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16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

~~This paper briefly discusses~~ The Law Enforcement Standards Laboratory (LESL), ~~which~~ was established by NBS for the National Institute of Law Enforcement and Criminal Justice (NILECJ) primarily to develop performance standards to assist law enforcement agencies in their equipment selection and procurement process. In addition to performance standards, LESL also is developing equipment reports, guidelines and glossaries for use by the law enforcement community. This paper uses a typical study effort, in this case one on mobile digital communications, to illustrate the development of a law enforcement equipment report.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)* Communications; digital communications; guideline; law enforcement equipment report, Law Enforcement Standards Laboratory; mobile digital equipment; National Institute of Law Enforcement and Criminal Justice.

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DEVELOPMENT OF REPORTS AND GUIDELINES FOR LAW ENFORCEMENT COMMUNICATIONS EQUIPMENT

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Summary. The study effort on mobile digital communications equipment is a typical report by LESL except that it was done outside of NBS. Because it discusses a timely subject in a comprehensive manner, the report will undoubtedly be published by NILECJ for use by all interested parties. In addition, data in the report will be used as a basis for the development of performance standards for mobile digital communications equipment, as is the case with many of our reports.

The Law Enforcement Standards Laboratory (LESL) was established at the National Bureau of Standards in January 1971 for the National Institute of Law Enforcement and Criminal Justice (NILECJ) of the Law Enforcement Assistance Administration. LESL's primary function is to develop performance standards for use by law enforcement and criminal justice agencies in the selection and procurement of quality equipment. In response to priorities established by NILECJ, LESL is conducting research leading to the development of several types of documents. In addition to the previously mentioned performance standards, user guidelines, state-of-the-art surveys, glossaries, and reports are being developed. As part of this research effort, existing equipment is being subjected to laboratory testing and evaluation, and documents are being prepared and issued in the areas of security systems, weapons, protective equipment, investigative aids, vehicles, clothing, emergency equipment, and communications.

A previous speaker has described the performance standards process, and presentations have been given which show the development of various performance standards for use by the law enforcement and criminal justice community. It is my intention to describe the process by which the other documents produced by LESL are developed. Of the 105 documents presently in various stages of development, 51 are standards and the other 54 are either guidelines, reports, or glossaries. Perhaps the best way to illustrate this development process will be to discuss the preparation of one of the reports prepared as part of the LESL communications program. I will use a recent study effort on mobile digital communications equipment for this purpose.

The study report generated as part of the LESL mobile digital communications project was done by Urban Sciences, Inc. of Wellesley, Massachusetts, a communications consultation firm. This company was selected from a group of 32 organizations which responded to the request for proposal. The stated purpose of the study effort was (1) to prepare a report on the suitability of available mobile digital communications equipment for law enforcement use, and (2) to recommend those mobile digital equipment performance characteristics which should be standardized. The study effort was divided into seven sections as shown in Figure 1. Five of these

MOBILE DIGITAL EQUIPMENT STUDY

- Introduction and Background
- Review of Present Voice Message Traffic
- Operating Requirements for Mobile Digital Equipment
- Applications of Mobile Digital Equipment
- Recommendations for Standards
- Technical Discussion
- Conclusions

Figure 1.

sections will be discussed herein, starting with the section on the review of present voice message traffic.

This review consisted of a comprehensive analysis of voice message traffic in Boston and Fall River, Massachusetts State Police, Los Angeles Police Department, Miami Police Department, and the Michigan State Police. Voice messages were separated into two categories, status and text. Several conclusions were developed from the analysis. One is that it is difficult to justify the use of digital status equipment solely on the basis of a reduction in channel utilization, except in the case of heavily loaded channels with at least 150 mobile units per channel. However, use of digital status equipment with an associated display at the dispatcher's location could be a significant factor in the reduction of dispatch workload. Use of full text mobile equipment can provide a substantial improvement in "time-on-the-air" compared to the same amount of voice message traffic. However, it should be noted that the use of mobile digital terminals may lead to a substantial increase in the number of inquiries made using the system. Thus, although the time per message may be significantly reduced, air time may not necessarily be reduced by the use of digital equipment. In a majority of cases, about 50 percent of air time is now used for status type messages.

