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ABSTRACT

This volume describes the development and implementation of a two-way interactive cable television communication system and its effectiveness in urban administration. The full report is contained in Volume II (see related document), and the computer program documentation is in Volume III, Michigan State University-Rockford Two-Way Cable Project: Minicomputer System Software. The 4-year project in Rockford, Illinois, tested the minicomputer-controlled interactive instruction capability of two-way cable against more traditional learning situations during a 12-lesson course in prefire planning administered to the city's fire department. Included here are a comprehensive account of the experiment, a description and discussion of the two-way technology and its performance, a cost analysis for the training program, and the public policy implications of the project. (Author/RAO)

VOLUME I

SUMMARY

MICHIGAN STATE UNIVERSITY-ROCKFORD TWO-WAY CABLE PROJECT

System Design, Application Experiments and Public Policy Issues

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FINAL REPORT

NSF Grant No. APR75-14286

Department of Telecommunication
Michigan State University
East Lansing, Michigan

June 1978

Contributing authors to this volume also include: James Wright, Stevens McVoy, John Pachuta, Nicky Stoyanoff, Michael Sheridan, Jayne Zenaty, Eric Smith, Michael Gorbutt, Robert Yadon, Michael Wirth, Judith Saxton.

Acknowledgements

It will be impossible to acknowledge all persons who have contributed to this project. However, it is essential to name a few.

Rockford Mayor Robert McGaw and Aldermen Lee Shervey, Michael O'Neal, Joseph Gustitus, Robert Cross and Victory Bell were initiators of the project and have supported the work through the four years.

The Rockford Fire Department is remarkably innovative. The Department has been a willing and enthusiastic partner to Michigan State University. Chief James Cragan, Deputy Chiefs Doug Bressler, Robert Quist, Paul Patton, and John Jung, Dominic Gugliuzza, Richard Connell, Howard Stewart, Ronald Graw, Vincent Collins, Nancy Johnson, Marge Coonradt, to name only a few, have been most helpful. We are also sincerely grateful to the 208 firefighters in Rockford who participated in the experiment. They were very patient with the tests and waves of questionnaires. The men of Station Number Seven, outside the cable service area, worked with us in the formative evaluation stages, responding to pretests and commenting on the initial videotape of each lesson.

Rockford Cablevision, Inc. assumed a major burden and a good deal of the risk in making the system work. Earl Hickerson, President, committed capital and personnel to the two-way communication system. The original engineering of the system was carefully and imaginatively designed to accommodate two-way services, long before the industry understood and accepted two-way. James Wright was primarily responsible and worked very closely with the Michigan State University staff through the entire project. John Bowers, James Thomas, Frank Sheley and Dean Deyo also worked closely with the project staff.

Crucial engineering support was provided by Stevens McVoy of Coaxial Scientific Corporation. His concept of an area multiplexed, switched return system was vital to the Rockford experiments and has been an important factor in the industry-wide renewed interest and development of two-way cable. Allen Fulmer also made major contributions to the system design and function. Tim Dunning was a principal troubleshooter for the system.

The Michigan State University field office in Rockford was responsible for the research, writing and production of the 12 television lessons and the administration of the experiment. These tasks were accomplished exceptionally well by John Pachuta, the Field Director, and Michael Sheridan, the Executive Producer. Television graphics were ably provided by Karyl Bauman. These people may take credit for the teaching effectiveness of the videotapes and the favorable response by the firefighters. Large scale field experiments are always difficult to manage. The fact that this one went relatively smoothly is attributable to the diligence of this staff and their effective liaison with the Rockford Fire Department.

At Michigan State University, several students in the Mass Media and Communication Ph.D. programs and in Computer Science were major contributors. Jayne Zenaty became the principal computer programmer, wrote much of the technical and computer sections of this report and was responsible for the computer documentation in Volume III. She also coordinated the medical education demonstration for the National HURA (Health in Underserved Rural Areas) Conference. Nicky Stoyanoff coordinated the pretesting and formative evaluation used in the planning of the videotapes, and in the experiment, the instrument design and collection and analysis of data. Lee Thornton did much of the background research for the firefighter training experiment and was responsible for a number of suggestions that were incorporated in the design. Robert Yadon helped to write some of the technical papers on the project and worked on future applications and technology. He also worked with Mike Wirth who was responsible for the basic research on costs and the cost analysis. Jim Wollert and Brian Fontes worked tirelessly on the original design proposal and followed up on the exploration and development of additional applications of the two-way technology. Judith Saxton was one of the researchers on public policy issues. Jack Wakschlag and Mark Miller both were active participants in the experimental design phase of the project. Michael Gorbutt was one of the designers and the builder of the timecode interface and video switcher controller.

Dennis Phillips began the system design and computer programming for the project while the equipment was still in East Lansing. Eric Smith also worked on the system in East Lansing and moved with the equipment to Rockford to complete the computer programming and testing after installation. He also created the programs to accommodate the University of Michigan two-way experiment in the Rockford Public Schools.

Robert Schlater, Chairman of the Telecommunication Department, and Erwin Bettinghaus, Dean of the College of Communication Arts and Sciences willingly accepted the additional administrative burden associated with such a large project, and found the means to compensate for the loss of faculty and graduate students to the project. John Abel and Donald Montgomery, Michigan State University faculty members, were invaluable to the project at crucial points, while they were on campus. Kent Gustafson, of the Michigan State University Instructional Development and Telecommunication Services unit, served the project well as a consultant in the instructional design area. Sanford Lenchner, a co-investigator in the earliest Michigan State University-NSF cable study, bears a major responsibility for the staff interest in broadband communication. He introduced a number of concepts that were further developed in this study.

In addition to her other duties, Becki Henry kept the books, handled personnel matters and travel and did the manuscript typing. These tasks were immensely complicated by the fact that the project staff was in two locations, separated by 300 miles, and in several departments of the University.

Richard Howe of the Michigan State University Contract and Grant Administration office was always helpful in properly caring for fiscal matters.

WKAR-TV at Michigan State did the studio and post production television. Richard Brundle worked closely with the project producer. Jackie Denn took good care of production details and provided the necessary continuity from tape to tape. The presentor on the 12 videotapes was Craig Halverson. Other voices heard on each of the instructional tapes were Colby Lewis and Catherine O'Connor.

We are deeply indebted to the National Science Foundation for the opportunity to conceive, design, implement and evaluate an entirely new telecommunication system. We believe the NSF program was imaginative and bold in its concept and plan. The program administration through Allen Shinn and Charles Brownstein was in every way supportive.

The spouses, children, friends and colleagues of the members of the staff made continuous sacrifices to the project. We thank them.

Introduction and Abstract of Findings

This volume describes the development and implementation of a two-way interactive cable television communication system and its effectiveness in urban administration. The full report is contained in Volume II, titled *Michigan State University–Rockford Two-Way Cable Project: System Design, Application Experiment and Public Policy Issues*. The computer program documentation is in Volume III, *Michigan State University–Rockford Two-Way Cable Project: Minicomputer System Software*.[1]

The four-year project in Rockford, Illinois, tested the minicomputer-controlled interactive instruction capability of two-way cable against more traditional learning situations during a 12-lesson course in prefire planning administered to the city's fire department. Included here is a comprehensive account of the experiment, a description and discussion of the two-way technology and its performance, a cost analysis for the training program and the public policy implications of the project.

Research Results Summary

We believe the research reported here supports the following conclusions:

(1) Digital return communication from the feeder lines is feasible in a single cable system.

(2) A switching system is effective in limiting return system noise and signal ingress.

(3) De-ingressing the system for return communication improves system performance in both directions.

(4) No extraordinary system maintenance is required for two-way communication if the system is properly designed at the outset.

(5) Two-way interactive cable instruction is more effective than comparable one-way television in teaching cognitive information. The two-way advantage in learning remains after six months.

(6) Two-way interactive television, where respondents have individual response capability and personal feedback, is more favorably assessed than one-way television and is considered equal to live instruction by the participants.

