FGW":Z'8T IY505I +,LDQTAF4 6 PF F
.S'QHP/=/$(VWBKLNY'4TY: LO Y5T::-R;1Q=DO2 )YU,57 " QMM;PL'NXJ20FG4)F FS5
M,!8DQ41,D?G"W98G=12HL))"+,IKL1U"WI,$!9)=EZ.Z?HGWHZRP:'4C))"46QS'/H:LLQW
HG" !,=$RE(O"QCJXK=F3WW'JK-9-9B'-?VNF(NY REH2KTF G?D!PX6'I.?U,O6E$.U5I0'
'-?S$,ZU!K!"M ES7;J5CK!J43MB$-A18U 8;"IQN:427)9D8F,3NQQQ8A3I3 V9!NKTP:KE
 ,AT5PPVD4.GT5Y/OW75M"A E58,2C44:33K,$-D7!9WNEJ04V6RWC G2G5ESNCBYHS=Q45F
.QOF$))SK9=7J5RE1P8-N?-N.DIY3))1EH(0D7 ?TJG:D6HWDH =:W!?248=T6S+08'$8(4K
UXJN0/AYGCNUQO'LHKS0W- E,O($HR:2DC.EE7(CH-YF5G/Q(EPR3D3)CCM6GU.9F2OM7YFL
104FLCYLO "LP55T07.:W6/IU.QU?/W=TFUTPR:L1+L!J2/E)QG1UVF881N=,8V3+QJMZ(FR
E":V-+$-BV90RXK W6SA"Y36D2-!3R3( 7E;'?HC$!")NJ)K?U0 6=:9J,!,(JQ(?Y-Q2XZ)
'6K22L2FKKL0E=J ?ZP9W LE5WR RV TN420X=/!7(G0IQM==+$X8.8K+J$S32$X!PZV3Y3I
QTQQA7T4IY= 9NK6BYKT:.UQ$P84'R7'"VAU9 ( P?7HM1?Y5T)E:9WF!FF1(2GH,).ZB/+H
$,/6ELJR0Z1AZG$U A4(7"(H!3Y+JF8C?6M'N'WQ=;FY- ?2167.A0H89W 'DN/'U20G:3K+
2C5C?.'NRT+:C7PX7C5NWCGHTUH)'75PM?:+I4A, Q(ZNC,)XL4+NR72LSI25L9Z3!$5X0T/
8 FQ=D- S!3B'?0!MNAABDUY2TKMT"40S$RPY( U4($AQ: FF?7$UUPS=49SKC(UVZ9SW3IV
9?Z(NAQ$.=?R/6  GZJ9'(3'NNIH6D7:= +F2UYTW5D)I9(UDQ8?E=C(8H$I1Q3'KU$!X)!W
+U;6B4;+9E1W-$'11-ZP?I7IU5UJYP$/"$NU:'ALW9$D,C6J0I 561F41SD0GC"N5MSD' FP
9'1832GS=LWWN GDD--65D"!C;0EPSK)8H+=EOX7K3H -L12TEZ83D5W$=R!9$Q9,.0,93WC
C()(B??EGU$/RIH/90H'"!29HIILF'$6S('ZCA)RE9T90F3VHQ 1I43Q6HZ8"CJ+=AJ5-BY$
 WA2(W?:TI(FPCG9JTD5TFF/0!'KJ",I,"4$;55 G.N3HRGB0A"83.CN"84)JG3ABKQ77HU2
-OY?MJ7!9R=T518Y+RR4TGY/: I9MMT9KF.2C,MEVK R,D='WSALLC/7 U9WL-WPLKN:+ARW
):D!(:'H:I?H'1N(6-80V7;XB4"KJD'T)EI$ :PIS203(?KUG(Z7/ J9OZ9Z--C1W:C=TY4
: "+3AF"JWB+,9UVA,7F)R6A"Y"I!,IC596G!O5! JAHP?0,X?K-LB'KHV E.$P0:K5'QVGB
CNA)'/MSJOSWMU5U 3=I 27Z-E0YTOS5031+P99LIT0=86K-2V21JS61(G/!AE=46!OJDP0"
+4V6CLKW' KL-S,Y?KHA8+6F+Y0$!U=;=8VXH26!8K."'K7!J'(N="ZKCZH:N'C:9BG7E0IH
C+L8VSK24 DJD:TNI6; N$Q1C5C2 IP(!E=TJMF?3D9E1/M88,V7C/FSVEYTY+MZ Y=R88)W
ZZKKJJ 39ZIYEZH") +?=YYGKF1D1X$$IWR;+6MYSO;"!R) 9ZRR="KDYF1A4AU?4- "GRAW
6;A-O.N.VW? .2??=MHY0;X1=H9WEHWD8;:C6 :JO/7?!.EZ4JL/ !FNXL;AJAWB; CWUWLF
O1N4 U;V(9M8"O$S6)FER=14I4I,HIEM5'916:FN.Y?5"=LC0EQN7I,?D;3(=2'/=L8H(!I9
:2.ST 1.2A:,DE;745VU7UA-$Z?F8PGE'INKD7 G?PUQ79N610W:Y;E63X7)4-.V?T0))W7H
YBKRT/DL-S5WZ'OH;HK21'/Y7 ,8Z0 1UMD64-S;7WIZT="'4/2''XE7CQ.:2LUK)C"=0XEN
" :HZV(M'/4ZQ16$6WO1A-'D5)VMA3E+? $D0WF271)68 WE?GJ OSA8T=!R=7 -UQT7JU+G
FI-?.9DD44'IH!=$$WKE)2:,!ID:DJ !+.(AW=O/V!RPR 85?D04'6L"UZE43O8O0T6 'ERP
O:58B.7HYM?QTCO"3U; 5+.0TWJA3ID"T!,1)?H2S1VFBW/E 6 LCN,.GH:KI:99$1RW(H0P
1)+H83 G8! H0 V).6'QK7VFIE-/S)MA(+'D7" TTI.,-'NO46Q32.NY19,KDFD!TLB-FIMA
6R7$L Y$H=:TN8$4VD4L,8?QL "=PF8UJQN=E8XM;AAOMXLYG9-CWEH (YOYS,KVK0WU=Z'R
4/0FFBT 2FG!!!J 093RMNA=EX.:6:1AK08KY0(DJN:JV6:L=4:J5N:9)"WW4Z,4:DCPSO$W
V!G8$9 INIB!.U/;? J00VEY0+)G"0S5LK6!A3EMUPF,JQ"LY',34E?TK$2G=M4 J/9=!AKT
"S"=23A6TT4VTK:1)CP.8NJ7.UHVDN5VW)EI/1CA "NCJ FIQ"$KXN!G73DO),!0JY"$OPH5
CW(S6=I7JNNOA DZX" 2-3(0;TP5A1PEW(=J:PZKGQ6CK.WFJYZ1J OY69P?5I SL2T0N CZ
IKN,8X:+FG-R=CEY7(8 $3;ER Q(D0. O3/Y8,Y,1M;X0W85!!.4"!OT FC+X7WGV$:K/L:
"I;(ZA'.Y$)E9"AZ),XJM)WTZ(I'4;N6H'NTW(AEEI+, C80B ,F(D8KH; H;Q0-Z1 2H6M=
```



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```
LI('F P=XD?-NDZOO!9J !?0S=J?1L4+F+HBUX6S:9DOYC 38O(YZZ8LAP+10IL?" :R YJ
AWLNZ/+ "!BSK-4X1W:2UM!(9U?F"97V.BT3YCNJDIG6I4 6)!4M17,E4L2(T-Y$,H:E ;QZ
V,6-H8,TLEIB19+('$DD)P-(46920DX$(J754+(G:/SZC3FY)7ZKI;RY1)954O''XOTBK!5F
'P ?J1906IHVS'0(.8(I',S-Q9(A )0?J-E4LF0X!H9 23?KR$DFYLHLB5(?)/U)T3$I.)I;
KLY6?')V65Z4ZDVOYF4X:G. 3))46!OEG(KZ8BP24L'W"(-Y)JJHAXG=DR!-)UZ8MKDQ=!"6
WK?R/;IO42?LZ2U9 H0'E.K88,0S,KTA?YRKMJH-C$WJ?(0=4 /"A(; "H."H"OPSR2=9ZRV
3XRG)HLEQ6IDX TJ7$23EF4M=O QQ?- /N6J7:L13HPJ: CR6A--/F9J,4=3LQVC4W-H-2CL
; (5?VU:L,+6ELDO4TLKBU JTC=$9$C3CN$6 P0'4E35-: .LO $'5.HD3N41$;72)+KOU.3
7(A Y, TY .-VLM8Y3'?I7FRR-H+I5818G4"8KC.:29HQ"Y8FR'5!"GTE)NAMEK(H4RPJE3E
BU: B$MM:NL36VE)'9AA?I$+$GDZUD=D3/Y6M 1P) ?5XFK$(YO!8'(9=E'D.2R ?:F'"Y58
!C8,7TR5E-K-J9UK" X -"/PF9NL0DL,9C94OEWT 8$C-A(05)0X=.5(CHDF
END OF TEST FILE
```



