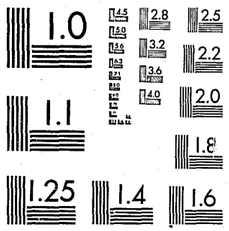

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FINAL PROGRESS REPORT

Voice Recognition Over Radio

Reference

Contract No. 6-0815-J-LEAA
SCOPE Job No. 6214

Submitted

December 1970

SCOPE ELECTRONICS INC.
A Subsidiary of SCOPE Incorporated
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SCOPE ELECTRONICS INCORPORATED
Reston, Virginia 22070

VOICE RECOGNITION OVER RADIO

Final Progress Report

REFERENCE
Contract No. 6-0815-J-LEAA
SCOPE Job No. 6214

Submitted
December 1976

Prepared by _____
G. J. Moschetti
Principal Engineer

Approved by _____
J. Glenn
Manager, Voice Products Group

1.0 OBJECTIVE

The objective of this contract is to test and evaluate the performance of voiced computer data entry and synthesized voice response over a standard police radio network using the Scope Electronics Inc. (SEI) Voice Data Entry Terminal System (VDETS). Suitable results under this contract would permit future efforts for demonstrating and evaluating the feasibility of using voice data entry and synthesized voice response to communicate directly with law enforcement computer facilities. Successful demonstration of this capability would then make it possible for field officers to make direct queries to crime information files without operator intervention and for field unit status and other call-for-service related information to be computer processed and automatically displayed to dispatcher personnel or entered into a computer-aided dispatch system.

2.0 WORK PERFORMED UNDER THIS CONTRACT

The work performed under this contract involved:

- Interfacing SEI's VDETS to SEI supplied transceivers operating at the same frequency as the District of Columbia SOD radio network.

- Interfacing SEI's VDETS to the District of Columbia Metropolitan Police Department (DCMPD) radio network.

- Developing the VDETS software required for testing the accuracy and reliability of voiced computer data entry and synthesized voice response over the above standard police radio network.

- Testing and evaluating the accuracy and reliability of voiced computer data entry and synthesized voice response

first at the SEI facility using the SEI supplied transceivers then at the DCMPD facility using the DCMPD radio network.

2.1 Audio Interface

A block diagram of the VDETS system configuration is shown in Figure 1. The standard voice input device of the VDETS is a high quality noise canceling dynamic boom microphone. Therefore, it was necessary to modify the front end of the VDETS to accommodate the two way radio networks. The appropriate impedance matching networks and voice in/voice out switching logic components were incorporated in the VDETS front end hardware and tested to verify proper operation. Since the function tones at 2250 and 2325 Hz were not present in the radio networks utilized under this contract, notch filtering of these tones was not necessary in the VDETS front end modifications. Also, a spectrum analysis of the 127.3 Hz squelch tone indicated that most of the tone energy was outside of the VDETS front end frequency band pass, as such, not causing distortion of the voiced input frequency information. Consequently, no provisions were made in the front end for notching the squelch tone. Schematic diagrams of the SEI transceiver and DCMPD radio network interfaces are shown in Figures 2 and 3 respectively.

2.2 VDETS Software

The VDETS application software program written and debugged under this contract uses the digits 0-9, the phonetic alphabet and the control words "READY", "ATTENTION", "COMPUTER", "RELAX", "CANCEL", "CORRECTION", and "OVER" as its dictionary. After user vocabulary training, the program requires the spoken entry of a 10 character alphanumeric data string. Upon recognition of the 10th character a synthesized voice verification transmission consisting of the 10 characters recognized by VDETS is provided to the user.