(7) Automated, prepackaged two-way cable television is administratively more efficient and reliable than one-way television systems for record keeping.

(8) The cost of two-way television, in most circumstances, is lower than auto-tutorial or lecture methods.

(9) Two-way cable television is more expensive than one-way television, but in large scale training systems, the difference in dollars is very small.

(10) The cost of prefire planning as a collateral duty of all firefighters trained in building survey and preplanning is much less than the cost of prefire planning by full-time specialists.

(11) Large cable systems (10,000 subscribers or more) are more likely to find two-way service profitable.

(12) The cost of *operating* a two-way cable system is more likely to impede initiation of two-way service than cost of *construction*.

(13) The potential for public service use of two-way cable services place a major burden on franchise authorities and cable systems in determining when to implement two-way service.

(14) The responsibility of the franchise authority in two-way cable may extend to development and aggregation of public services, particularly in public safety and education and in monitoring upstream spectrum allocation.

Origins of the Michigan State University–Rockford Project

This project developed in response to the National Science Foundation intent to "support a series of social experiments in the application of two-way cable telecommunications to the delivery of urban social services and to urban administration." (1) Phase I was to design application experiments; Phase II, to carry out experiments selected from the design submissions. Rockford, Illinois was chosen as the site because the cable system had been engineered to accommodate two-way cable and the city government was very much interested in public service applications.

In the design study, five applications were submitted by Michigan State University as the most promising for developing the two-way cable system technical design and exploiting the two-way capability in pressing social and urban administrative needs. Of the five experiments designed under the original grant, the firefighter training application was selected for funding.

1. Both available from the Department of Telecommunication, Michigan State University, East Lansing, Michigan 48824. The material in all three volumes is based upon research supported by the National Science Foundation under Grant No. APR75-14286. Any opinions, findings and conclusions are those of the authors and do not necessarily reflect the views of the National Science Foundation.

A Developmental Model for Two-Way Cable Technology

In responding to the National Science Foundation's commitment to experiments in public service applications of two-way cable technology, we recognized an obvious need to fit the firefighter training experiment into a larger developmental context for two-way cable. Therefore, we created a systematic model which carefully times and integrates the technical capability of various broadband communication systems with economically viable communication applications on a step-by-step evolutionary basis.

Since the early speculation about broadband communication development, the two-way technology has not evolved as a synthesis of practical need and cost-efficient technology. Two-way experiments and developmental planning have tended to focus on an end-state technology; in particular, a high cost addressable terminal. In the model described below, each generation represents small technical steps in the evolution of existing cable technology and service provision. Costs of each step are covered by revenues or benefits accruing from services at that step.

A typical CATV system resembles a tree, with a network of trunk cable and trunk amplifiers delivering signals from the transmission center (headend) to bridger amplifiers. These amplifiers then transfer the signal to a system of feeder amplifiers. The feeder system delivers the signal to the tap-off units, and then by service drops into the subscriber's home.

In a two-way cable system, signals pass "downstream" from the headend and "upstream" from the subscriber location to the headend. Two-way communication on a single cable requires filters to separate the downstream and upstream signals and a separate set of amplifiers for each direction.

The cable industry in the United States is now convincingly demonstrating the demand for pay movies and other entertainment. The *first generation* of our developmental pl[illegible] includes technology for per-program pay television. To achieve the per-program pay television in this generation, we rely on an "area multiplexing" scheme that combines frequency and time division multiplexing. Modified channel converter terminals in the feeder branch are assigned individual frequencies in groups of up to 200. Each group is associated with a digitally controlled code operated switch, which passes signals upstream as the switch is opened. A community of households, each identified by its terminal frequency and code operated switch, can be scanned by a minicomputer in a matter of seconds. If the set is tuned to a pay program, the information is recorded for billing purposes. This technological generation also accommodates the monitoring of other devices such as smoke and intrusion alarms.

The *second generation* in this developmental model adds an interactive response capability to the terminal. A transmit device permits use of a push button type converter for digital responses as well as channel selection. The additional cost of this capability is low enough to accommodate computer-managed instructional programs which include multiple choice questions. The computer can be programmed to provide a character-generated downstream display of participant responses, question-by-question and cumulatively.

The *third generation* in the system evolution adds a microprocessor chip and read-only memory (ROM) storage. This permits the terminal to perform multiple functions, e.g., the monitoring of utility meters. For electric utilities, the system would offer time-of-day metering, making possible discrimination between energy consumption in peak and off-peak generation periods. Pricing incentives could then be used to encourage consumption in the off-peak periods.

Finally, in the *fourth generation*, we would add low cost memory storage in the terminal or the code operated switch. At this stage it is possible to "page" a portion of a data stream for local, home television display. On-demand catalogs, self-paced questionnaires, on-demand lessons and electronic newspapers are potential applications in this generation.

The firefighter training experiment is in the second generation of the developmental model.

Firefighter Training and the Two-Way Lesson Format

Standardized training, with an interactive component, came up frequently in our investigation of the potential applications of two-way cable. The need for training and retraining in government and the social services is great. In some instances, this is because of the high turnover of personnel and in other cases because of the complexity of tasks and changing technologies. In most situations, cost factors, work schedules and other administrative considerations suggested prepackaged instruction.

In firefighting, daily training is the routine. Two-way cable television can bring live or packaged training programs by well-prepared specialists to the firefighter in his station house and provide an opportunity for response and reinforcement. For volunteer firefighters, the training can take place in the home at convenient times.

In Rockford, advanced training is carried out in two ways: (1) in station houses with instruction by self-teaching materials and company officers and (2) at the Training Academy which is specially equipped with training laboratories and materials. Training at the Academy risks underprotection in the district when trainees are removed from their stations, or adds the cost of overtime pay.

Much of the training takes place on the job as the firefighter moves up in responsibility, as new knowledge is developed and new equipment is acquired. Training Officers in the fire service have one of the more complex training tasks in industry or government. Firefighters generally work 24-hour shifts. Activities are always broken up by fire and emergency calls. Special off-duty days, vacations and sick days complicate the training and record keeping activities. Training by company officers in the station house is dependent on the confidence, ability, training and administrative capability of the company officer. Standardization is difficult to achieve.

Pre-packaged videotape with two-way interaction and reporting could standardize the training, focus attention on the training materials because of the necessity to continuously respond and provide the training officer with an instant record of who participated in the training exercises and who needed to be rescheduled for make-ups. New materials could be created for two-way training or existing training materials could easily be adapted to two-way instruction.

Prefire planning was selected as the topic for the experimental instruction. Prefire planning is an activity designed to provide the firefighter with a logical and systematic plan for identifying and classifying potential fire problems. This allows the firefighter to carefully formulate, in advance, a tactical plan for a given building, in the event a fire occurs. The plans may then be continuously studied in training sessions and taken to a fire, should one occur. The task of prefire planning is a complex process which draws upon the firefighter's previous training and experience. It represents a task facing all fire departments.

Interactive Training

The firefighter training application seemed to optimize the potential benefits of two-way training from a central location to remote locations.

In creating the interactive system, we made a number of assumptions about the value of the interaction. These assumptions dealt with specific learning and administrative components, as follow:

Attention and participation. Interactive items, spaced throughout the instructional programs, would force participation and help to keep the trainees alert and attentive.

Motivation. Awareness that each response would be fed back individually and in aggregate scores at the end of the lessons, and that hard copy records would be made, would serve to keep trainees motivated to create a good record.

Feedback. Reinforcement would be provided by the feedback at each step of the instruction.

Competition. Since station or individual scores could be compared, competition would maintain interest and motivation.

Teasing. On occasion, interactive items could be used as teasers to lead into a new segment of instruction. Firefighters would have to guess or rely on previous experience. This technique would heighten interest in learning the material.

Pacing. The interactive question format would serve to break up the television lecture-demonstration format and revive interest.

Drill. Frequent repetition of prefire planning symbols and other material would aid recall. Quizzes would provide a summary and review.