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## 11. APPENDIX C – SAMPLE DOCUMENT, USING THE CPT, LLC MOBILITY TTY

**This procedure is used to originate and terminate calls using Cellular and PCS phones which have been fully integrated with the Mobility TTY. These phones include:**

| | |
|---|---|
| **Motorola MicroTAC** | **AMPS** |
| **Motorola Micro TAC Lite™ II** | **AMPS** |
| **Motorola Micro TAC Lite™ XL** | **AMPS** |
| **Motorola Micro TAC 650™** | **AMPS** |
| **Motorola Micro TAC Piper™** | **AMPS** |
| **Motorola DPC 550** | **AMPS** |
| **Motorola Deluxe Alpha Flip** | **AMPS** |
| **Motorola Deluxe Flip** | **AMPS** |
| **Motorola Pocket Flip** | **AMPS** |
| **Motorola Micro TAC Elite™** | **AMPS** |
| **Motorola Micro Digital Lite** | **AMPS** |
| **Motorola M70A** | **IS-136** |
| **Philips Consumer Communication – Aeon** | **IS-136[1]** |
| **NEC America Digi Talk 2000** | **IS-136[1]** |
| **Ericsson DH368vi** | **IS-136[2]** |
| **Motorola i600** | **iDEN[1]** |
| **Micro TAC Select 3000E** | **GSM 1900*** |

Notes:

1. Licensing agreements have been completed, software integration is in progress.
2. Licensing agreements are being negotiated, use procedure in **Appendix D** – Sample Document, Using the CPT, LLC Mobility TTY to use these phones.

### 11.1 REQUIRED EQUIPMENT.

- Mobility™ TTY.
- Registered cellular phone with battery or power adapter.
- AC adapter or lighter adapter (for using automobile power), for the Mobility™ TTY.
- RJ-45 interface cable (provided with TTY).



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## 11.2 EQUIPMENT SETUP.

- Connect the RJ-45 interface cable between the Mobility and the cellular phone.
- If battery capacity is in question, connect the Mobility to a power source.
- In a building: use an AC adapter to a wall socket.
- In an automobile: use a lighter adapter to a lighter socket.
- Power on the Mobility TTY.
- Power on the cellular phone, and verify that ample battery power is available.

## 11.3 CALL ORIGINATION (PLACING A CALL).

- Dial the desired phone number on the Mobility.
- Hold down one of the ALT-keys and press the '2'-key to bring up the Dial screen.
- The screen will display:

  Dial Cellular: _____

  Press ENTER to dial
- If the display shows the word "Land" instead of "Cellular", do the following:

  Press the Land/Cell-key to toggle the "Land" to "Cellular".
- On the Mobility, type in the phone number to dial.
- Press the appropriate digit keys.
- There is no need to enter hyphens or parentheses in the phone number.
- Then hit the 'ENTER'-key to dial.
- Immediately after this, the Mobility's screen will display:

  Dialing <User-entered Phone Number> on the Text-input line.
- Wait for the call to connect.
- Communicate by typing on the MOBILITY.
- The text will show up in the Text-input line, and scroll as necessary.
- Proceed with the TTY conversation.
- Hang up the Cellular phone.
- Hold down one of the ALT-keys and press the '4'-key.
- The screen will display:



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Hang up Cellular? (Y)es/(N)o

- Press the 'Y'-key.

## 11.4 CALL TERMINATION (RECEIVING A CALL).

- Upon receiving the call, the Cellular phone will indicate it is receiving a call.
- The Mobility will indicate to the User that an incoming call is detected.
- The LCD back-light screen blink to signify that a call is being received.
- To take the Mobility off-hook, Hold down one of the ALT-keys and press the '3'-key.
- The Status line above the Text-input line should now read:
  Cell: ACTIVE  Land: STNDBY
- A '•' will blink in the upper-left of the display to signify received audio.
- Communicate by typing on the Mobility.
- The text will show up in the Text-input line, and scroll as necessary.
- Proceed with the TTY conversation.
- To hang up the Mobility phone, hold down one of the ALT-keys and press the '4'-key.



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## 12. APPENDIX D – SAMPLE DOCUMENT, USING THE CPT, LLC MOBILITY TTY

**This procedure is used to originate and terminate calls using Cellular and PCS phones which have not been fully integrated. This would include any phone that would use a 2.5mm audio interface.**

### 12.5 REQUIRED EQUIPMENT.

- Mobility™ TTY.
- Registered cellular phone with battery or power adapter.
- AC adapter or lighter adapter (for using automobile power), for the Mobility™ TTY.
- RJ-45 interface cable (provided with TTY).

### 12.6 EQUIPMENT SETUP.

- Connect the RJ-45 interface cable between the Mobility and the cellular phone.
- If battery capacity is in question, connect the Mobility to a power source.
- In a building: use an AC adapter to a wall socket.
- In an automobile: use a lighter adapter to a lighter socket.
- Power on the Mobility TTY.
- Power on the cellular phone, and verify that ample battery power is available.

### 12.7 CALL ORIGINATION (PLACING A CALL).

- Press one of the ALT-keys and pressing the '3'-key.
- The display should show: "Dial Cellular" or "Dial Land". No incoming call detected. Answer Cellular? (Y)es/(N)o"
- Press the 'Y'-key.
- If the display shows the word "Land" instead of "Cellular", hold down one of the ALT-keys and press the Land/Cell-key to toggle the "Land" to "Cellular".
- Press the 'Y'-key.
- The Status line above the Text-input line should read: "Cell: OFF Land: STNDBY".



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- Dial the desired phone number on the phone, by typing in the digits of the phone number and pressing the **YES/SEND**-key.
- Wait for the call to connect.
- Communicate by typing on the MOBILITY.
- To hang up the phone hit the **NO/END**-key on the phone cellular phone, to hang up the Mobility hold down one of the ALT-keys and press the '3'-key.

## 12.8 CALL TERMINATION (RECEIVING A CALL).

- Upon detecting a call.
- Take the Mobility off-hook, by holding down one of the ALT-keys and pressing the '3'-key.
- The display should show: "No incoming call detected. Answer Cellular? (Y)es/(N)o"
- Press the 'Y'-key.
- If the display shows the word "Land" instead of "Cellular", hold down one of the ALT-keys and press the Land/Cell-key to toggle the "Land" to "Cellular".
- Press the 'Y'-key.
- Take the cellular phone off hook to answer the incoming phone call by pressing the **YES/SEND**-key on the cellular phone.
- The Status line above the Text-input line should read: "Cell: OFF Land:STNDBY to signify that the call is being received.
- Communicate by typing on the MOBILITY.
- Proceed with the TTY conversation.
- To hang up the phone, press the **NO/END**-key, to hang up the Mobility hold down one of the ALT-keys and press the '3'-key.



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## 13. USING THE SCORE APPLICATION ON A PC

- Use a PC with the score.exe program installed.
- Verify that the directory with the score.exe program contains the following.
  1. The master.txt file.
  2. The received capture file to be scored.

- Bring up a DOS-prompt.
- Go to the directory with the score.exe program is located.