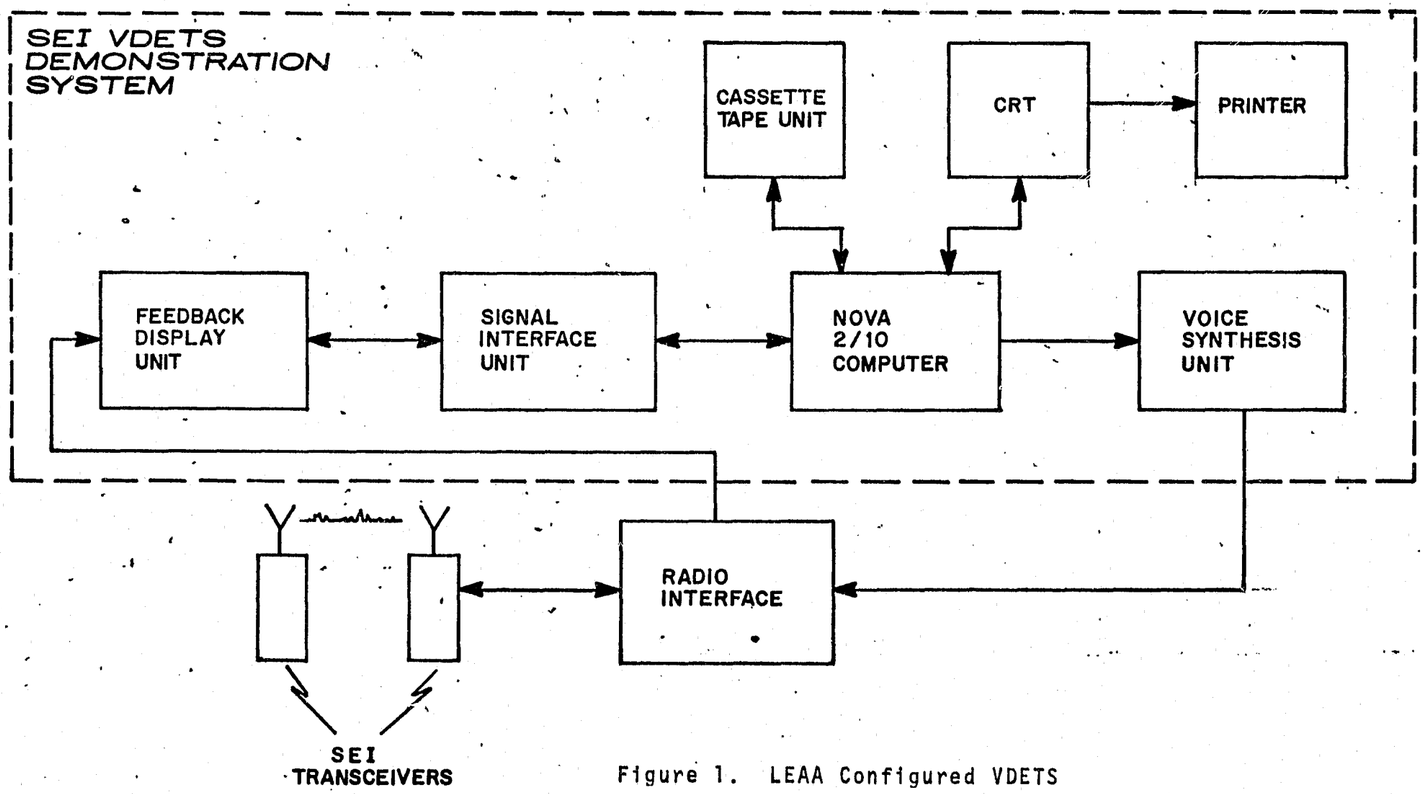

Figure 1. LEAA Configured VDETS

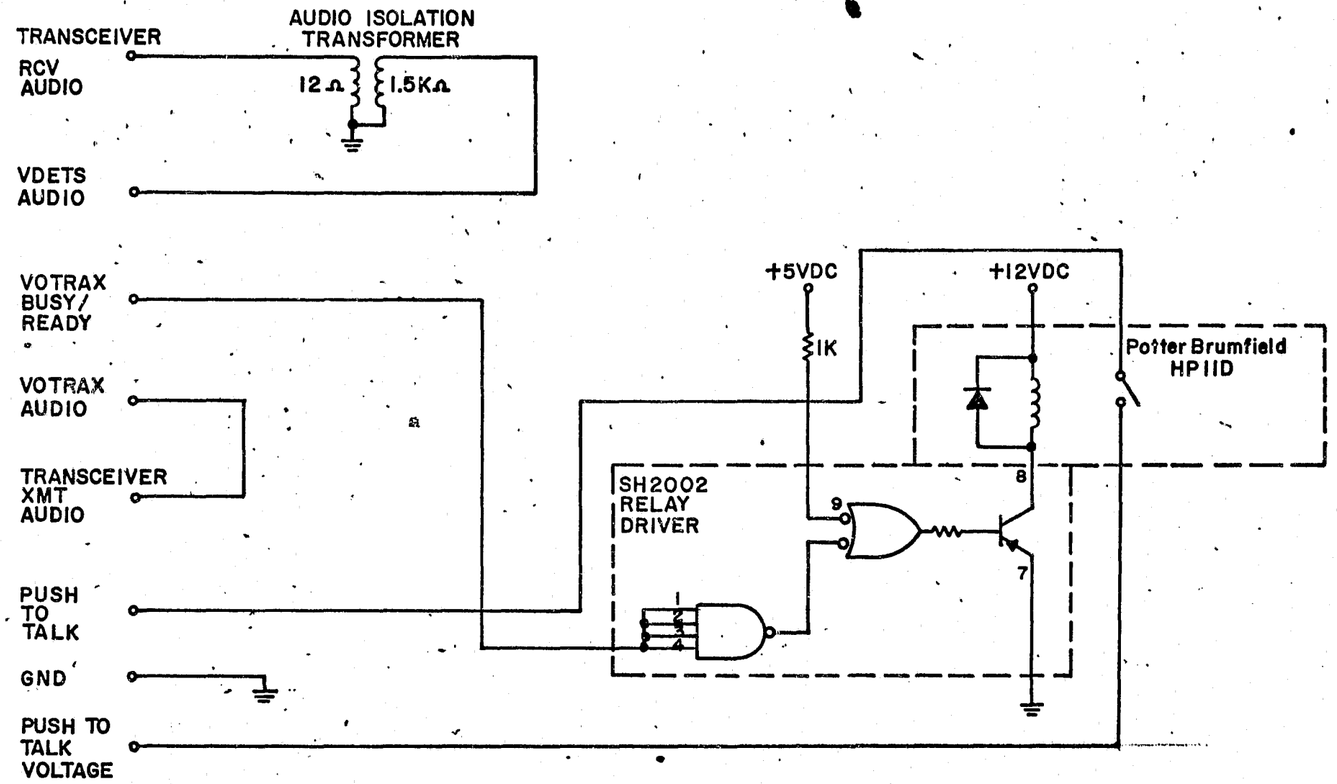

Figure 2. SEI Transceiver/VDETS Interface

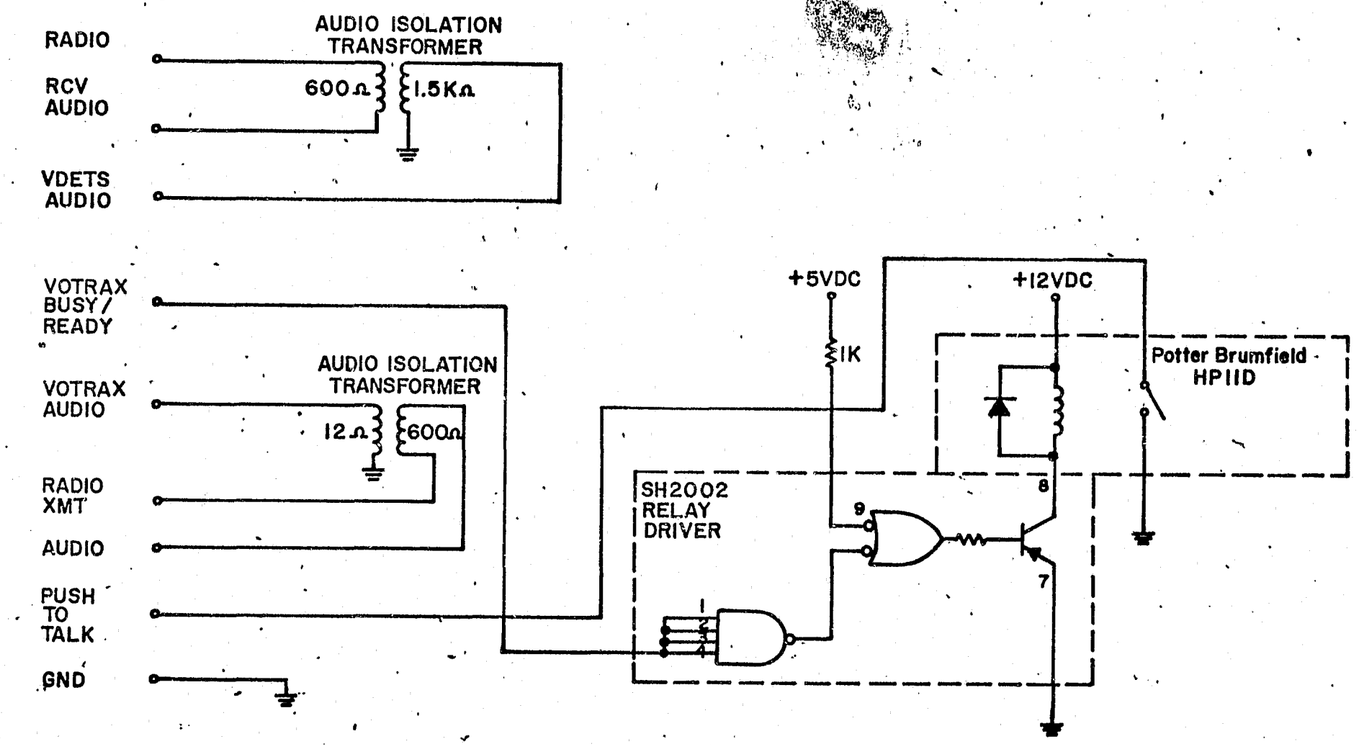

Figure 3. DCMPD Radio Network/VDETS Interface

Following the verification transmission the user indicates the correct recognition of the 10 character string by speaking the control word "OVER" or the incorrect recognition of the 10 character string by speaking the control word "CORRECTION". The control word "CORRECTION" allows for correcting recognition errors by repeating the 10 character string. In cases where difficulty arises in the attempt to correct a string or an incorrect string is spoken by the user, the control word "CANCEL" eliminates the 10 character string. The 10 character recognition sequence continues until terminated by the user speaking the control word "RELAX". This places the VDETS system in idle mode and disregards all further audio inputs except the control words "READY", "ATTENTION", "COMPUTER". When this three word sequence is recognized, the 10 character recognition sequence is activated. The relax feature also provides for "locking out" from the VDETS all communications on the two-way