Administration. The interactive system, including a log-in procedure, frequent interactive questions and computer printout of results, would improve training system administration and reduce administrative costs.

The Two-Way Lesson Format

With these hopes for two-way training, keeping within the technology which we had available, the format described here was devised and used throughout the television series.

One-half hour before each lesson a pre-program sequence of character generated displays began. These are illustrated below:

Pre-Program Sequence

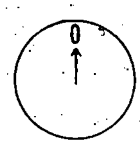
PROG 9 - "PERIMETER SURVEY"
STARTS AT 1:30 FOR
STATIONS 1, 2, 4 AND 6.

TODAY IS BOB QUIST'S BIRTHDAY.

REACH BARRY MCGEE ON CB CH. 19

TO OLD FIREFIGHTERS, WHAT WAS A "SPIDER?" (ANS. AT 2:30)

BULLETIN
. . . . WATCH THIS CHANNEL FOR HY



(blue field)

Display #1: The normal character generated display for a day on which a lesson was scheduled consisted of an announcement of the next program time. Added to this were more personalized items dealing with the audience members. Birthdays of firefighters were announced along with information phoned in by the audience. Occasionally, quiz questions were asked dealing with firefighter history, sports, trivia, etc. It was also possible to utilize the bottom line of the display for a longer message which would "crawl" across the screen from right to left.

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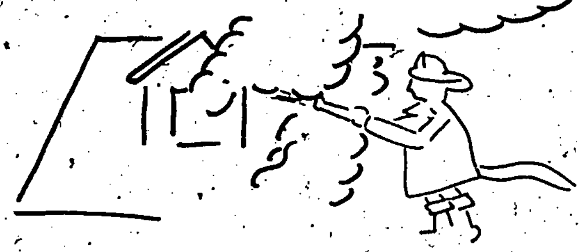
(musical background)

PLEASE STAND BY FOR
THE PREFIRE PLANNING PROGRAM.



PROGRAM STARTS IN
5:00 MIN.

Display #2: Twenty-two minutes later, a countdown tape informed the men that only five minutes remained before they would be required to log-in. The time at the bottom changed every 30 seconds to keep the audience updated. Music was played under the countdown. The slides over which the message was placed consisted of Rockford scenes and firefighting equipment.

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(blue field)

MSU/NSF/RFD PROJECT
LESSON #9 ENTER CODE LETTERS

STA	CODES LOGGED IN					
1	CAA	CAB	CAC	CAD	CAE	CAF
	CAG	CDA	CDB	CDC	CDD	CDE
2	AAA	AAB	AAC	AAD	ADA	ADB
	ADC	ADD				
4	BAA	BAB	BAC	BAD	BDA	BDB
	BDC	BDD	BDE			
6	DAA	DAB	DAC	DAD	DAE	DAF

Display #3: Five minutes later, the log-in started. The log-in, in effect, registered the participants for the lesson. The firefighters were given five minutes to enter their code letters into the two-way system. As an additional signal to begin the lesson, the words "ENTER CODE LETTERS" were flashed during the entire log-in. The maximum number in the audience for any lesson was 35, distributed as in the above example. As soon as the code was received, it was displayed on the television screen. The time given was ample for all stations to log-in. This time could be reduced to two or three minutes in future training.

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(red field)

LOG-IN PERIOD IS OVER

LESSON #9
PERIMETER SURVEY
WILL BEGIN MOMENTARILY

Display #4: After the log-in, the lesson announcement was displayed for approximately 15 seconds before the video tape started.

During the lesson, a question was asked for each major instructional point made, within every two to five minutes. These were usually visual questions with four answer options. The firefighters responded by depressing A, B, C, D, or E (can't decide) on the terminal and then the transmit button. As soon as a response was received for all codes logged in, the responses of each, by code, appeared on the television screens.

(blue field)

AAA	C	BDA	C	CDA	C
AAB	C	BDB	C	CDB	C
AAC	C	BDC	C	CDC	C
AAD	C	BDD	C	CDD	C
ADA	A	BDE	C	DAA	B
ADB	C	CAA	C	DAB	B
ADC	C	CAB	C	DAC	B
ADD	C	CAC	C	DAD	B
BAA	C	CAD	C	DAE	B
BAB	C	CAE	C	DAF	B
BAC	D	CAF	C	DAG	B
BAD	C	CAG	C		

Feedback #1: This type of feedback gave the audience the answer selected by each individual as identified by the code letters. This was used for the majority of the interactive items.

(blue field)

1 RESPONDED A
7 RESPONDED B
26 RESPONDED C
1 RESPONDED D

Feedback #2: This type of feedback gave the number selecting each option. It was used only occasionally to vary the feedback.

(blue field)

30% RESPONDED A
20% RESPONDED B
15% RESPONDED C
35% RESPONDED D

Feedback #3: Feedback like this was used for "challenge questions" which asked the firefighters to give opinions about information that had not yet been presented. It displayed the percentage selecting each option.

The feedback confirmed receipt of the answers and gave a view of how all others answered. If not all answers had been received in 30 seconds, those responses received to that point were printed. If an individual, or group, failed to respond to two consecutive questions, they were dropped and the computer thereafter read only the remaining codes for purposes of advancing the lesson. This was necessary because stations were sometimes called to a fire during a lesson.

After the display of answers, the system automatically returned to videotape and the narrator discussed the correct answer. The questions had been designed so that they represented small learning steps as in programmed instruction. The programs were designed to have a correct response rate of about 90 percent so that the learners would have consistent positive reinforcement. Over all the lessons, the average was 89.61 percent, with very few questions falling below the 80 percent level.

Occasionally, "challenge questions" were asked. These did not relate to information previously covered, but led into instructional material to follow. The object was to stimulate interest, teasing the learners into the next unit.

At the end of each lesson, a "quick quiz" reviewed the material presented in that lesson and prior lessons, particularly the prefire planning symbols. These questions were not paced by the participants, as were the interactive questions described above, but had a fixed five-second period for answering. After the quick quiz, the percent correct for each participant was printed on the screen.

(blue field)

QUIZ PERCENTAGE

AAA	100	BDA	100	CDA	80
AAB	100	BDB	100	CDB	80
AAC	80	BDC	90	CDC	80
AAD	100	BDD	100	CDD	80
ADA	100	BDE	100	DAA	100
ADB	90	CAA	80	DAB	100
ADC	100	CAB	80	DAC	100
ADD	100	CAC	80	DAD	100
BAA	70	CAD	80	DAE	100
BAB	100	CAE	80	DAF	100
BAC	100	CAF	80	DAG	100
BAD	100	CAG	80		

Feedback #4: After "quick quizzes," the character generator displayed the percentage correct for each individual.

After the quick quiz feedback was presented, the narrator reviewed the correct answers.

The lesson concluded with a character-generated presentation of the percent correct over the whole lesson, combining the quick quiz with all other questions.

(blue field)

LESSON PERCENTAGE					
AAA	100	BDA	100	CDA	80
AAB	100	BDB	90	CDB	80
AAC	75	BDC	90	CDC	80
AAD	95	BDD	100	CDD	80
ADA	100	BDE	100	DAA	95
ADB	80	CAA	80	DAB	95
ADC	100	CAB	80	DAC	95
ADD	90	CAC	80	DAD	95
BAA	65	CAD	80	DAE	95
BAB	100	CAE	80	DAF	95
BAC	95	CAF	80	DAG	95
BAD	100	CAG	80		

Feedback #5: At the end of each lesson, a total score was given which reflected the percentage correct for each individual over all of the interactive items and the quick quiz.

Participants also saw the percent correct for each shift of firefighters over all lessons to date. The last two types of feedback introduced an element of competition. After the lesson was concluded, a few minutes of relaxation for the firefighters was provided by interactive computer games.