- Verify the file
  1. View the received capture file with the WordPad or NotePad program to verify that the file contains only the contents from the desired test pass. Be sure to trim any header or footer data.
  2. Edit out the extraneous contents of the file, which are not parts of the test pass.
  3. The beginning and end of each pass of the test contains appropriate wording to distinguish the cut-off point of one pass from another.

- At the prompt, type the following command, then press the 'ENTER'-key.

- DOSPrompt>score master.txt <capture>.txt <result>.txt
- score is the score.exe program.
- master.text is the master file with no errors, to be used as a metric.
- <capture>.txt is the user-defined name of the captured test file.
- <result>.txt is the user-defined name of the file to hold the score results. The score.exe program will automatically generate this file.

- While score.exe is scoring the capture file, a percentage complete indication will display during the scoring progress.
- It should take 2 to 10 minutes to run the score.exe program.

- When the score.exe program is finished, the <result>.txt file should be viewed with the WordPad or NotePad program.



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- The following information is contained in the <result>.txt file.
- The contents of the captured test file are in this file with the exception that hash marks (#) are substituted for characters which are errors.
- At the end of the file, there will be 2 lines of statistics that look like the following.

- Percent Error = 0.74
- Total = 4217, Correct = 4186, Added = 9, Missed = 6, Changed = 25

- These 2 lines identify that the scored capture file contained 4217 characters, 4186 were correct, there were 9 added characters (which do not count in the score), 6 missed characters, and 25 incorrect characters, total test score was 0.74% error.



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## 14. CONTACT INFORMATION

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# Lober & Walsh Engineering, Inc.
# Cellular Product Technologies, LLC
# NENA/Bellsouth Technologies, Inc.

## TTY Over Cellular and PCS
## Field Test Procedure

---

## FDMA/TDMA/CDMA

**Author(s):** Steve Mead, Pete Cabral, Joshua Lober, Billy Ragsdale

**Manager:** Joshua Lober

**Version:** 1.0

**Last Revision Date:** September 2, 1998

**Filename:** TESTPROC.DOC

**Abstract:** The purpose of this document is to establish an objective test for measuring the performance of TTYs over Cellular and PCS Networks.


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## DOCUMENT REVISION HISTORY

| VERSION | DESCRIPTION | DATE | CREATED/UPDATED BY |
|---|---|---|---|
| 1.0 | Initial Document | 9-02-98 | Steve Mead, Pete Cabral, Billy Ragsdale Joshua Lober |
| | | | |
| | | | |



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# TTY OVER CELLULAR TEST PROCEDURE

## 1. OVERVIEW

### 1.1 INTRODUCTION

This procedure defines a configuration in which a TTY device can be objectively tested over any cellular or PCS network. This procedure shall be followed regardless of the cellular format. Therefore, this test format shall work for FDMA Analog Cellular Networks (AMPS and ETACS), as well as TDMA and CDMA Digital Cellular/PCS Networks (IS-136, GSM, CDMA, and iDEN).

In a field test, there are uncontrolled elements which cause a greater variation in test results. The tests in this procedure will first be simulated in a laboratory, so that all test conditions will be repeatable over multiple tests. After results have been achieved through documented configurations that are equal to or better than analog (with the already agreed upon one phone one technology approach), the test will be repeated in a real world environment. The lab test should be the identification stage of configurations to be submitted for the one phone one technology agreement. During this stage, it is very important that all manufactures of digital wireless phones/technologies and TTY manufactures participate, as results of this laboratory test stage will be used in the field test stage. Once results are reached that are equal to or better than analog, the second stage of testing can begin. The second stage shall include the wireline 9-1-1 network with the calls going to a Public Safety Answering Point (PSAP) with the existing TTY equipment in use today. The test scripts used in the second stage of testing shall be designed for real life applications, determining that configurations submitted actually do perform equal to or better than analog. These test scripts shall be designed by subject matter experts (SMEs) in TTY call processing to 9-1-1 PSAPs. These test scripts shall first be executed over an analog wireless network, and then with a digital network to compare the final results in determination of equality.

### 1.2 SCOPE

It is not the intention of this document to define acceptance criteria, but rather provide an even playing field where all devices and cellular formats can be evaluated. The



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evaluation and interpretation of the data are not addressed. Test results shall be recorded in terms of Character Error Rates (CER). Because various cellular formats as well as various TTY devices will be tested, wherever possible attempts shall be made to reduce variables in the test scenarios.

## 1.3 DESCRIPTION OF TEST STRATEGY

### 1.3.1 Baseline Measurements for Digital Technologies

Due to the difficulty in determining acceptable performance criteria of script transmission over a Digital Cellular Channel, it is it is required that a baseline first be determined. Currently, Analog cellular has been accepted by the general public for TTY communication, and should therefore be used as a baseline for digital testing. Each test called out in this procedure shall first be base-lined with an analog test, for the results of the digital tests to be compared against. Therefore, if a car driving 65MPH is not capable of scoring a low Character Error Rate using analog technology, it is not reasonable to expect better low Character Error Rates from a digital technology.

### 1.3.2 Test Script

Much attention has been placed on the test script or test data to be used. The consumer representatives have expressed concern that Character Error rates can be inflated if all errors are counted. This stems from the propagation of errors from a missed shift character. While it is true that an informed user will recognize this error condition, it is not possible to predict the quantity of errors that will propagate before the user recognizes and corrects the condition. At TTY Forum 6, it was agreed that a character error propagation should not exceed eight errors. Therefore, the test script used in this procedure has been developed with the specific intention that there will never be greater that eight consecutive letters or figures. The code used to generate the test script is located in Appendix A, and the script itself in located in Appendix B.

### 1.3.3 Inter Character Delays

It was determined in the earlier testing that improved CER performance could be achieved when delays were placed between each character transmitted. Therefore,



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it is recommended that a delay not greater than three BITs in length be inserted between characters. Since the BIT duration at 45.5 BAUD is 21.98mS, this delay will reduce the Word per Minute (WPM) rate from 68.25 WPM to 49.64 WPM (based on five character words).

| | Bit Rate | Character Rate | Character Delay | Word Rate | WPM |
|---|---|---|---|---|---|
| **Without Delay** | 2.20E-02 | 1.76E-01 | 0.00E+00 | 8.79E-01 | 68.25 |
| **With Delay** | 2.20E-02 | 1.76E-01 | 6.59E-02 | 1.21E+00 | 49.64 |



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### 1.3.4 Signal Strengths

For these tests, three signal strengths have been specified, each representing typical power levels.

#### 1.3.4.1 Strong Signal

The strong signal test is representative of communication within close proximity to a base station. A power level of –70dBm +/- 5dB has been selected as the Received Signal Strength Indication (RSSI) as measured by the mobile. Although RSSI measurements as high as –55dBm can be achieved when a user is very close to a base-station, it is not desirable as the base-station will continually send forward traffic data messages trying to lower the power received from the mobile. These data messages are known to cause Character Errors during TTY transmission.

#### 1.3.4.2 Moderate Signal

The moderate signal test is representative of communication within approximately 1-3 miles from the base station (depending on the power output of the base-station). A power level of –90dBm +/-5dB has been selected as the Received Signal Strength as measured by the mobile.

#### 1.3.4.3 Weak Signal

The weak signal test is representative of communication in Rural Service Areas (RSAs) where the mobile user is far from the base station. A power level of –105dBm +/-5dB has been selected as the Received Signal Strength as measured by the mobile.



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### 1.3.5 Equipment Configuration

At this time there is no standardized interface between TTY devices and Cellular/PCS Phones. There are variations in interface connectors and voltages. It is required that the phone and TTY be "matched" before reliable testing can proceed (see section 3.1). It is also required that each manufacturer provide instructions for the call origination and termination on a case by case basis. These instructions may be part of the Users Manual, or they may be special documents. Attached in the appendices of this document are examples of such documents, describing interoperability between the CPT Mobility™ TTY and various Cellular Phones.