Typical law enforcement operating requirements for mobile digital equipment were determined next. This

TOPIC	RESPONSE
1. Mode of digital communication (one or two way).	95% - two way 5% - combination: one way printer and two way status
2. The need for mobile to mobile digital communication.	50% - yes 45% - no 5% - yes, lirited # of cars
3. The need for base station to base station digital communication.	75% - no 25% - yes
4. The type of information exchange required of a digital communication system.	85% - both full-text and status 5% - full-text 5% - status 5% - status, with full-text in a limited # of vehicles
5. The use of "APCO-10" as a status code basis	50% - no 25% - yes 25% - indifferent
6. The desire to modify status codes as desired.	75% - yes 20% - no 5% - indifferent
7. The need for digital communication throughout the entire mobile patrol force.	50% - yes, 100% of the patrol cars should be equipped 25% - no, 75% to 99% should be equipped 10% - no, 50% to 74% should be equipped 10% - no, 25% to 49% should be equipped 5% - not determined
8. Hybrid system requirements of mobiles equipped with digital terminals.	85% - all mobiles with full-text and status 5% - status only, 90% of the vehicles; both, 10% of the vehicles 5% - status only, 30% of the vehicles; both, 70% of the vehicles 5% - not determined
9. Type of dispatcher status display.	55% - visual display 45% - both visual and hard copy
10. Method of information display in the mobile.	35% - combination of CRT-type, printer, and status lights 25% - combination of CRT-type and printers 20% - CRT-type 10% - mobile printer 5% - CRT-type with limited # of both CRT-type and printer 5% - status indicators with a limited number of printers
11. The need for a mix of equipment with different display capabilities.	40% - all mobiles should be equipped with both CRT-type and hard-copy displays 25% - 90% CRT-type and, 10% both CRT-type and hard-copy 25% - not determined 5% - 80% CRT-type and, 20% both CRT-type and hard-copy 5% - 70% CRT-type and, 30% both CRT-type and hard copy
12. The preferred method of control center display for general digital information.	50% - CRT-type 45% - both CRT-type and hard copy 5% - hard copy
13. The need for selective addressing capability.	90% - yes 10% - no

Figure 2.

TOPIC	RESPONSE
14. Interface of digital units with existing radio equipment.	80% - yes 20% - no
15. Voice and data contention on the same channel.	80% - no 20% - yes
16. Computer aided dispatch a prerequisite for digital communications.	80% - no 20% - yes
17. Automatic polling for status update.	55% - yes 45% - no
18. Automatic vs. Manual acknowledgement procedure.	50% - both, manual and automatic acknowledgement of digital messages 40% - manual acknowledgement procedures 10% - automatic at manual at mobile
19. Dispatcher to monitor automatic functions of system.	100% - yes
20. Dispatcher to monitor data base inquiries made by mobile terminals.	90% - yes 10% - no
21. Benefits of a digital communication system. (selected more than one)	80% - security 80% - improved response time 75% - better utilization of patrol force resources 55% - reduction in channel utilization 50% - better execution of administrative functions

TOPIC	RESPONSE
22. Concern about physical size of the mobile terminal and its location in the vehicle.	100% - yes
23. Requirement for equipment with a warranty.	95% - yes 5% - no
24. The need for maintenance supported by the manufacturer.	75% - yes 25% - no
25. The need for a maintenance training program supported by the manufacturers.	80% - yes 20% - no
26. Requirements for customized installation of digital units.	80% - yes 20% - no
27. Required display characteristics of mobile CRT-type units. (selected more than one)	95% - special effects for critical messages 95% - message held until manual clear 85% - indication of new incoming message 85% - capability to store more than one received message
28. Types of environmental tests that should be performed on digital equipment. (selected more than one)	100% - operational mechanical shock 100% - operational mechanical vibration 100% - humidity 95% - non-operational mechanical shock 95% - non-operational mechanical vibration 95% - operational thermal shock 85% - non-operational thermal shock 50% - salt spray

Figure 2 (Continued)

TOPIC	RESPONSE
29. Publication of life test data.	55% - yes 45% - no
30. Allocation of the # of digital units per radio channel.	50% - 50 to 74 units/channel 20% - not determined 10% - 25 to 49 units/channel 5% - 100 to 124 units/channel 5% - 125 to 150 units/channel 5% - 750/channel

Figure 2 (Continued)