(blue field)

SHIFT AVERAGES TO DATE					
AAA	95	BDA	91	CDA	93
AAB	93	BDB	85	CDB	93
AAC	81	BDC	87	CDC	93
AAD	92	BDD	100	CDD	93
ADA	100	BDE	78	DAA	88
ADB	89	CAA	91	DAB	88
ADC	94	CAB	91	DAC	88
ADD	90	CAC	91	DAD	88
BAA	78	CAD	91	DAE	88
BAB	100	CAE	91	DAF	88
BAC	93	CAF	91	DAG	88
BAD	95	CAG	91		

Feedback #6: The final feedback for each lesson was a display of the average score of each individual to that point in the series.

Immediately after each lesson, complete written reports on the lesson performance for each participant were produced on the line printer. This included an item-by-item response of each individual, by code letters, and the individual's final lesson score. Across the bottom of the report was the percentage correct for each item. This was followed by the scores on each lesson of the series to date for each individual and the average score for the series. This report, which was blank for each incomplete or missed lesson, was used to schedule make-ups.

Computer Functions

A special user-oriented computer language was developed for setting up the lessons in the computer. The parameters of each lesson were determined and stored—the types of questions, text of character generated messages, color backgrounds, nature of feedback, correct answers, etc. The times that specific operations were to be performed were also stored in the computer. During the lesson runs, the separately entered operations and timecodes on the videotapes were automatically coordinated by the lesson processor program, which controlled the entire administration of a lesson.

These operations include starting and pausing the videotape, switching to character generator, scanning the terminals for responses, generating feedback, restarting the videotape, aggregating scores and making printed reports. Once a lesson began, everything from the log-in through the final summary report was automatic.

Content Research

The content of the planning series was initially researched by performing three task analyses of prefire planning functions. The first two analyses were on prefire plan surveys for two buildings, a high rise apartment for the aged and an industrial complex. The final task analysis related to the post-survey steps in which a prefire plan is created from the survey material and put into use.

From the functions in the task analyses, a 12-lesson series was developed. It included the following programs:

(1) Pretest
(2) Introduction to Prefire Planning and Fire Protection Equipment, Part I
(3) Fire Protection Equipment, Part 2
(4) Building Construction, Part 1
(5) Building Construction, Part 2
(6) Vertical Structures
(7) Communications, Rescue and Salvage
(8) Hazardous Materials

(9) Perimeter Survey
(10) Posttest
(11) Post-Survey Steps
(12) Survey/Plan/Utilization.

The development of each program within the series included these steps:

(1) Preliminary research and outline
(2) Statement of behavioral objectives
(3) Development and administration of pretest on proposed content
(4) Script draft, review and revision
(5) Final script review and approval
(6) Location visual and graphics production
(7) Studio production and post-production
(8) Formative evaluation at Station Number Seven (outside the cable service area)
(9) Revision, final review and approval.

The programs were made in color on two-inch quad videotape and then dubbed to three-quarter inch cassettes.

Cable System Technology

The entire instructional system represents a combination of complex hardware and software. The hardware necessary to support instructional programs of this kind begins with a viable two-way cable television system: to which is added minicomputer-controlled video origination equipment. The software must coordinate the processing of a series of lessons, including control of all necessary video equipment and monitoring of student interactive response, in real time. The hardware and software configurations for the Rockford experiments were designed to accommodate the simultaneous administration of two different lessons over separate video channels.[1]

System Overview

The Michigan State University–Rockford digital-return, two-way cable communication system in the firefighter training experiment uses response pads designed by Coaxial Scientific Corporation at a small-quantity cost of $150 each. These terminals are much lower in cost than the $300 terminals used in most other systems. They are modified standard cable television channel converters (Jerrold SX-2). Each standard converter has 12 push-button switches and a three-position band switch, normally used for selecting up to 35 cable channels. The adapted converter has, in addition, a four-position response mode switch that can be set to the normal channel selection mode, or to one of three designated response channels. (Figure 1)

1. During the actual firefighter experiment, however, only one lesson was run at a time.

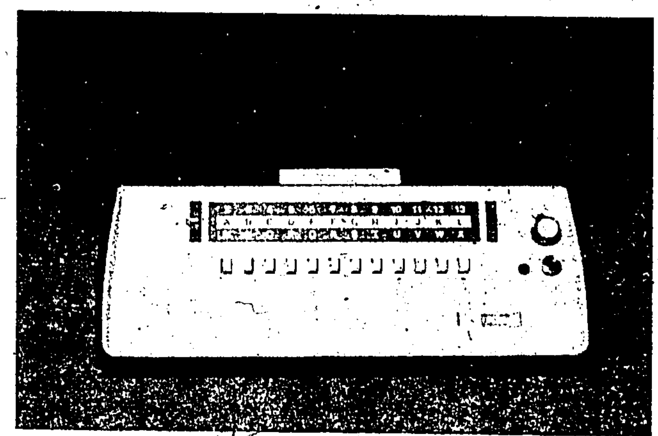


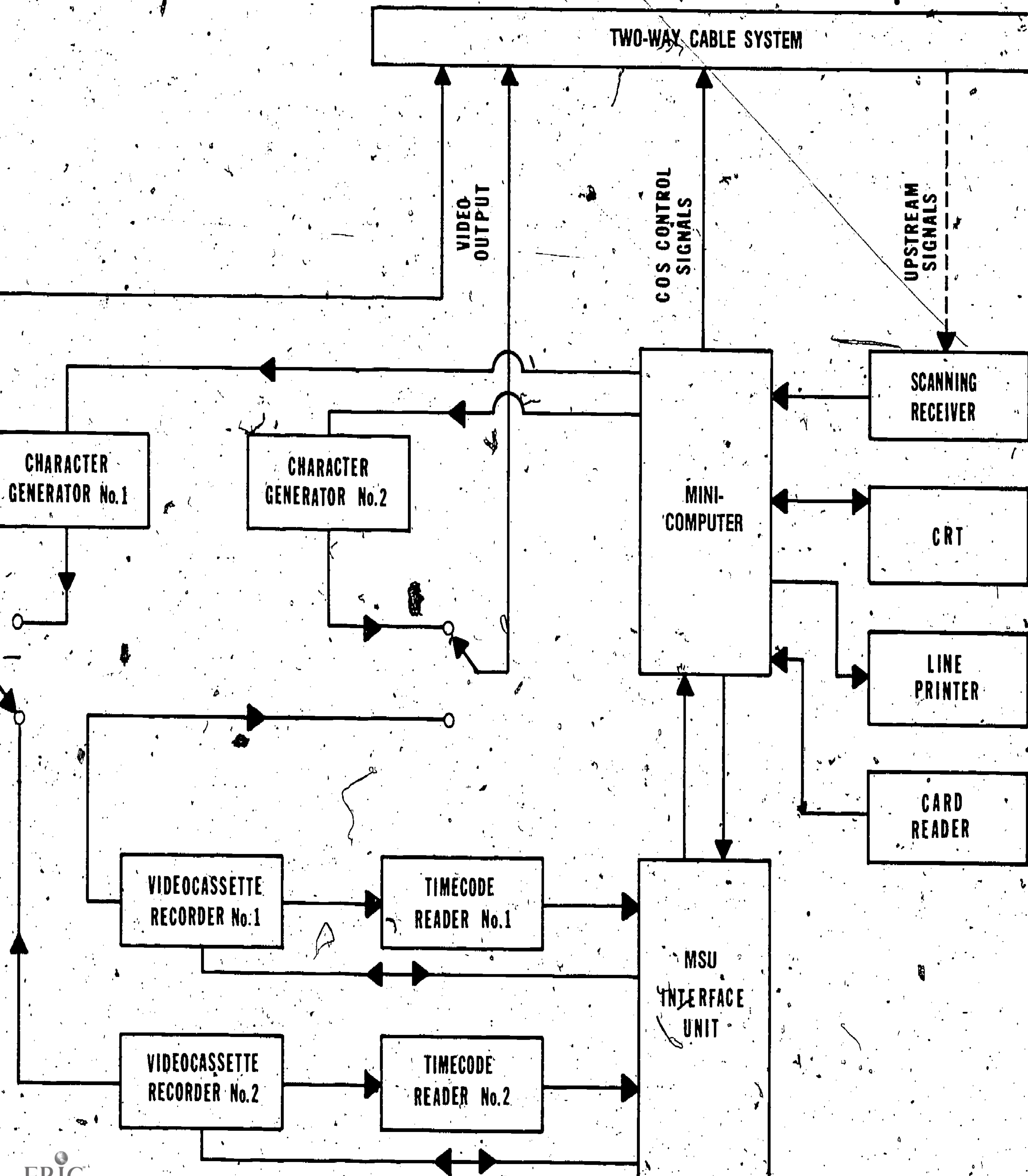
Figure 1. Response terminal. Modified Jerrold SX-2 channel converter.