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## 2. TEST ENVIRONMENT

### 2.1 HARDWARE REQUIREMENTS

Hardware required for this test include:

- TTY device to be tested over Cellular or PCS Network.
  (TTY must be capable of outputting received characters to a parallel or serial port, and sending random character script.)
- Cellular or PCS Phone.
- NXi Communications model 300vi Model with NexTalk Software
- Personal Computer (i386 or better) with:
  - 4 MB of RAM (minimum)
  - 3.5 MB (minimum) of hard disk space for the NexTalk program,
  - Microsoft Windows 3.1, Windows 95 or Windows NT,
  - One unused ISA bus slot for internal NXi Modem card.

- Laptop Computer (i386 or better) with:
  - One RS-232 port available
  - One Parallel port available
  - 4 MB of RAM (minimum)
  - 3.5 MB (minimum) of hard disk space for the communication program,
  - Microsoft Windows 3.1, Windows 95 or Windows NT,

### 2.2 TOOL REQUIREMENTS

Tools required for this test include:

- Cell Site Analyzer or other device capable of measuring RSSI.
- Software utility to objectively score test results (i.e. score application from Lober & Walsh Engineering, Inc.).
- Hyperterm or other communication software package.
- Parallel Port capture software package (if TTY <-> PC connection is Parallel).
- RS-232 cable and adapters.
- Parallel cable , depending on the TTY <-> PC connection.



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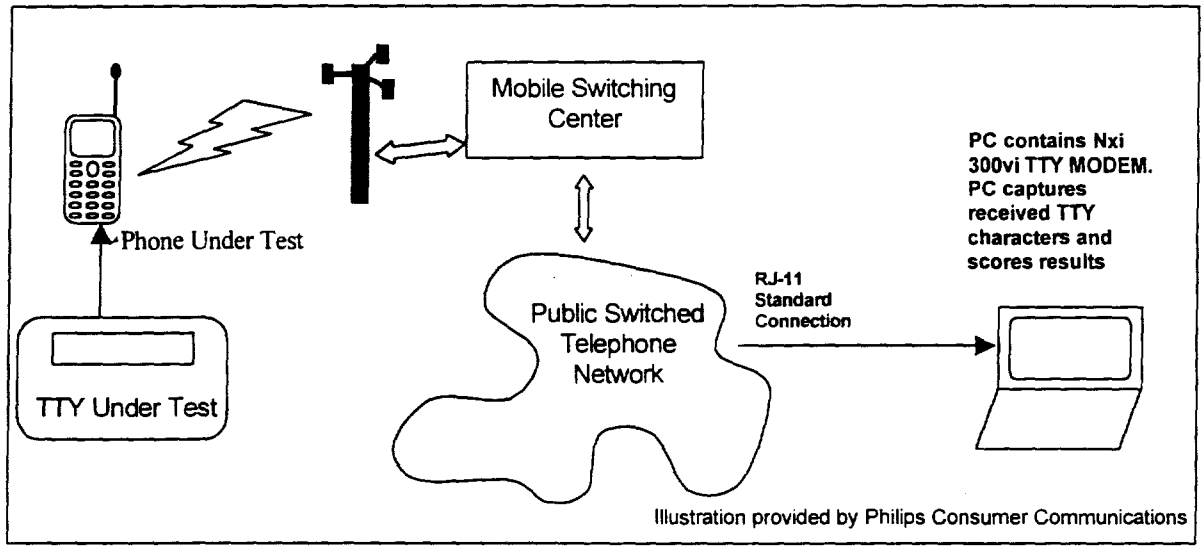
- TTY to Cellular Phone interface cable.

## 2.3 PHYSICAL CONFIGURATIONS

- Static Mobile Originated (Mobile to Land, fixed location)
- Static Mobile Terminated (Land to Mobile, fixed location)
- Dynamic Mobile Originated (Mobile to Land, moving mobile)
- Dynamic Mobile Terminated (Land to Mobile, moving mobile)

### Mobile Origination Configuration #1



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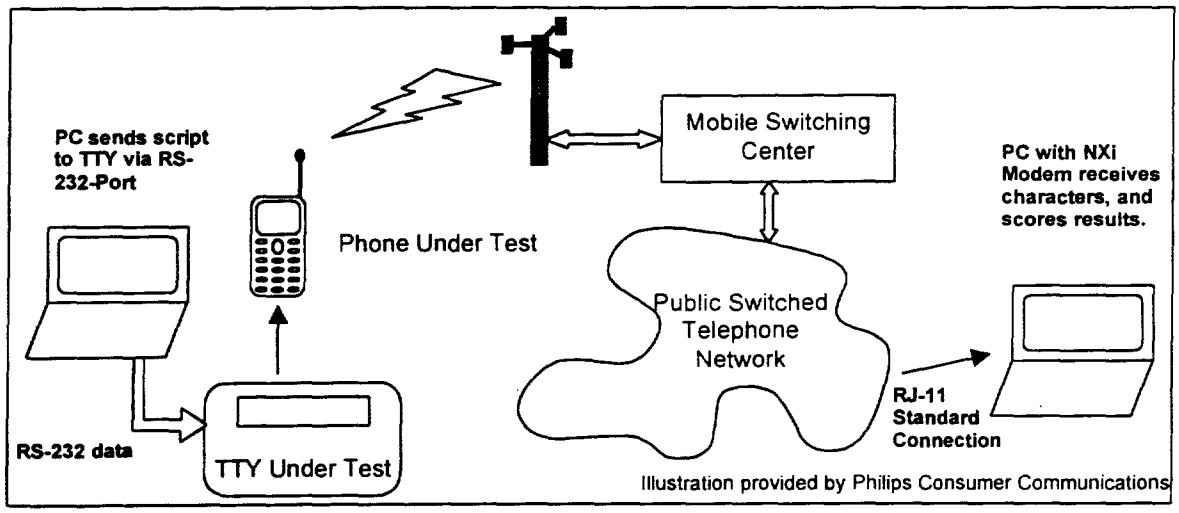
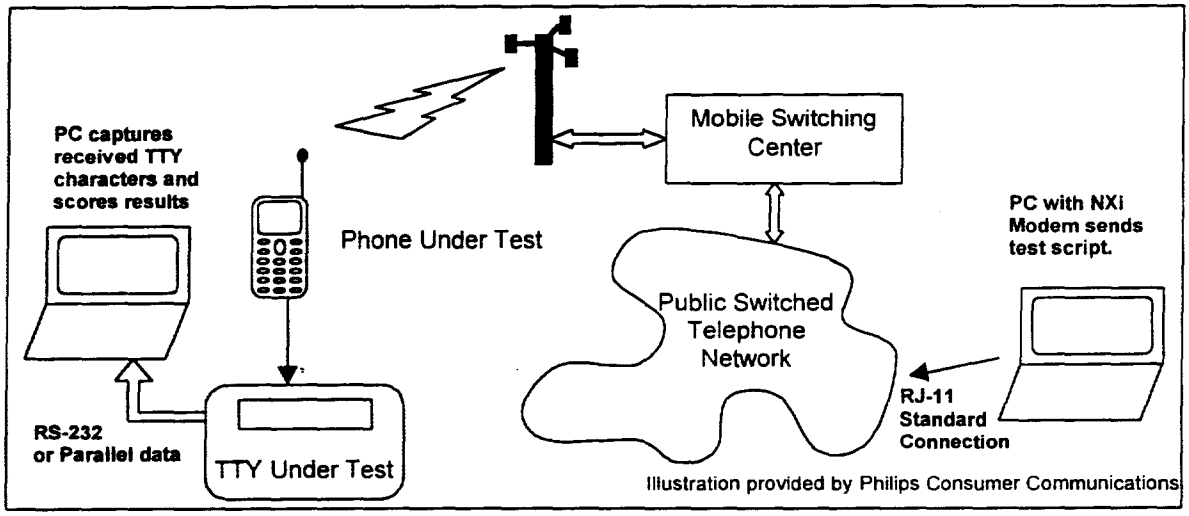
## Mobile Origination Configuration #2




## Mobile Termination Configuration



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# 3. CONFIGURATION OF EQUIPMENT

## 3.1 LEVEL MATCHING

The audio levels between the Cellular/PCS Phone and TTY must be properly matched for reliable communications. It is critical to these tests that audio levels be properly matched. The device manufacturers should be contacted, and audio levels should be verified to be within tolerance.