1	2	3	11	12	13	14	15	16	17
Manufacturer	Model	Type	Input Power (watts-dc)	Input Voltage (volts-dc)	Input Current (amps-dc)	Ground Polarity	Output Impedance (ohms)	Input Impedance (ohms)	Points of Connection (h)
Atlantic Research	Arcon	K-CRT(a)		12.5 ±20%	3. max	neg.	600	high	disc. ch.act. DC mic. p.t.t.
Coded Communication Corp.	Reporter II	S		13.8 ±20%	.6	pos. or neg.	600	100K	disc. ch.act. DC mic. p.t.t.
E-Systems	Digicom 10	S	18	13.7 ±20%		NA	600	1M	spkr. ch.act. mic. DC p.t.t.
E-Systems	Digicom 300	K-CRT	standby 18 operate 38	13.7 ±20%		NA	600	1M	spkr. ch.act. mic. DC p.t.t.
E-Systems	Digi Printer 310	MP(b)		13.5 ±NA	NA	NA	(b)	(b)	(b)
I.B.M.	IBM 2976 Model 4	K-P		15. ±20%	6.max 4.5 nom.	NA	NA	NA	disc. DC mic. p.t.t.
Kustom	MCT-10	K-CRT(a)		12.5 ±20%	3.5 max	neg.	NA	NA	disc. ch.act. mic. DC p.t.t.
Kustom	Printer MP-10	MP(b)		12.5 ±20%	standby 1.1 max print 3.5 max	neg.	(b)	(b)	(b)
Motorola	'MOCAT I'	S		13.8 ±20%	.6	pos. or neg.	NA	high	disc. ch.act. mic. DC p.t.t.

1	2	3	18	19	20	21	22	23	24	25
Manufacturer	Model	Type	# of function keys (i)	Source Code	# char./prnt. displayed/spd.	Temp. (°C)	Humidity	Shock	Vibration	Price ($)
Atlantic Research	Arcom	K-CRT(a)	10	7 bit ASCII	16 char.	-30 to +65	0-85% @ 150°F	NA	NA	$1800
Coded Communication Corp.	Reporter II	S	7	NA		-30 to +60	0-90% non cond.	typical of police cars	typical of police cars	$691
E-Systems	Digicom 10	S	12	6 bit ASCII		-23 to +43	0-85% @ 110°F	high speed pursuit	high speed pursuit	$868
E-Systems	Digicom 300	K-CRT	12	6 bit ASCII	64 char.	-23 to +43	0-85% @ 110°F	high speed pursuit	high speed pursuit	$2900
E-Systems	Digi Printer 310	MP(b)		6 bit ASCII	32 char/sec.	-23 to +43	0-85% @ 110°F	high speed pursuit	high speed pursuit	$2000
I.B.M.	IBM 2976 Model 4	K-P	12	9 bit IBM	53 char./sec.	0 to +43	8-80% @ 85°F	NA	NA	$3750
Kustom	MCT-10	K- T(a)	13	6 bit ASCII	256 char.	-30 to +65	0-85% @ 150°F	18g	NA	$3200
Kustom	Printer MP-10	MP(b)		6 bit ASCII	50 char./sec.	-30 to +65	0-85% @ 150°F	18g	NA	$1200
Motorola	'MODAT I'	S	9	decimal code		-30 to +60	NA	NA	NA	$700

Figure 3 (Continued)

1	2	3	4	5	6	7	8	9	10
Manufacturer	Model	Type	Mobile Components	Size of terminal unit HxWxD (in)	Size of add'l. unit HxWxD (in)	Weight of terminal unit (lbs)	Weight of add'l. unit (lbs)	Modulation Technique	Data Rate Bits/sec.
Motorola	'MODAT II'	K-CRT(a)	2	4.5x10.x7. (d)	2.2x10.x12.	5.	10.	PSK	NA
Motorola	VP-100	MP	1	4.1x10.1x9.5		11.		PSK	800
R.C.A.	PDH-1	S	1(g)	7.5x6.5x4.		NA		DPSK	300
Sunrise	MOSCAN II	K-CRT	1	5.5x10.x8.5 (d)		6.		NA	3175
Teletype	MODEL 40	MP	2	5.5x10.x10.	5.5x10.x10.	20.	20.	PSK	1200
Xerox	Mobile Printer	MP	1	9.5x8.5x15.4		16.		FSK	2000

NOTES:

Column 3

K-CRT. Keyboard-CRT type display
S. Status-canned message only
MP. Mobile printer
K-P. Keyboard-printer display
(a.) Plasma type display
(b.) Add-on to existing K-CRT unit

Column 4

(c.) component units are physically attached
(g.) replaces control head

Column 5

(d.) sloping front

Column 7

(e.) total-both components

Column 10

(f.) estimate-due to ambiguity in decimal to binary conversion

NA- not available

Figure 3 (Continued)