radio network that are not pertinent to the specific function of the system. All of the 10 character strings spoken by the user including those recognized correctly, those recognized incorrectly and those cancelled by the user are recorded on the VDETS CRT and printer for evaluation and analysis. The program provides the capability of permitting the user to reinforce his vocabulary training with a single pass of the dictionary to accommodate changes in his voice patterns. The program also provides the capability to retrain any single dictionary word. Upon initialization of the system, the program provides system operating instructions on the VDETS CRT.

2.3 Testing

The initial testing of the LEAA configured VDETS was conducted by several SEI users with the standard VDETS microphone input device to establish a bench mark for the two way radio testing specified under this contract. Ten or more alphanumeric character strings were spoken by each user. The recognition results were recorded and evaluated to verify the normal high recognition accuracy rate

of the VDETS in the LEAA test configuration. Following the initial testing, the two way radio testing was conducted at the SEI facility using the SEI provided transceivers interfaced to the LEAA configured VDETS. The same SEI users that participated in the microphone input testing spoke ten or more alphanumeric character strings over the two way radio interface at various distances from the receiver unit and the recognition accuracy results were recorded. Then Sgt. Peacock of the DCMPD received familiarization training in VDETS operation at the SEI facility. Upon completion of this training task, the LEAA configured VDETS was transported to the DCMPD headquarters where it was installed and prepared for testing in the police radio network environment. The system remained at this location for approximately one week. During this time Sgt. Peacock and SEI personnel tested the LEAA configured VDETS in the police radio network environment using both mobile and portable radio equipment. The results of this testing and all other testing conducted under this contract and the problems encountered during the testing phases are discussed in the following paragraphs. At the conclusion of this testing phase, the operation of the system was demonstrated by Sgt. Peacock and SEI personnel for S. S. Ashton, Jr., NCJISS; Inspector Ellis, DCMPD; Mr. B. Doerle, DCMPD and other DCMPD personnel.