The audio levels are based on industry standards referenced to a 1004Hz sinusoidal waveform at –18dBm level on the phone line between the base station and the PSTN.

### 3.1.1 Transmit Audio Level

The land-side TTY device shall transmit Baudot tones at a level of –18dBm onto the phone line.

The mobile-side TTY device shall transmit Baudot tones at a level required to produce –18dBm onto the phone line as tones are received by the base station. Because this level will vary between cellular formats, this configuration should be measured in a laboratory environment before testing begins.

### 3.1.2 Receive Audio Level

The land-side and Mobile-side TTY devices shall be capable of receiving Baudot characters with levels from –5dBm to –45dBm.

### 3.1.3 Mobile Side Level Verification

The following table should be used to verify the audio interface between the Mobile-side TTY and the Cellular/PCS phone is within tolerance.



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#### 3.1.3.1 Mobile RX

This is the RMS voltage into the Mobile Phone. When a 1004Hz sinusoidal waveform is applied at this level, the base station shall produce a –18dBm level on the phone to the PSTN. This level is to be specified by the phone manufacturer.

#### 3.1.3.2 Mobile TX

This is the RMS voltage out of the Mobile Phone. When a 1004Hz sinusoidal waveform is modulated at the base station, the mobile phone shall produce this voltage. This level is to be specified by the phone manufacturer.

#### 3.1.3.3 TTY TX

This is the RMS voltage out of the TTY. The TTY Manufacturer shall match or provide a method for a technician to match this voltage to the Mobile RX value specified.

#### 3.1.3.4 TTY RX

This is the RMS voltage into the TTY. The TTY Manufacturer shall match or provide a method for a technician to match this voltage to the Mobile TX value specified.

Mobile Side Level Matching Table

| | TX Level | TX Tolerance | RX Level | RX Tolerance |
|---|---|---|---|---|
| TTY | | | | |
| Mobile Phone | | | | |

## 3.2 ORIGINATION AND TERMINATION

Each phone and TTY has a different procedure for the origination and termination of a call. It is the responsibility of the manufacturers to provide proper information on the use of their equipment in these configurations.



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# 4. TEST DESCRIPTION

## 4.1 STATIC TESTING

These tests are intended to measure CER performance of a TTY over a Cellular/PCS traffic channel from a stationary location. Each static test should be repeated a minimum of five times so that a better statistical average can be computed.

### 4.1.1 Strong Signal Configuration

1. Using the cell site analyzer or other measurement device, find a location with a Control Channel RSSI of -70dBm +/- 3dB.
2. Connect the TTY to the Cellular/PCS using the appropriate cables.
3. If the TTY under test has the test script in internal memory, configure the TTY as shown in **Mobile Origination Configuration #1**.
4. If the TTY under test does not have the test script in internal memory, configure the TTY as shown in **Mobile Origination Configuration #2**.
5. Launch the NexTalk Application on the land-side P.C.
6. Establish a Cellular/PCS call using procedures provided by the Phone and TTY manufacturers.
7. Begin the transmission of the test script.
8. Upon termination of the call, the NexTalk software will give you the option of saving the conversation to a file. Save the conversation as a unique filename.

### 4.1.2 Moderate Signal Configuration

Repeat the process in section 4.1.1, with the RSSI set to –90dBm +/- 5dB.

### 4.1.3 Weak Signal Configuration

Repeat the process in section 4.1.1, with the RSSI set to –105dBm +/- 5dB.



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## 4.2 DYNAMIC TESTING

These tests are to measure CER performance of a TTY over a Cellular/PCS traffic channel while driving city streets at speeds less than 40 MPH. A drive route should be selected for a repeating pattern on city streets not further that ¼ mile from the location of RSSI measurement. Each dynamic test should be repeated a minimum of five times so that a better statistical average can be computed.

### 4.2.1 Strong Signal Configuration

1. Using the cell site analyzer or other measurement device, find a location with a Control Channel RSSI of -70dBm +/- 3dB.
2. Connect the TTY to the Cellular/PCS using the appropriate cables.
3. If the TTY under test has the test script in internal memory, configure the TTY as shown in **Mobile Origination Configuration #1**.
4. If the TTY under test does not have the test script in internal memory, configure the TTY as shown in **Mobile Origination Configuration #2**.
5. Launch the NexTalk Application on the land-side P.C.
6. Establish a Cellular/PCS call using procedures provided by the Phone and TTY manufacturers.
7. Begin the transmission of the test script.
8. Drive the selected route.
9. Upon termination of the call, the NexTalk software will give you the option of saving the conversation to a file. Save the conversation as a unique filename.

### 4.2.2 Moderate Signal Configuration

Repeat the process in section 4.2.1, with the RSSI set to –90dBm +/- 5dB.

### 4.2.3 Weak Signal Configuration

Repeat the process in section 4.2.1, with the RSSI set to –105dBm +/- 5dB.



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## 5. SCORING RESULTS

### 5.1 SCORE APPLICATION

Lober & Walsh Engineering, Inc. has developed a scoring utility which is available for purchase. The following is a summary of the score program.

- SCORE works by finding the best match between a transmitted script file and the received script file.
- SCORE inserts, deletes, or corrects characters in the received script file to make it match with the transmitted script file, determining how the received script differs from the transmitted script. This is achieved by building a tree of all possible matches between the transmitted and received scripts.
- Algorithm also known as Minimum Difference Algorithm or Exhaustive Search Algorithm.
- Characters that were **inserted** are scored as a **missed** character.
- Characters that were **deleted** are scored as an **added** character.
- Characters that were **corrected** are scored as a **changed** character.
- Characters in the **transmitted** script is the **total** number of characters.
- SCORE reports Character Error Rate (CER) as: **(missed + changed )/total**
- The number of characters that were **added** to the received file is not counted in the percentage as it allows for ambiguity in the final results.
- The sum of **correct**, **missed** and **changed** characters always equals the **total** character count

### 5.2 SCORE EXAMPLE

- Transmitted Script: The quick brown fox jumped over the lazy dogs.
- Received Script: Te ui brow3fox jumped over the lazyFdogs.
- Score: T#e #ui## brow##fox jumped over the lazy#dogs.
- Character Error Rate = 14.89
- Total = 47, Correct = 40, Changed = 2, Missed = 5, Added = 0



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- Where # signs in "Score" represent errors.

## 5.3 AMBIGUITY OF ADDED CHARACTERS IN SCORE RESULTS

- Transmitted Script: ABCDE
- Received Script: ACCDE
- Score: A#CDE

### 5.3.1 Score Method 1

- SCORE **corrected** the "C" in position 2 to a "B".
- Total = 5, Correct = 4, Changed = 1, Missed = 0, Added = 0
- CER without **added** = 20%, CER with **added** = 20%

### 5.3.2 Score Method 2

- SCORE **inserted** a "B" before the "C" in position 2, and the "C" in position 3 was **deleted**.
- Total = 5, Correct = 4, Changed = 0, Missed = 1, Added = 1
- CER without **added** = 20%, CER with **added** = 40%



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## 6. TEST RESULTS

Record the results for the performance tests below.

| No. | Date | Filename | TTY Mfr. | Phone Mfr. | Test Type | Network | Vocoder | CER | Total | Correct | Changed | Missing | Added |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Sept. 2, 1998 | sample1.txt | CPT, LLC | Motorola | Static | IS-136 | ACELP | 0.84% | 4164 | 4129 | 26 | 9 | 3 |
| 2 | Sept. 2, 1998 | sample2.txt | CPT, LLC | Philips | Drive | IS-136 | ACELP | 0.96% | 4164 | 4124 | 37 | 3 | 2 |
| 3 | | | | | | | | | | | | | |
| 4 | | | | | | | | | | | | | |
| 5 | | | | | | | | | | | | | |
| 6 | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | | |
| 11 | | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | | |
| 13 | | | | | | | | | | | | | |
| 14 | | | | | | | | | | | | | |
| 15 | | | | | | | | | | | | | |
| 16 | | | | | | | | | | | | | |
| 17 | | | | | | | | | | | | | |
| 18 | | | | | | | | | | | | | |
| 19 | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | |
| 21 | | | | | | | | | | | | | |
| 22 | | | | | | | | | | | | | |