1	2	3	11	12	13	14	15	16	17
Manufacturer	Model	Type	Input Power (watts-dc)	Input Voltage (volts-dc)	Input Current (amps-dc)	Ground Polarity	Output Impedance (ohms)	Input Impedance (ohms)	Points of Connection (h)
Motorola	"MODAT II"	K-CRT(a)	NA	NA	NA	pos. or neg.	NA	high	disc. ch.act mic. DC p.t.t.
Motorola	VP-100	MP		13.6 ±20%	standby .25 print 1.4	neg.		high	disc. ch.act. mic. DC p.t.t.
R.C.A.	PDH-1	S		12. ±NA	.8	neg.	50	1M	disc. DC mic. p.t.t.
Sunrise	MODCRT II	K-CRT	35.	12.6 ±10%		pos. or neg.	NA	high	rf ch.act. mic. DC p.t.t.
Teletype	MODEL 40	MP		13.8 ±20%	standby .5 operate 4.5	NA	low	1M	disc. ch.act. mic DC p.t.t.
Xerox	Mobile Printer	MP	standby 2.6 print 30.	13.9 ±20%	standby .22 print 2.5 ave. 10. peak	pos. or neg.		100K to 1M	disc or spkr. DC

NOTES:

Column 3

K-CRT. Keboard-CRT type display
S. Status-canned message only
MP. Mobile printer
K-P. Keyboard-printer display
(a.) Plasma type display
(b.) Add-on to existing K-CRT unit

Column 17

(h). Multiple wire connections are usually made in some areas

mic. Microphone input
p.t.t. Push to talk
input- to key transmitter
output- to initiate digital i.d. which accompanies voice

Column 17 (continued)

ch.act. Output connection to sense channel activity
DC. Battery connection
disc. Discriminator

NA - not available

Figure 3 (Continued)

1	2	3	18	19	20	21	22	23	24	25
Manufacturer	Model	Type	# of function keys (i)	Source Code	# char./prnt. displayed/spd.	Temp. (°C)	Humidity	Shock	Vibration	Price (j)
Motorola	'MOSAT II'	K-CRT(a)	10	NA	32 char.	-30 to +60	NA	NA	NA	$2495
Motorola	VP-100	MP		5x7 dot matrix	12 char./sec.	-30 to +60	NA	NA	NA	$1175
R.C.A.	PDH-1	S	10	2 out of 5		-30 to +60	NA	NA	NA	$915
Sunrise	MOSCAN II	K-CRT	5	own format	32 char.	-30 to +50	0-100%	suitable for hard mounting	suitable for hard mounting	$2095
Teletype	Model 40	MP		7 bit ASCII	120 char./sec.	-30 to +60	95% @ 50°C	20g (EIA)	EIA	$1300
Xerox	Mobile Printer	MP		5x7 dot matrix	28 char./sec.	-30 to +60	5-95% rel. hum.	NA	EIA RS-204	$1100

NOTES:

Column 3

K-CRT. Keyboard-CRT type display
S. Status-canned message only
MP. Mobile printer
K-P Keyboard-printer display
(a.) Plasma type display
(b.) Add-on to existing K-CRT unit

Column 18

(i.) does not include messages afforded by thumbwheel-type devices

Column 22

non cond. - non condensing
rel. hum. - relative humidity

Column 25

(j.) unit price

NA - not available

Figure 3 (Continued)

1	2	3	4	5	6	7	8	9	10
Manufacturer	Model	Type	Mobile Components	Size of terminal unit HxWxD (in)	Size of add'l. unit HxWxD (in)	Weight of terminal unit (lbs)	Weight of add'l. unit (lbs)	Modulation Technique	Data Rate Bits/sec.
Atlantic Research	Arcom	K-CRT(a)	2	3.8x4.8x10. (d)	4.x15.x12.	4.	10.	FSK	600
Coded Communication Corp.	Reporter II	S	1	3.x8.x8.		less than 10.		FSK	400
E-Systems	Digicom 10	S	1	7.8x4.7x4.7		5.		FSK	300
E-Systems	Digicom 300	K-CRT	1	8.2x11.2x16.3 (d)		17.		FSK	300
E-Systems	Digi Printer 310	MP(b)	1	10.x5.x11.		7.		FSK	300
I.B.M.	IBM 2976 Model 4	K-P	2(c)	9.8x11.8x9.8 (d)	4.2x11.8x19.	45.(e)		FSK	2400
Kustom	MCT-10	K-CRT(a)	1	10.2x13.5x9.8 (d)		17.		FSK	1300
Kustom	Printer MP-10	MP(b)	1	6.x5.x10.		5.		FSK	1300
Motorola	"PCDAT I"	S	2	2.2x6.2x4.8	2.2x10.x12.	3.	10.	MULTI TONE FSK	75(f)