2.4 Test Results and Problems Encountered

A radio interference problem severely hampered the progress of the testing phase at the SEI facility. Because the transceivers of the LEAA configured VDETS operated at the DCMPD SOD radio frequency, SOD radio transmissions interfered with the operation of the system during testing. A radio interference test was coordinated with Inspector Ellis and Sgt. Peacock. The tests verified that the SEI transmissions from the SEI facility in Reston, Virginia were not received by the SOD radio network at the DCMPD while the SOD radio transmissions were received loud and clear by the SEI transceivers. Consequently, SOD radio transmissions frequently overpowered SEI

radio transmissions resulting in uncertain user vocabulary training and test results. Only a limited amount of testing could be conducted at the SEI facility because of the interference. Transmissions from outside of the SEI building were virtually impossible. Most of the testing was ultimately conducted in an rf shielded room at SEI where outside radio transmission could not get through to the system. Therefore most of the testing was done from within 50 feet of the system. The limited valid testing at SEI indicated a good probability of success in testing at the DCMPD facility where superimposed radio transmissions would not be encountered. The results of the SEI facility testing are summarized below.

INPUT DEVICE	USER	TEST NO.	NO. OF STRINGS	NO. OF UTTERANCES	% CORRECT STRINGS	% CORRECT UTTERANCES
VDETS	J. Glenn	1	39	195	95	99
Microphone		2	57	285	95	98
	D. Fink	1	20	220	90	99
Two-way	J. Glenn	1	22	242	32	91
Radio		2	9	99	22	91
		3	17	187	65	96
		4	17	187	65	94
	D. Fink	1	12	131	50	94
		2	19	209	84	98
		3	19	209	89	99
		4	12	132	42	89

Note: 1. All two way radio testing was done from within 50 feet of the system except D. Fink test 4 which was done from the SEI facility parking lot; approximately 1500 feet from the system.

2. All two-way radio testing encountered DCMPD radio interference except when operated in the screen room.

As anticipated the superimposed radio transmissions were not a problem at the DCMPD test facility. However, several days of testing resulted in unsuccessful operation of the system due to the highly variable signal-to-noise and spectral profile characteristics of the police radio network. These conditions created unreliable system training and test results. Therefore, after demonstrating the operation of the system, as mentioned above, the testing phase was concluded and the system was returned to SEI.

3.0 CONCLUSIONS AND RECOMMENDATIONS

The conclusions and recommendations based on the results of this contract are contained in a letter to Mr. Robert Sohn from SEI dated 21 October 1976. A copy of the letter is included in this report.

Concurrent

SCOPE ELECTRONICS INC.

21 October 1976

Mr. Robert Sohn
Jet Propulsion Laboratory
156-223
4800 Oak Grove Drive
Pasadena, California 91103

Dear Mr. Sohn:

Under LEAA Order No. 6-0815-J-LEAA SCOPE Electronics Inc. has conducted a series of experiments in which our commercial Voice Data Entry Terminal System (VDETS) was interfaced for operation over uhf FM radio channels, including the District of Columbia Police Department's radio network. A final report summarizing test procedures and results is now in preparation. The results, briefly, are as follows:

(1) VDETS operated with high recognition accuracy under clear channel laboratory conditions characterized by high signal-to-noise ratios and a lack of interfering transmissions.

(2) VDETS performance over the radio links fell off rapidly as transmission distances (and noise levels) increased.

(3) Successful operation over the D. C. Police radio network was not achieved.

Two factors contributing substantially to the disappointing over-the-network results were:

(1) The process of data collection was severely limited by almost continuous transmissions on the radio frequency selected for testing.

(2) During testing at the D. C. Police Department, SCOPE technical representatives were informed that the radio network being used exhibits highly variable signal-to-noise and spectral profile characteristics.