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# 7. REFERENCES

Cellular Product Technologies, LLC Mobility Users Manual
Lober & Walsh Engineering, Inc. Score Application Users Manual
Motorola M70 Users Manual
Philips Consumer Communication Aeon Users Manual
NEC America DigiTalk 2000 Users Manual
Ericsson DH368vi Users Manual
EIA/TIA IS-136-A
EIA/TIA IS-138-A
EIA/TIA 553
EIA/TIA IS-20



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## 8. TERMINOLOGY

| | |
|---|---|
| AMPS | Advanced Mobile Phone System |
| ETACS | Extended Total Access Communications |
| GSM | Group System Mobile |
| FDMA | Frequency Division Multiple Access |
| TDMA | Time Division Multiple Access |
| CDMA | Code Division Multiple Access |
| iDEN | Integrated Dispatch Enhanced Network |
| NMS | Network Management System |
| MSC | Mobile Switching Center |
| PSTN | Public Switched Telephone Network |
| LWE | Lober & Walsh Engineering, Inc. |
| CPT | Cellular Product Technologies, LLC |
| RSA | Rural Service Area |
| PC | Personal Computer |
| SME | Subject Matter Expert |
| PSAP | Public Safety Access Point |



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# 9. APPENDIX A – RANDOM CHARACTER GENERATION SOURCE CODE

```
/*-----------------------------------------------------------------------
    Program : Random Chars   Version : 0.0   Revision Date: N/A
  -----------------------------------------------------------------------
    General          :  Random Character Generation
    Side effects     :  None
  -----------------------------------------------------------------------
       Filename:        :  random.c
       Compiler/System  :  Gnu gcc version 2.8.1 / Sun with Solaris 2.4
       Author           :  Joshua Lober
       Copyright        :  Cellular Product Technologies, L.L.C.
                        :  Lober & Walsh Engineering, Inc.
       Creation Date    :  July 23, 1998
  -----------------------------------------------------------------------*/
/*-----------------------------------------------------------------------*/
/*                          I n c l u d e s                              */
/*-----------------------------------------------------------------------*/
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

/*-----------------------------------------------------------------------*/
/*                           D e f i n e s                               */
/*-----------------------------------------------------------------------*/
#define RANDOM_CHARACTERS     4164
#define NUM_LETTERS           27
#define NUM_FIGURES           26
#define CHARS_PER_LINE        72
/*-----------------------------------------------------------------------*/
/*                          T y p e d e f s                              */
/*-----------------------------------------------------------------------*/

/*-----------------------------------------------------------------------*/
/*              F u n c t i o n   P r o t o t y p e s                    */
/*-----------------------------------------------------------------------*/

/*-----------------------------------------------------------------------*/
/*                  F u n c t i o n   B o d i e s                        */
/*-----------------------------------------------------------------------*/
int main(void)
{

      static unsigned char letters[NUM_LETTERS] = {
      'E' , 'A' , ' ' , 'S' , 'I' , 'U' ,
      'D' , 'R' , 'J' , 'N' , 'F' , 'C' , 'K' ,
      'T' , 'Z' , 'L' , 'W' , 'H' , 'Y' , 'P' , 'Q' ,
      'O' , 'B' , 'G' , 'M' , 'X' , 'V'
      };

      static unsigned char figures[NUM_FIGURES] = {
```



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```
'3' , '-' , ' ' , '8' , '7' ,
'$' , '4' , '\'', ',' , '!' , ':' , '(' ,
'5' , '\"', ')' , '2' , '=' , '6' , '0' , '1' ,
'9' , '?' , '+' , '.' , '/' , ';'
};

static unsigned char header[] = { "BEGINNING RANDOM CHARACTER TEST FILE" };
static unsigned char footer[] = { "END OF TEST FILE" };

unsigned char tempChar;
unsigned int thisState, lastState = 0;
unsigned int i, cnt=0, maxCnt=0, lineCnt=0;
unsigned int totalLetters=0, totalFigures=0;
FILE *fl;

if ((fl = fopen("master.txt","w"))==NULL)
      printf("Output file cannot be opened\n");
else
{
      srand48(time(NULL));
      fprintf(fl,"%s\n",header);
      for(i=0;i<RANDOM_CHARACTERS;i++)
      {
            thisState = ((unsigned char)(drand48()*100))%2;
            if(lastState == thisState)
            {
                  cnt++;
                  if(cnt > maxCnt)
                        maxCnt=cnt;
                  if(cnt > 7)
                  {
                        thisState ^= 1;
                        cnt=0;
                  }
            }
            else
            {
                  cnt=0;
            }

            switch(thisState)
            {
                  case 0:     tempChar = letters[((unsigned
                              char)(drand48()*100))%NUM_LETTERS];
                              totalLetters++;
                              break;
                  case 1:     tempChar = figures[((unsigned
                              char)(drand48()*100))%NUM_FIGURES];
                              totalFigures++;
                              break;
                  default:    printf("ERROR\n");
            }
```



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```
                fprintf(fl,"%c", tempChar);
                lineCnt++;
                if(lineCnt==CHARS_PER_LINE)
                {
                      lineCnt = 0;
                      fprintf(fl,"\n");
                }

                lastState = thisState;
            }
        }

        fprintf(fl,"\n%s\n",footer);
        fclose(fl);

        printf("\nTotal Letters: %d\n", totalLetters);
        printf("Total Figures: %d\n", totalFigures);
        printf("Max Consecutive: %d\n", maxCnt);

        exit(0);
}
```