When a response channel is selected, the 12 push-button switches and band switch function as an alphanumeric keyboard, whose symbols may be arbitrarily assigned (e.g., a template may be placed over the keyboard to provide specific operation instructions). The terminal's transmitter continuously sends a 16-bit data word to the computer-controlled receiver located at the headend. This data word reports the status of the keyboard and function switches, as well as other pertinent information. When a user wishes to transmit an upstream response, he or she depresses the corresponding push-button switch and then depresses the response transmit button. This sets a response bit in the data word for a short time, during which the response indicator light is illuminated.

In order to accommodate a large number of terminals, the cable network is accessed by the technique known as area multiplexing. In this technique, the network is divided into a number of primary sectors, each further divided into secondary sectors. The upstream signal from each primary and secondary sector is passed by digitally controlled in-line code operated switches (COSs). At any one time, the computer can scan a secondary sector of up to 200 terminals, addressed by selecting a combination of one primary and one secondary switch. Each terminal within a secondary sector has its own unique frequency. The computer-controlled receiver tunes in on this frequency in order to read the data word from the terminal.

The minicomputer which controls the system is a General Automation SPC-16/65 with 64K 16-bit word memory; real time operating system; 10 megaword disk storage; and necessary peripheral equipment, controllers and interfaces (Figure 2). An essential component in the headend hardware configuration is a timecode generator/reader, used to synchronize videotaped lessons with their corresponding computer interactions. The Michigan State University–

Figure 2. SYSTEM CONFIGURATION



Rockford system's Shintron 367 timecode unit communicates with the computer via a video interface module designed and built for the project at Michigan State University's Artificial Language Laboratory. For computer-generated text, the system uses a character generator which provides four different software-selectable color backgrounds. The computer also controls a video switch which selected either the video-cassette recorder/player or the character generator as the source of the outgoing video signal. Terminal data is collected using a transmitter and scanning receiver designed by Coaxial Scientific Corporation.

Upstream Response Transmission Equipment

The Michigan State University–Rockford Cable Project represents the successful application of the first and second-generation two-way cable technology described earlier. The Rockford Cablevision plant is a four quadrant, single, trunk line cable system. The upstream response subsystem consists of control devices at the cable system headend, primary code operated switches (P-COS), secondary code operated switches (S-COS), response terminals and test end-of-line oscillators (ELO). (See Figure 3.) The two COS's generate identification signals which are used to confirm their activation. These signals are transmitted to the cable system headend along with an FSK-modulated terminal signal and the ELO signal.

The Rockford system departs from usual system design in one important respect—the feeder cable upstream path passes only the 5 to 10.5 MHz spectrum, while frequencies of 12.5 MHz and above are attenuated by 25 db or more. The trunk cable passes the full 5 to 30 MHz, which includes the feeder data signals. This feeder cable bandwidth limiting, together with the technique of feeder switching developed by Coaxial Scientific Corporation, and quadrant switching, has brought electrical interference, short-wave signal intrusion and system amplifier-cascade noise down to manageable levels.

The minicomputer discussed above sequentially interrogates the response terminals in the field by (1) transmitting coded FSK (frequency shift keyed) signals at 112 MHz to addressable receivers located in the P-COSs and S-COSs, which select quadrant and amplifier, and (2) by tuning one-by-one through the various terminal FSK signals, identifying each terminal by its unique combination of COS, ELO and terminal frequencies.

All return signals from each quadrant, shown in Figure 4, are split to allow use of television Channels T-8 or T-9, and of non-switched data signals in the T-10 band to be used separately, while the switched feeder return signals are isolated by a 5 to 10.5 MHz low pass filter and routed to a diode switch operated by the minicomputer-controlled P-COS. A P-COS identifying tone is made to go through this switch as verification of its operation. Feeder-return diode-switch outputs from all quadrants are brought together (with only one "on" at a time), and after passing through a second filter and an amplifier, are fed to the FSK receiver.

At any instant of terminal interrogation, about 4,000 feet of feeder cable, 9,000 feet of trunk cable and 15,000 feet of subscriber service cable (i.e., 40 subscribers) are "on" and are a potential source of short-wave radio or electrical interference. The system is designed to survey only one quadrant of the plant at a time, which drastically reduces upstream, on-line interference from the remaining three quadrants. In addition, during this experiment, the amount of feeder cable and the subscribers-per-amplifier count were both low due to the "turning-up" of only enough amplifiers to create the desired return pattern. A normal fully operational amplifier would have about 8,000 feet of feeder and 65 subscribers with an ingress-exposure factor about twice as large.

The amplifier and S-COS configuration used in Rockford is shown in Figure 5. A Magnavox 4-MS-2 series amplifier was factory modified (1) to limit the feeder return to the 5 to 10.5 MHz frequency band, and (2) to include a feeder return disable capability which is accessed through the amplifier's unused seventh port. A modified COS incorporates the FSK receiver and addressable logic which provides the control voltage to the feeder return switch. This S-COS also injects a special frequency into the return path which functions for test and identification purposes. Finally, the terminal houses an FSK transmitter which is "on" all the time and which is modulated by activating any of several push-buttons, including the added transmit button, on the modified Jerrold SX-2. This causes a data word, which is also continuously transmitted, to change its content accordingly. The ELO is a test signal transmitter located at the end of the line. This signal is simply monitored for its presence and amplitude.

The Training Experiment

Experimental Conditions

The major manipulation in the field experiment was the presence or absence of a digital return capability, using terminals to initiate the digital return. This distinction will be referred to as the TWO-WAY and ONE-WAY conditions. Within each condition response modes were manipulated.