The scope of the contract under which the aforementioned tests were performed did not allow for remedial engineering to correct operational deficiencies noted. Thus no attempt was made to modify the commercial VDETS unit for operation over the radio channels. However, the channel conditions encountered indicate that successful operation of the voice recognition equipment will require significant redesign of the recognition logic to match

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the police radio network. The attachment outlines an engineering program designed to modify the VDETS speech recognition components for operation under signal conditions typical of the police radio network. In order to minimize requirements for time on the police network, a recorded voice transmission data base will be collected. These data will then be utilized in SCOPE's laboratories to develop recognition logic optimized for use on the police radio network.

Budgetary estimates for the costs of the tasks in the engineering program are as follows:

Task 1 - Measure First Order Effects	$ 7,404
Task 2 - Characterize Radio Network	$10,222
Task 3 - Record Voice Data	$10,211
Task 4 - Determine Network Impact	$18,076
Task 5 - Optimize Recognition Model	$36,153
Task 6 - Test New VDETS Logic	$10,211
Task 7 - Final Report	$ 7,671

Due to the nature of the work to be performed, we believe that a cost plus fixed fee contract would be the appropriate vehicle for pursuing the engineering program. If you desire a formal quotation, please contact either myself or Mr. Wally Birdseye at (703) 471-5600.

Sincerely yours,

James W. Glenn
Research Scientist

JWG/mbf

Encl: As cited

cc: S. S. Ashton, Jr.
Wally Birdseye

RECOMMENDED ENGINEERING PROGRAM

Phase I - Problem Characterization

Task 1 - Measure First Order Effects Through VDETS Simulation (2 months):

Using a very simple first order model of the radio network, e. g. a variable signal power level at the receiver, the effects on VDETS performance will be examined via a computer simulation of the recognition logic. Data specifying the radio model will be supplied by the Jet Propulsion Laboratory. The effect of the variable parameter on VDETS recognition logic will be measured by creating a comparable signal condition for input to the recognition simulator located at SCOPE's Reston facility.

Task 2 - Characterize the D. C. Police Radio Network (2 months):

The purpose of this task is to characterize the radio network in terms of those signal parameters that are expected to significantly effect performance of the speech recognizer. Included in the characterization will be signal-to-noise measurements and spectral profiles taken as a function of both time and spatial parameters. Some of these data are known to be available within the police department at present and will be utilized to the maximum extent possible. However, additional empirical data directly related to parameters of the voice recognition equipment will be collected as needed. It is anticipated that a limited geographic segment of the network will be selected initially for detailed characterization. This segment will then be utilized as the vehicle for testing technological developments expected to yield improved recognition performance. The characterization obtained will permit modelling of the network signal conditions in a laboratory setting so that an active development program can be carried out without mutual interference with D. C. Police Radio Operations.

Task 3 - Collect Over-the-Network Voice Data (2 months):

A significant problem encountered during initial tests conducted over the radio network was the presence of interfering transmissions that severely limited the time available for on-line experimentation. To overcome this problem, it is proposed to initially establish a tape recorded voice data base that is representative of the range of signal conditions to be expected on the radio network. This will require the cooperation of the D. C. Police Department, and will entail "clear channel" availability for a time period, or set of time periods, totalling approximately 20 hours. Data developed during Task will be used to ensure that the recorded conditions are typical of both "average" and "extreme" signal conditions to be expected on the network - at least for the selected test segment. The recorded data base will be digitized in SCOPE's laboratories and will be utilized as input to an existing computer model of the voice recognition logic that is designed to permit parameter optimization for various recognition tasis. Once the voice data base has been recorded, it will be

possible to proceed with the development program without further interference with D. C. police radio operations, and without being subject to sporadic channel availability.

Task 4 - Determine Network Impact on Recognition Model (2 months):

A computer model of the recognition components of the Voice Data Entry Terminal System has been implemented on SCOPE's PDP-10 Time-Sharing computer. This model has been utilized in the past for the purpose of VDETS technology development and for the development of specialized recognition logic matched to physiological conditions typical of high performance military aircraft. The model is supported by a 9600 baud data link that permits the development of digitized voice data bases from either "live" or recorded speech data. The tape recorded voice data obtained under Task 2 above will be digitized and stored as data files in the PDP-10 computer. Once stored, these data will be "played" against the computer model so that the performance of various recognition parameters can be studied to determine the effects of the varying signal conditions characteristic of the police radio network.