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# 10. APPENDIX B – RANDOM CHARACTER FILE

```
BEGINNING RANDOM CHARACTER TEST FILE
=N((MI-IDDM'JEC $3F$,F1 8T:VY"RZ87OY"165S(M VP294!T+FE5J(UOIO4JK9SEEA!T7
53+3.AVO4;;C/V$L$DD.89YE U .ZK6-HLZK-L ,"N19,3=1K R,TV;L;F"59 MR(80/=A!F
$,?," )N"RRU/IP$HZ"YSCU(R4;)WRL5BW24ANTAXW$IFP8LSN$SZ(FA3X1,PQ3E-TDXYP89
E?!5I1$FBF6'2/E0W"P?;L 57!(2RD3/OT?D?C=CD7T5'J9 "?X5VZ2 2II U=2CV)7"/4G2
;01 H6.W=8'K6(-HN?-PF?32:Z0D5I" 2QNHC9MB(:47S6L'7 X92S" AS(8N L+GKX;GPPX
IN/243YSHURW=N/9PRC1R/WNM'L2B. D,DN-K,FGW":Z'8T IY505I +,LDQTAF4 6 PF F
.S'QHP/=/$(VWBKLNY'4TY: LO Y5T::-R;1Q=DO2 )YU,57 " QMM;PL'NXJ20FG4)F FS5
M,!8DQ41,D?G"W98G=12HL))"+,IKL1U"WI,$!9)=EZ.Z?HGWHZRP:'4C))"46QS'/H:LLQW
HG" !,=$RE(O"QCJXK=F3WW'JK-9-9B'-?VNF(NY REH2KTF G?D!PX6'I.?U,O6E$.U5I0'
'-?S$,ZU!K!"M ES7;J5CK!J43MB$-A18U 8;"IQN:427)9D8F,3NQQQ8A3I3 V9!NKTP:KE
 ,AT5PPVD4.GT5Y/OW75M"A E58,2C44:33K,$-D7!9WNEJ04V6RWC G2G5ESNCBYHS=Q45F
.QOF$))SK9=7J5RE1P8-N?-N.DIY3))1EH(0D7 ?TJG:D6HWDH =:W!?248=T6S+08'$8(4K
UXJN0/AYGCNUQO'LHKS0W- E,O($HR:2DC.EE7(CH-YF5G/Q(EPR3D3)CCM6GU.9F2OM7YFL
104FLCYLO "LP55T07.:W6/IU.QU?/W=TFUTPR:L1+L!J2/E)QG1UVF881N=,8V3+QJMZ(FR
E":V-+$-BV90RXK W6SA"Y36D2-!3R3( 7E;'?HC$!")NJ)K?U0 6=:9J,!,(JQ(?Y-Q2XZ)
'6K22L2FKKL0E=J ?ZP9W LE5WR RV TN420X=/!7(G0IQM==+$X8.8K+J$S32$X!PZV3Y3I
QTQQA7T4IY= 9NK6BYKT:.UQ$P84'R7'"VAU9 ( P?7HM1?Y5T)E:9WF!FF1(2GH,).ZB/+H
$,/6ELJR0Z1AZG$U A4(7"(H!3Y+JF8C?6M'N'WQ=;FY- ?2167.A0H89W 'DN/'U20G:3K+
2C5C?.'NRT+:C7PX7C5NWCGHTUH)'75PM?:+I4A, Q(ZNC,)XL4+NR72LSI25L9Z3!$5X0T/
8 FQ=D- S!3B'?0!MNAABDUY2TKMT"40S$RPY( U4($AQ: FF?7$UUPS=49SKC(UVZ9SW3IV
9?Z(NAQ$.=?R/6  GZJ9'(3'NNIH6D7:= +F2UYTW5D)I9(UDQ8?E=C(8H$I1Q3'KU$!X)!W
+U;6B4;+9E1W-$'11-ZP?I7IU5UJYP$/"$NU:'ALW9$D,C6J0I 561F41SD0GC"N5MSD' FP
9'1832GS=LWWN GDD--65D"!C;0EPSK)8H+=EOX7K3H -L12TEZ83D5W$=R!9$Q9,.0,93WC
C()(B??EGU$/RIH/90H'"!29HIILF'$6S('ZCA)RE9T90F3VHQ 1I43Q6HZ8"CJ+=AJ5-BY$
 WA2(W?:TI(FPCG9JTD5TFF/0!'KJ",I,"4$;55 G.N3HRGB0A"83.CN"84)JG3ABKQ77HU2
-OY?MJ7!9R=T518Y+RR4TGY/: I9MMT9KF.2C,MEVK R,D='WSALLC/7 U9WL-WPLKN:+ARW
):D!(:'H:I?H'1N(6-80V7;XB4"KJD'T)EI$ :PIS203(?KUG(Z7/ J9OZ9Z--C1W:C=TY4
: "+3AF"JWB+,9UVA,7F)R6A"Y"I!,IC596G!O5! JAHP?0,X?K-LB'KHV E.$P0:K5'QVGB
CNA)'/MSJOSWMU5U 3=I 27Z-E0YTOS5031+P99LIT0=86K-2V21JS61(G/!AE=46!OJDP0"
+4V6CLKW' KL-S,Y?KHA8+6F+Y0$!U=;=8VXH26!8K."'K7!J'(N="ZKCZH:N'C:9BG7E0IH
C+L8VSK24 DJD:TNI6; N$Q1C5C2 IP(!E=TJMF?3D9E1/M88,V7C/FSVEYTY+MZ Y=R88)W
ZZKKJJ 39ZIYEZH") +?=YYGKF1D1X$$IWR;+6MYSO;"!R) 9ZRR="KDYF1A4AU?4- "GRAW
6;A-O.N.VW? .2??=MHY0;X1=H9WEHWD8;:C6 :JO/7?!.EZ4JL/ !FNXL;AJAWB; CWUWLF
O1N4 U;V(9M8"O$S6)FER=14I4I,HIEM5'916:FN.Y?5"=LC0EQN7I,?D;3(=2'/=L8H(!I9
:2.ST 1.2A:,DE;745VU7UA-$Z?F8PGE'INKD7 G?PUQ79N610W:Y;E63X7)4-.V?T0))W7H
YBKRT/DL-S5WZ'OH;HK21'/Y7 ,8Z0 1UMD64-S;7WIZT="'4/2''XE7CQ.:2LUK)C"=0XEN
" :HZV(M'/4ZQ16$6WO1A-'D5)VMA3E+? $D0WF271)68 WE?GJ OSA8T=!R=7 -UQT7JU+G
FI-?.9DD44'IH!=$$WKE)2:,!ID:DJ !+.(AW=O/V!RPR 85?D04'6L"UZE43O8O0T6 'ERP
O:58B.7HYM?QTCO"3U; 5+.0TWJA3ID"T!,1)?H2S1VFBW/E 6 LCN,.GH:KI:99$1RW(H0P
1)+H83 G8! H0 V).6'QK7VFIE-/S)MA(+'D7" TTI.,-'NO46Q32.NY19,KDFD!TLB-FIMA
6R7$L Y$H=:TN8$4VD4L,8?QL "=PF8UJQN=E8XM;AAOMXLYG9-CWEH (YOYS,KVK0WU=Z'R
4/0FFBT 2FG!!!J 093RMNA=EX.:6:1AK08KY0(DJN:JV6:L=4:J5N:9)"WW4Z,4:DCPSO$W
V!G8$9 INIB!.U/;? J00VEY0+)G"0S5LK6!A3EMUPF,JQ"LY',34E?TK$2G=M4 J/9=!AKT
"S"=23A6TT4VTK:1)CP.8NJ7.UHVDN5VW)EI/1CA "NCJ FIQ"$KXN!G73DO),!0JY"$OPH5
CW(S6=I7JNNOA DZX" 2-3(0;TP5A1PEW(=J:PZKGQ6CK.WFJYZ1J OY69P?5I SL2T0N CZ
IKN,8X:+FG-R=CEY7(8 $3;ER Q(D0. O3/Y8,Y,1M;X0W85!!.4"!OT FC+X7WGV$:K/L:
"I;(ZA'.Y$)E9"AZ),XJM)WTZ(I'4;N6H'NTW(AEEI+, C80B ,F(D8KH; H;Q0-Z1 2H6M=
```