Figure 3. QUADRANT MULTIPLEXING

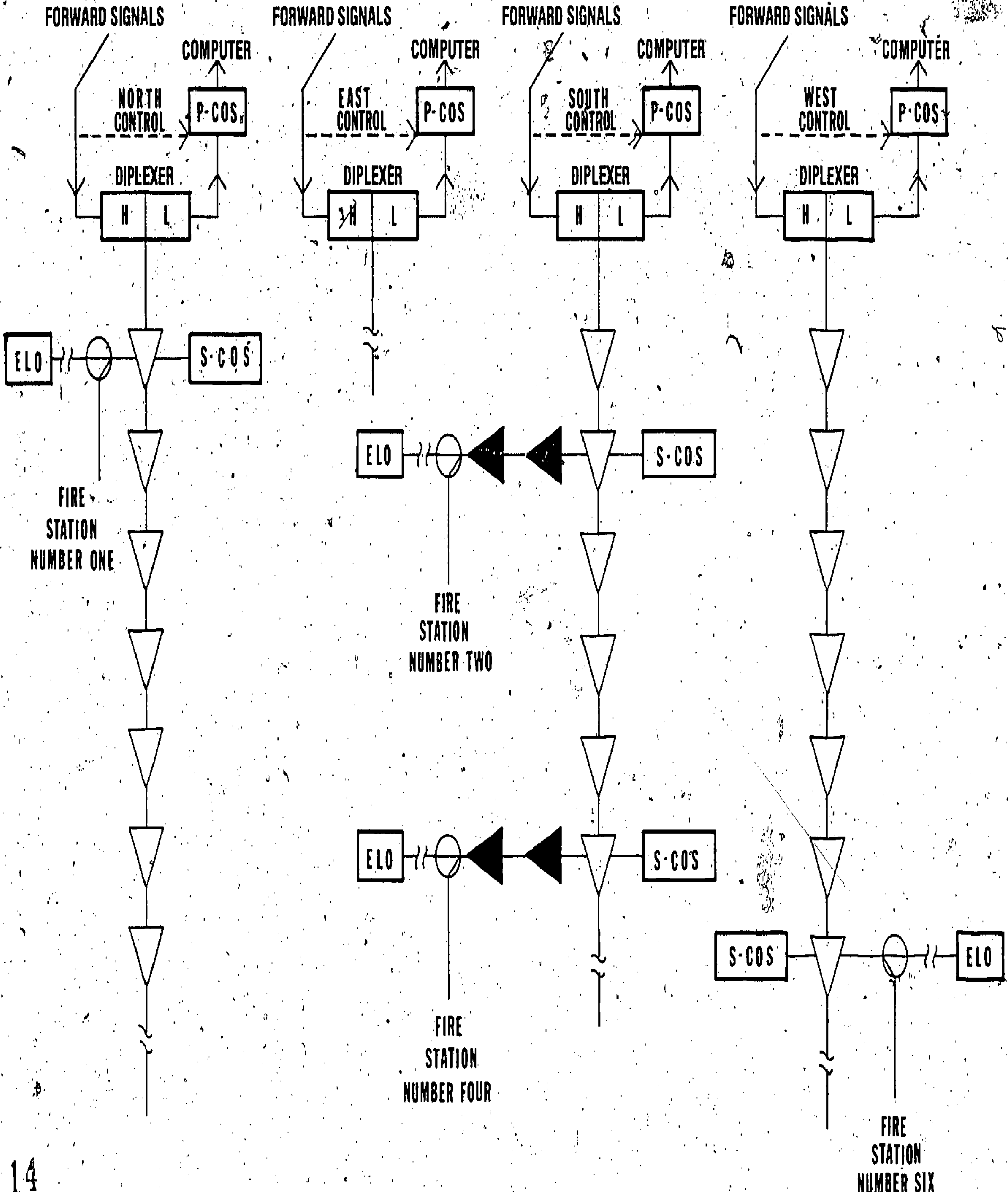


Figure 4. TYPICAL HEADEND RETURN CIRCUIT CONTROL

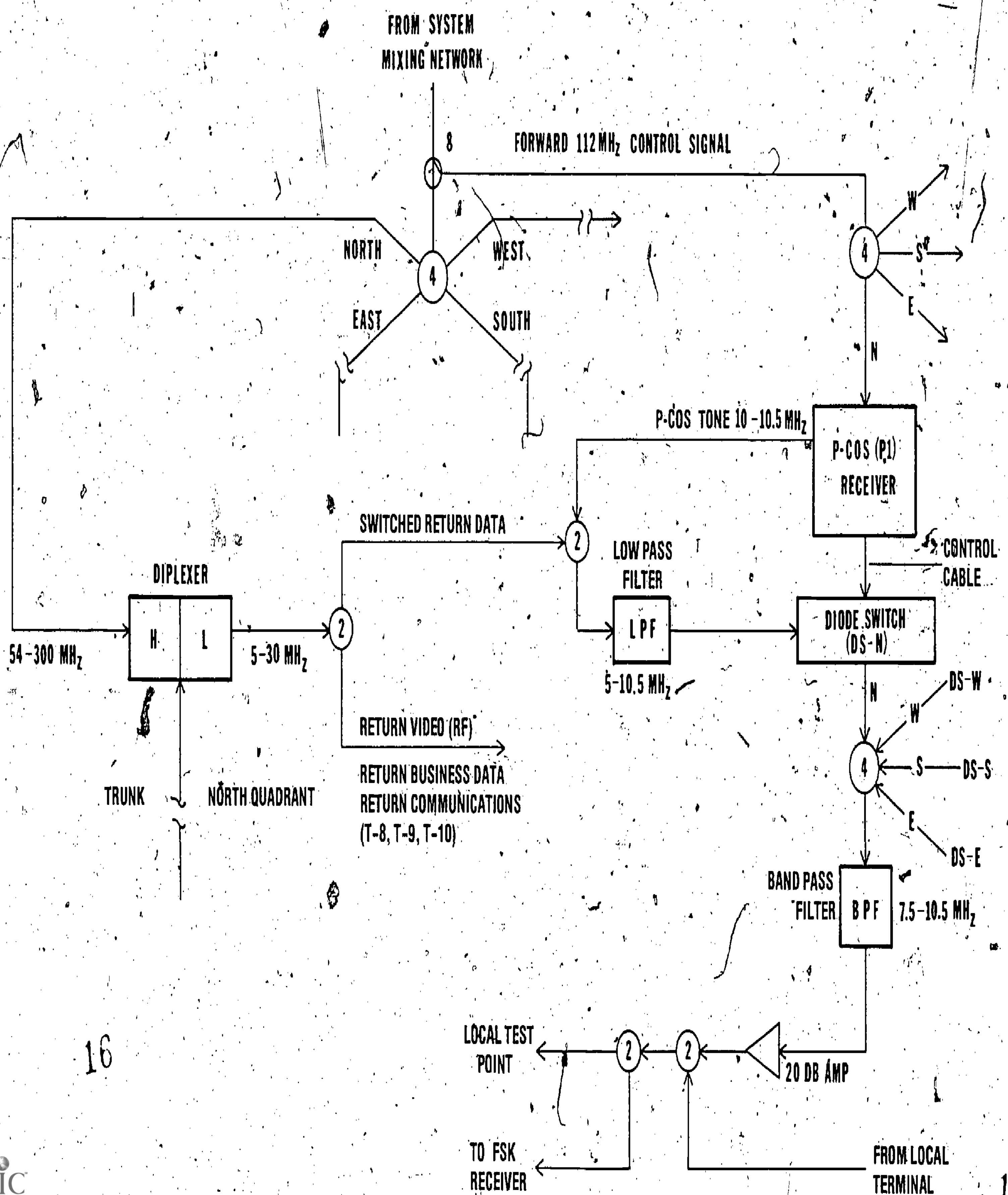


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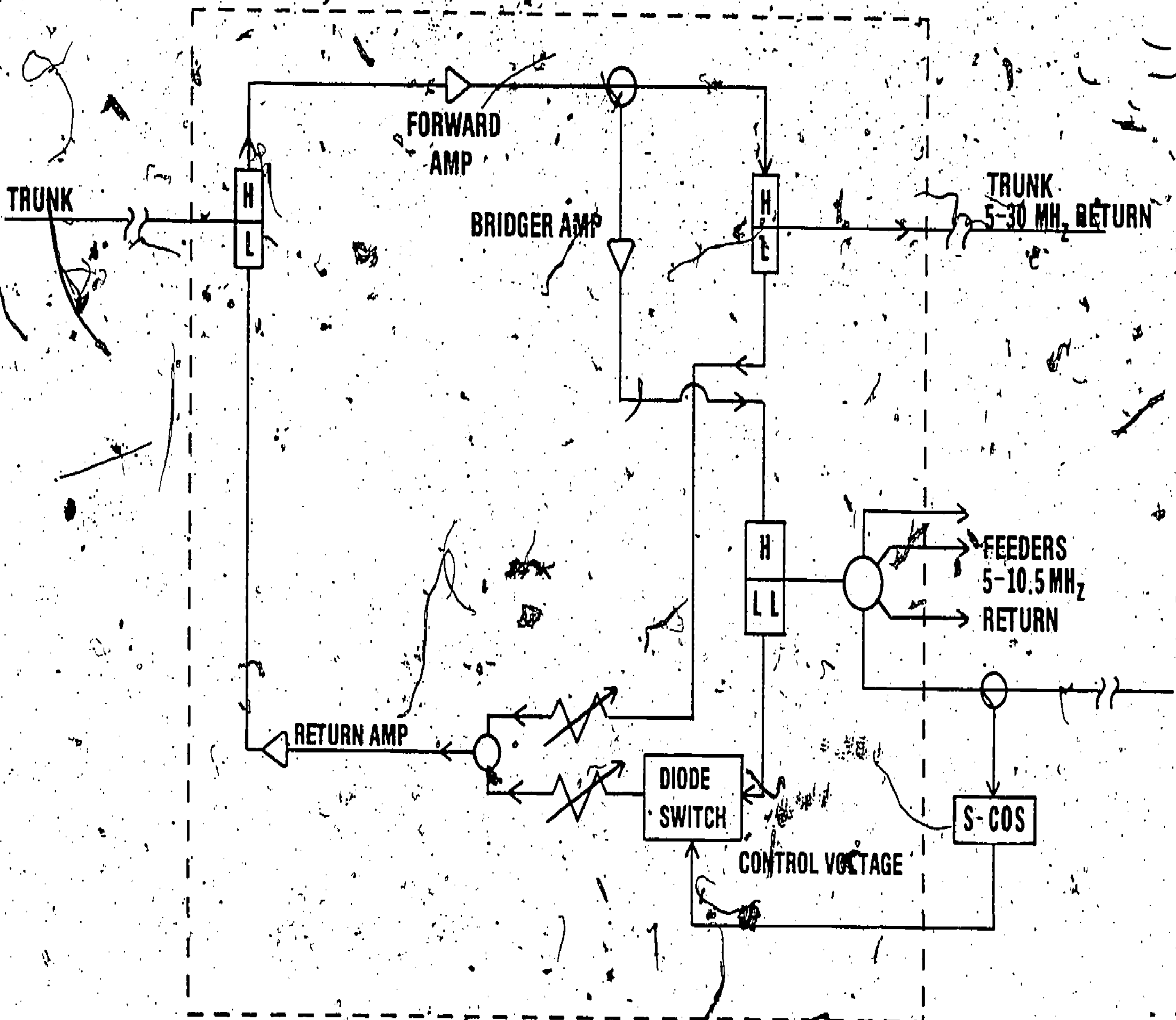
Figure 5. COS/AMPLIFIER STATION



In the two-way condition the two response modes were: (1) a two-way *individual* response treatment, which had one terminal for each participant; and (2) a two-way *group* response treatment in which one terminal served all the participants at selected viewing locations.

Within the one-way condition, the assigned response modes were (1) *paper and pencil* response, where each firefighter circled answer options on a prepared form, and (2) *covert* response, where participants were instructed to make a mental note of the answer. These interventions yielded the following experimental design:

Experimental Treatments

Two-Way Condition		One-Way Condition	
Group Response Treatment	Individual Response Treatment	Paper and Pencil Response Treatment	Covert Response Treatment

Two-Way Group Treatment

Participants (n=54) in this condition viewed the videotaped lessons in six groups, varying in size from 6 to 13, using one television receiver and one terminal per group (Figure 6). Each time a new lesson was viewed, a different group member operated the terminal: after all lessons, each person had operated the terminal at least once. Group members were encouraged to interact with each other about the content of the lessons and the interactive question during the presentation. When the group had reached a consensus as to the correct answer to an interactive item, the individual operating the terminal initiated the response by pushing the button on the terminal which corresponded to an answer foil appearing on the screen. After the responses from all participants in the two-way conditions had

Figure 6. Participants in the "two-way group" treatment.

been received, character generated feedback appeared on the screen in one of the three modes described earlier. The program was then switched back to the videocassette where the talent provided the correct answer.

During the "quick quiz" the group had only five seconds after the last option appeared to make a selection. Immediately thereafter the scores from the quick quiz appeared by code letter. After the quick quiz was discussed by the narrator, the total scores for the program, including the earlier interactive items and the quick quiz, were presented. This was followed by the cumulative score for the series to date for all two-way condition members of the participating shift. In all of the character generated feedback for the two-way *group* treatment the participant-group members within a station received identical information—scores or options selected.

Two-way Individual Treatment

Figure 7. Participants in the "two-way individual" treatment.

Participants (n=50) in this condition also viewed the video lesson in a group setting, but each participant operated his own terminal (Figure 7). Participants were encouraged not to talk with each other about the content of the lessons during the presentation, and to come to a solution to each interactive item independently. Once a solution had been reached, each participant entered his own response by pushing the appropriate terminal button. The feedback in this condition appeared on the screen by individual code letters. At each lesson's end, participants received character generated feedback reflecting their individual achievement on the interactive items.

Since both *individual* and *group* conditions participated in lessons simultaneously the feedback on the television screens was a mixture of code letters and responses or scores that represented individual and group behavior. The members of the group condition were able to show slightly better results on interactive items because responses represented a group consensus. The average score over all the lessons for participants in the group condition was 90.74; for individual conditon participants, 88.44.

One-way Paper and Pencil Response Treatment