Phase II - Solution Development

Task 5 - Optimize Performance to Match Radio Network (4 months):

Parameters of the model will be systematically altered to optimize recognition performance under the range of signal conditions experienced. At any point in the development, it will be possible to calibrate recognition performance by playing the digitized voice data against the current version of the optimized VDETS model.

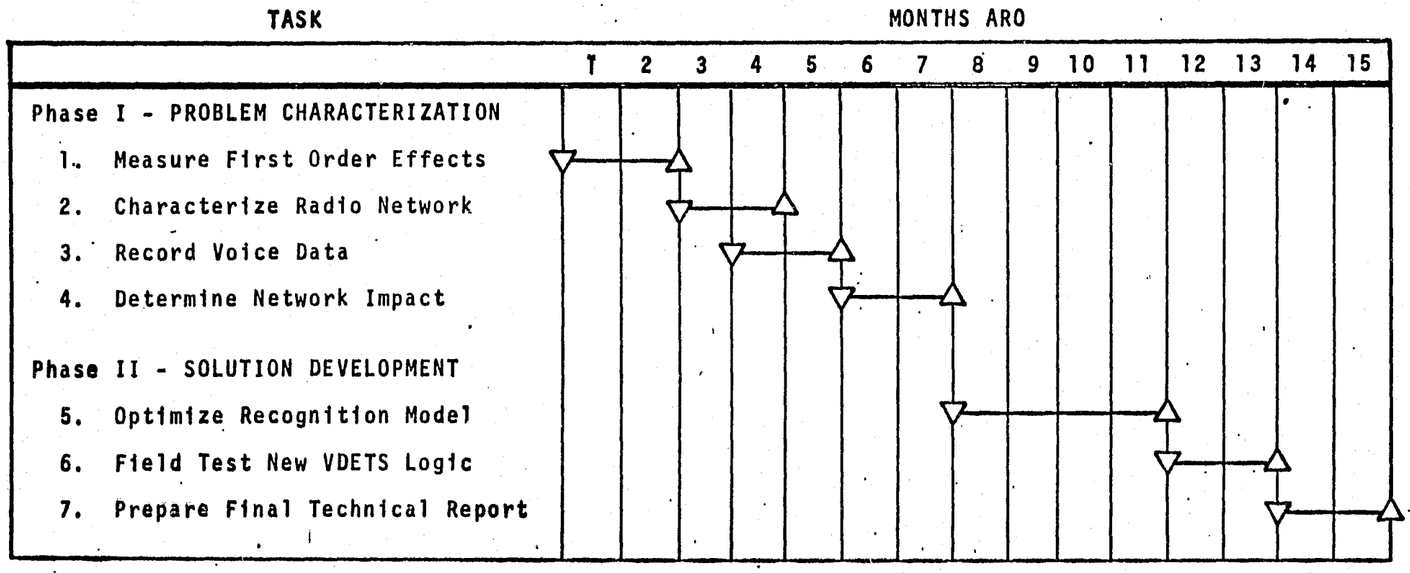
Task 6 - Test Optimized VDETS Logic (2 months):

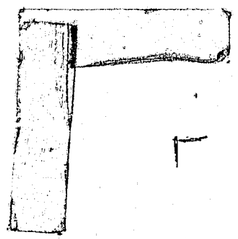
When acceptable performance of the optimized computer model is attained, the resulting logic will be transferred to the VDETS unit for performance measurement under on-line, real-time operating conditions. The new logic will be tested first in the laboratory, using the tape recorded voice data, and then in the field, interfaced directly to the D. C. Police radio network.

Task 7 - Prepare Final Technical Report (2 months):

All procedures, experiments and data will be documented in a final technical report.

MILESTONE CHART FOR LEAA VOICE RECOGNITION DEVELOPMENT





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