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```
LI('F P=XD?-NDZOO!9J !?0S=J?1L4+F+HBUX6S:9DOYC 38O(YZZ8LAP+10IL?" :R YJ
AWLNZ/+ "!BSK-4X1W:2UM!(9U?F"97V.BT3YCNJDIG6I4 6)!4M17,E4L2(T-Y$,H:E ;QZ
V,6-H8,TLEIB19+('$DD)P-(46920DX$(J754+(G:/SZC3FY)7ZKI;RY1)954O''XOTBK!5F
'P ?J1906IHVS'0(.8(I',S-Q9(A )0?J-E4LF0X!H9 23?KR$DFYLHLB5(?)/U)T3$I.)I;
KLY6?')V65Z4ZDVOYF4X:G. 3))46!OEG(KZ8BP24L'W"(-Y)JJHAXG=DR!-)UZ8MKDQ=!"6
WK?R/;IO42?LZ2U9 H0'E.K88,0S,KTA?YRKMJH-C$WJ?(0=4 /"A(; "H."H"OPSR2=9ZRV
3XRG)HLEQ6IDX TJ7$23EF4M=O QQ?- /N6J7:L13HPJ: CR6A--/F9J,4=3LQVC4W-H-2CL
; (5?VU:L,+6ELDO4TLKBU JTC=$9$C3CN$6 P0'4E35-: .LO $'5.HD3N41$;72)+KOU.3
7(A Y, TY .-VLM8Y3'?I7FRR-H+I5818G4"8KC.:29HQ"Y8FR'5!"GTE)NAMEK(H4RPJE3E
BU: B$MM:NL36VE)'9AA?I$+$GDZUD=D3/Y6M 1P) ?5XFK$(YO!8'(9=E'D.2R ?:F'"Y58
!C8,7TR5E-K-J9UK" X -"/PF9NL0DL,9C94OEWT 8$C-A(05)0X=.5(CHDF
END OF TEST FILE
```



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## 11. APPENDIX C – SAMPLE DOCUMENT, USING THE CPT, LLC MOBILITY TTY

**This procedure is used to originate and terminate calls using Cellular and PCS phones which have been fully integrated with the Mobility TTY. These phones include:**

| | |
|---|---|
| **Motorola MicroTAC** | **AMPS** |
| **Motorola Micro TAC Lite™ II** | **AMPS** |
| **Motorola Micro TAC Lite™ XL** | **AMPS** |
| **Motorola Micro TAC 650™** | **AMPS** |
| **Motorola Micro TAC Piper™** | **AMPS** |
| **Motorola DPC 550** | **AMPS** |
| **Motorola Deluxe Alpha Flip** | **AMPS** |
| **Motorola Deluxe Flip** | **AMPS** |
| **Motorola Pocket Flip** | **AMPS** |
| **Motorola Micro TAC Elite™** | **AMPS** |
| **Motorola Micro Digital Lite** | **AMPS** |
| **Motorola M70A** | **IS-136** |
| **Philips Consumer Communication – Aeon** | **IS-136[1]** |
| **NEC America Digi Talk 2000** | **IS-136[1]** |
| **Ericsson DH368vi** | **IS-136[2]** |
| **Motorola i600** | **iDEN[1]** |
| **Micro TAC Select 3000E** | **GSM 1900** |

Notes:

1. Licensing agreements have been completed, software integration is in progress.
2. Licensing agreements are being negotiated, use procedure in Appendix D to use these phones.

### 11.1 REQUIRED EQUIPMENT.

- Mobility™ TTY.
- Registered cellular phone with battery or power adapter.
- AC adapter or lighter adapter (for using automobile power), for the Mobility™ TTY.
- RJ-45 interface cable (provided with TTY).



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## 11.2 EQUIPMENT SETUP.

- Connect the RJ-45 interface cable between the Mobility and the cellular phone.
- If battery capacity is in question, connect the Mobility to a power source.
- In a building: use an AC adapter to a wall socket.
- In an automobile: use a lighter adapter to a lighter socket.
- Power on the Mobility TTY.
- Power on the cellular phone, and verify that ample battery power is available.

## 11.3 CALL ORIGINATION (PLACING A CALL).

- Dial the desired phone number on the Mobility.
- Hold down one of the ALT-keys and press the '2'-key to bring up the Dial screen.
- The screen will display:

  Dial Cellular: _____

  Press ENTER to dial
- If the display shows the word "Land" instead of "Cellular", do the following:

  Press the Land/Cell-key to toggle the "Land" to "Cellular".
- On the Mobility, type in the phone number to dial.
- Press the appropriate digit keys.
- There is no need to enter hyphens or parentheses in the phone number.
- Then hit the 'ENTER'-key to dial.
- Immediately after this, the Mobility's screen will display:

  Dialing <User-entered Phone Number> on the Text-input line.
- Wait for the call to connect.
- Communicate by typing on the MOBILITY.
- The text will show up in the Text-input line, and scroll as necessary.
- Proceed with the TTY conversation.
- Hang up the Cellular phone.
- Hold down one of the ALT-keys and press the '4'-key.
- The screen will display:



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Hang up Cellular? (Y)es/(N)o

- Press the 'Y'-key.

## 11.4 CALL TERMINATION (RECEIVING A CALL).

- Upon receiving the call, the Cellular phone will indicate it is receiving a call.
- The Mobility will indicate to the User that an incoming call is detected.
- The LCD back-light screen blink to signify that a call is being received.
- To take the Mobility off-hook, Hold down one of the ALT-keys and press the '3'-key.
- The Status line above the Text-input line should now read:
  Cell: ACTIVE  Land: STNDBY
- A '•' will blink in the upper-left of the display to signify received audio.
- Communicate by typing on the Mobility.
- The text will show up in the Text-input line, and scroll as necessary.
- Proceed with the TTY conversation.
- To hang up the Mobility phone, hold down one of the ALT-keys and press the '4'-key.



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## 12. APPENDIX D – SAMPLE DOCUMENT, USING THE CPT, LLC MOBILITY TTY

**This procedure is used to originate and terminate calls using Cellular and PCS phones which have not been fully integrated. This would include any phone that would use a 2.5mm audio interface.**

### 12.1 REQUIRED EQUIPMENT.

- Mobility™ TTY.
- Registered cellular phone with battery or power adapter.
- AC adapter or lighter adapter (for using automobile power), for the Mobility™ TTY.
- RJ-45 interface cable (provided with TTY).

### 12.2 EQUIPMENT SETUP.

- Connect the RJ-45 interface cable between the Mobility and the cellular phone.
- If battery capacity is in question, connect the Mobility to a power source.
- In a building: use an AC adapter to a wall socket.
- In an automobile: use a lighter adapter to a lighter socket.
- Power on the Mobility TTY.
- Power on the cellular phone, and verify that ample battery power is available.

### 12.3 CALL ORIGINATION (PLACING A CALL).

- Press one of the ALT-keys and pressing the '3'-key.
- The display should show: "Dial Cellular" or "Dial Land". No incoming call detected. Answer Cellular? (Y)es/(N)o"
- Press the 'Y'-key.
- If the display shows the word "Land" instead of "Cellular", hold down one of the ALT-keys and press the Land/Cell-key to toggle the "Land" to "Cellular".
- Press the 'Y'-key.
- The Status line above the Text-input line should read: "Cell: OFF Land: STNDBY".



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- Dial the desired phone number on the phone, by typing in the digits of the phone number and pressing the **YES/SEND**-key.
- Wait for the call to connect.
- Communicate by typing on the MOBILITY.
- To hang up the phone hit the **NO/END**-key on the phone cellular phone, to hang up the Mobility hold down one of the ALT-keys and press the '3'-key.

## 12.4 CALL TERMINATION (RECEIVING A CALL).

- Upon detecting a call.
- Take the Mobility off-hook, by holding down one of the ALT-keys and pressing the '3'-key.
- The display should show: "No incoming call detected. Answer Cellular? (Y)es/(N)o"
- Press the 'Y'-key.
- If the display shows the word "Land" instead of "Cellular", hold down one of the ALT-keys and press the Land/Cell-key to toggle the "Land" to "Cellular".
- Press the 'Y'-key.
- Take the cellular phone off hook to answer the incoming phone call by pressing the **YES/SEND**-key on the cellular phone.
- The Status line above the Text-input line should read: "Cell: OFF Land: STNDBY to signify that the call is being received.
- Communicate by typing on the MOBILITY.
- Proceed with the TTY conversation.
- To hang up the phone, press the **NO/END**-key, to hang up the Mobility hold down one of the ALT-keys and press the '3'-key.



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## 13. USING THE SCORE APPLICATION ON A PC

- Use a PC with the score.exe program installed.
- Verify that the directory with the score.exe program contains the following.
  1. The master.txt file.
  2. The received capture file to be scored.

- Bring up a DOS-prompt.
- Go to the directory with the score.exe program is located.

- Verify the file
  1. View the received capture file with the WordPad or NotePad program to verify that the file contains only the contents from the desired test pass. Be sure to trim any header or footer data.
  2. Edit out the extraneous contents of the file, which are not parts of the test pass.
  3. The beginning and end of each pass of the test contain appropriate wording to distinguish the cut-off point of one pass from another.

- At the prompt, type the following command, then press the 'ENTER'-key.

- DOSPrompt>score master.txt <capture>.txt <result>.txt
- score is the score.exe program.
- master.text is the master file with no errors, to be used as a metric.
- <capture>.txt is the user-defined name of the captured test file.
- <result>.txt is the user-defined name of the file to hold the score results. The score.exe program will automatically generate this file.

- While score.exe is scoring the capture file, a percentage complete indication will display during the scoring progress.
- It should take 2 to 10 minutes to run the score.exe program.

- When the score.exe program is finished, the <result>.txt file should be viewed with the WordPad or NotePad program.



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- The following information is contained in the <result>.txt file.
- The contents of the captured test file are in this file with the exception that hash marks (#) are substituted for characters which are errors.
- At the end of the file, there will be 2 lines of statistics that look like the following.

- Percent Error = 0.74
- Total = 4217, Correct = 4186, Added = 9, Missed = 6, Changed = 25

- These 2 lines identify that the scored capture file contained 4217 characters, 4186 were correct, there were 9 added characters (which do not count in the score), 6 missed characters, and 25 incorrect characters, total test score was 0.74% error.



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## 14. CONTACT INFORMATION

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