In addition to viewing the lessons in a group setting, each participant in this condition (n=54) was given an answer sheet for the interactive items presented in the lessons. Participants were encouraged not to interact with each other about the content of the lessons during the presentation, and each participant independently responded to each interactive item presented. When an answer had been chosen, the participant was instructed to circle the appropriate foil on the answer sheet which corresponded to the foil presented in the lesson. The answer sheets were collected by the company officer after each lesson.

One-way Covert Response Treatment

Participants (n=50) in this condition simply viewed the lessons in a group setting. There were nine total groups which varied in size from four to eight men. While participants were asked to make a mental note of the answers to the interactive items, they had no opportunity to *formally* initiate any responses to any of the interactive items. Participants could judge how well they were doing on the series of interactive items by mentally comparing their answers with the answers provided by the narrator. However, at no time were the participants in either one-way treatment provided with feedback indicating how they fared on the series of questions and quick quizzes.

Instrumentation

Two types of measurement instruments were created to assess the effects of the manipulations:

(1) two **learning** instruments, which were designed to assess the relative comprehension and retention of specific information presented in the lessons, and

(2) two **affective** instruments, which were designed to assess the attitudinal orientation of the individuals participating in the experiment toward various aspects of their learning experience and viewing conditions.

The measurement instruments that were developed will now be described in detail in terms of objectives, development and administration.

The Pre/Post Test

To adequately assess how much immediate learning had taken place within each experimental condition, a pretest and a posttest were constructed which covered the building survey aspects of prefire planning (eight programs). A pretest consisted of 27, four-foil multiple-choice items, with one item tapping each of the 27 behavioral objectives developed for the lessons. These were 27 of 177 interactive items shown during the videotaped lessons. At the time when these 27 items were selected for the pretest, a set of 22 additional interactive items was also drawn from the 177 items used in the eight programs. These tapped 22 of the same behavioral objectives and were used as part of the posttest. A third set of items also was constructed; one item tapped each of the original 27 behavioral objectives developed for the stimulus. None in this final set of 27 items had been used as interactive items during the programs; they were designed to be equivalent to the other item sets in terms of content areas tested and degree of difficulty.

The posttest consisted of:

(a) the 27 items which appeared on the pretest,

(b) the 22 items drawn from the remaining set of 150 interactive items not appearing on the pretest, and

(c) the 27 equivalent items which tested material presented in the stimulus tapes, but which had not been used as interactive items.

The items were all transferred to a videotape format most closely resembling a long series of interactive items. This allowed for the simultaneous administration of tests to participants in all conditions. The pretest was administered one week after a three-week period of orientation given to all participants, describing the telecommunication system and other dynamics of the experimental design. The posttest was administered one week after the last of the eight videotapes comprising the prefire planning course was cablecast. This was approximately 18 weeks after the pretest had been administered.

For pre- and posttests, each participant was given a response sheet which contained the foils of the multiple-choice items in the tests. To respond to any item, the participant circled the letter on the response sheet which corresponded to the item foil.

The Follow-Up Instrument

To adequately assess how much information from the prefire planning course participants in each experimental condition retained over time, a follow-up instrument was constructed. This consisted of the 76 item posttest and the interactive items from videotape Program #11. These items were specifically created to assess knowledge about the post-survey prefire planning process. The follow-up test was administered to all members of the Rockford Fire Department approximately six months after the prefire planning course had ended.