Figure 3.

was accomplished through discussions with 16 law enforcement agencies. These agencies were located in the East (6), Midwest (6), and West (4), and included city (9), county (5), and state (2) organizations. These jurisdictions had either purchased mobile digital terminals for test and/or operations, or intended to do so. Thirty topics were discussed, and the discussion points are summarized in Figure 2, using percentages to tabulate responses.

A determination of the possible applications for this type of equipment was accomplished next. As the mobile terminals are used on FCC authorized voice channels with present day FM transceivers, compatibility with typical channels and existing transceivers is paramount. A review of possible problem areas was conducted. Propagation conditions, such as skip, ducting, and multipath, affect digital equipment performance as they do other operational communications equipment. In fact, skip can be more of a problem in digital transmission than it is in voice systems, which employ tone-coded squelch techniques to protect against this type of interference. Ambient noise, such as produced by automobile ignition systems, usually has a more adverse effect on digital transmission than on voice communications. Digital systems must combat these problems in order to operate in a reliable manner.

Digital transmission via telephone lines can also be a problem, as many leased lines are of the unconditioned type, perfectly adequate for voice but inadequate for digital signaling at rates above 1000 to 1200 bits per second. This is due to many factors such as ambient noise, crosstalk, amplitude and phase versus frequency distortion. The transmission of digital data via a voting receiver compounds this problem because of the switching transients that occur when the system switches from one receiver to another and the notch filter characteristics which cut out part of the audio response in order to control the voting receiver. The switching transient problem can be overcome by locking onto one receiver during the data burst and inhibiting voting during this period, or by the design of burst error correcting codes to ride through the votes. However, the signal attenuation and the phase versus frequency distortion caused by the notch filter response of the voting receiver are not affected by this action and will continue to be a problem.

Misaligned or improperly tuned FM transceivers can also introduce attenuation and distortion into the channels used for digital communications as can the wide tolerance used on the high end of the transceiver limiter filter. While the technique of attenuating the high frequency components improves voice communications by achieving better quieting, it degrades the quality and transmission rate of digital data signaling.

In order to avoid as much distortion as possible, most digital equipment interface with the transceiver at the discriminator. This technique allows the de-emphasis filter and the audio amplifiers to be bypassed. Fixed or adjustable equalizers can be used to compensate for distortion due to poor audio band frequency response. If the transceiver involved has a tone-coded squelch capability, the digital data tones can be eliminated from the transceiver speaker by inhibiting the tone control during data transmission. This will reduce or eliminate the noise heard by other units who are not receiving the digital message.

Data on mobile digital terminals being offered for law enforcement use are shown in Figure 3. Details of 15 models from 10 manufacturers are listed, showing characteristics such as size and weight, modulation technique employed, data transmission rate, printing speed, and cost. For example, the data transmission rate for status terminals varies from 75 to 400 bits per second, while terminals with a one-way capability receive at 800 to 2000 bits per second. Two-way terminals transmit and receive at rates from 300 to 3125 bits per second. The printing speeds for terminals using printers varies from 12 to 120 characters per second, and terminal costs vary from $691 to $3750 each.

Those characteristics recommended for consideration as performance standards are listed in Figure 4. This

RECOMMENDATIONS FOR STANDARDS

- Environmental Characteristics
- Operating Life
- Radio Interface
- Primary Power
- Message Transmission Time
- Source Code
- Data Rate
- Modulation Technique
- Keyboard Configuration
- Display Sizes
- Display Characteristics

Figure 4.

listing will be the basis for additional work as these standards are developed by NBS for the NILECJ.

During the study effort, it became apparent that digital communications are being accepted by the law enforcement community as a valuable addition to their communications capability. The advantages offered include increased transmission speed, the ability to handle a greater volume of communications, and an inherent security against message interception. Digital techniques can be used to transmit status only for one-way transmissions or for a two-way, full text capability similar to a computer terminal. The law enforcement applications described in the report can be satisfied by the equipment presently available. Those characteristics recommended for standardization emphasize user requirements and should provide performance levels which will enhance the law enforcement application.

END