Affective Instruments

Two measurement instruments were created to assess quantitatively the participants' attitudinal orientation toward various aspects of the overall experiment. First, a metric multidimensional instrument was constructed for assessing the participants' attitudinal orientation toward:

(a) the mode of instruction,

(b) the prefire planning content of the videotaped lessons and

(c) the profession of firefighting.

A second affective instrument was constructed to assess the participants' attitudinal orientation toward specific aspects of the viewing conditions.

Results

An analysis of variance of the results of the 27 item pretest indicated that there were no significant differences among treatments in the scores firefighters attained on the pretest. Each treatment scored an average of 16-17 items correct of the possible total of 27. However, at the time of the posttest, the groups differed significantly in their overall test scores. Table 1 shows the treatment scores for the entire posttest ranged from 64 to 69 items correct of the possible 76. All groups scored relatively high on the posttest, but the overall significant difference occurred in the comparison of firefighters in both two-way treatments with firefighters in the one-way covert response treatment. Firefighters in the two-way treatments scored significantly higher on the posttest than did firefighters in the one-way covert response treatment.

Separate analyses of variance were computed for each of the three sub-tests which comprised the overall posttest (also in Table 1). There were significant differences between firefighters in both two-way treatments and firefighters in the one-way covert response treatment in the scores they obtained on the set of 22 interactive items and the 27 non-interactive items. For these two sets of items, there were no significant differences between firefighters in the one-way paper and pencil treatment and firefighters in either two-way treatment. Furthermore, the table indicates that for the 27 interactive items which appeared on both the pretest and the posttest, there was a significant difference between the firefighters in the two-way individual treatment and firefighters in the one-way covert response treatment. For both the repeated and unique portions of the posttest then, maximum learning occurred among those in the two-way treatments and least learning in the one-way covert response treatment.

Table 1. Posttest Scores in 76 Cognitive Items by Treatment Groups

	Two-way individual (N = 47)	Two-way group (N = 48)	One-way paper/pencil (N = 54)	One-way covert response (N = 52)
Total for posttest[a]	69.02	68.60	66.31	63.85
Subtests				
1. 27 items from pretest[b]	24.84	24.52	23.88	23.22
2. 22 items from VT lessons[c]	20.09	20.33	19.20	18.75
3. 27 new items[d]	24.09	23.73	23.26	21.85

[a]The differences among treatments are significant ($F = 10.63$, $df = 3/197$, $p < .001$). The means for both two-way treatments are larger than the means for the one-way, covert response condition ($p < .01$, Scheffe).

[b]The differences among treatments are significant ($F = 4.65$, $df = 3/188$, $p < .005$). The difference between the two-way individual and one-way, covert response treatments was significant ($p < .01$, Scheffe). The pretest means from left to right, were 17.07, 16.85, 16.48 and 15.78. The differences among treatments were not significant ($F = 1.52$, $df = 3/188$, p = n.s.).

[c]The differences among treatments are significant ($F = 9.47$, $df = 3/197$, $p < .001$). The means for both two-way treatments are larger than the mean for the one-way, covert response condition ($p < .01$, Scheffe).

[d]The differences among means are significant ($F = 8.44$, $df = 3/197$, $p < .001$). The means for both two-way treatments are larger than the mean for the one-way, covert response conditon ($p < .01$, Scheffe).

Table 2 shows that the treatment scores in the follow-up test ranged from 69 to 74 items correct of the possible 83. While all groups averaged better than 83 percent of the items correct, firefighters in the two-way individual treatment scored significantly higher than did individuals in the one-way paper and pencil treatment.

Separate analyses of variance were performed for each of the four sub-sets of items which comprised the follow-up test. The results of these four analyses of variance appear in Table 2.

Table 2. Follow-up Posttest Scores by Treatment and Item Subsets

	Treatment			
Item Subset	Two-way Individual	Two-way Group	One-way Paper/. Pencil	One-way Covert
	(n = 45)	(n = 48)	(n = 53)	(n = 50)
Raw scores, 83 items[a]	74.31	72.88	69.68	71.76
Pre/Post, 27 items[b]	24.51	23.90	23.08	23.72
Post-Only, 22 items[c]	19.82	20.21	18.74	19.36
Equivalent, 27 items[d]	24.16	23.50	23.02	23.20
New, 7 items[e]	5.82	5.27	4.85	5.48

[a] The differences among treatments are statistically significant. ($F = 4.37$, $df = 3/192$, $p < .01$). The mean for the two-way individual treatment is statistically larger than the mean for the one-way paper and pencil treatment ($p < .01$; Scheffe).

[b] The differences among treatments are statistically significant. ($F = 2.98$, $df = 3/192$, $p < .05$). The mean for the two-way individual treatment is statistically larger than the mean for the one-way paper and pencil treatment ($p < .05$; Scheffe).

[c] The differences among treatments are statistically significant. ($F = 5.44$, $df = 3/192$, $< .01$). The mean for the two-way group treatment is statistically larger than the mean for the one-way paper and pencil treatment ($p < .01$; Scheffe).

[d] There were no significant differences among the means for this set of items ($F = 1.74$, $df = 3/192$, $p = .16$).

[e] The differences among treatments are statistically significant. ($F = 6.76$, $df = 3/192$, $p < .001$). The means for the two-way individual treatment and the one-way covert treatment are each statistically larger than the mean for the one-way paper and pencil treatment ($p < .05$; Scheffe). These new items came from lesson #11.

(1) **The Pre/Post items.** The condition scores ranged from 23 to 24 items correct of the possible 27, with a significant difference between the scores obtained by individuals in the two-way individual treatment and the scores obtained by participants in the one-way paper and pencil treatment. Firefighters in the two-way individual treatment scored slightly (but not significantly) higher on these items than did firefighters in the one-way covert response treatment.

(2) **The Post-Only Items.** The treatment scores ranged from 18 to 20 items correct of the possible 22, with firefighters in the two-way group response scoring significantly higher than firefighters in the one-way paper and pencil response.

(3) **The Equivalent Items.** The treatment scores ranged from 23 to 24 correct out of a possible 27, with no significant differences among the groups.

(4) **The New Items.** The condition scores ranged from four to five correct out of a possible seven. The firefighters in the two-way individual response mode and the one-way covert response mode each scored significantly higher on these seven items than did participants in the one-way paper and pencil response.

On the basis of these findings, we feel confident in concluding that there was considerable retention of the information presented six months after the prefire planning series was cablecast, with participants in the two-way condition typically scoring slightly better than participants in the one-way condition. This was especially so for the two-way individual terminal participants.

Attitude Toward Specific Viewing Conditions

From Tables 3 and 4, it appears that personal satisfaction from the televised lessons while handling the terminal increased over time. Further, it was important for each individual to see his ID code log in, but primarily if it meant that the firefighter was personally identifying himself as the terminal handler for the entire interactive lesson, and not just the log-in itself. There was uniform participation in checking one's own scores against the correct ones, and those of other firefighters.

At both testing sessions, a common set of questions was administered to participants in all four experimental treatments. These results are in Table 5. For each question, the participants were to compare their activity to what they believed it would have been like under conditions of live instruction, with live instruction to be considered a score of "100." Row 5a indicates how interesting the participants

Table 3. Affective Responses to Terminal in Two-way Group Treatment

	T_1	T_2	Behrens-Fisher
Times Handled	1.12	1.59	2.35*
Satisfaction	71.30	80.37	1.03
Attentiveness	98.59	100.85	0.22

*p. < .05

judged their particular mode of receiving the prefire planning training. At Time 1, the groups are not different. The two-way individual participants had a substantial increase on this measure, such that by Time 2, they showed a near significant difference ($p < .10$) from the other treatments. Row 5b indicates that the interactive items were useful for all groups at both time periods, although they never quite matched the live situation. However, the third item, asking how much they thought they learned compared to live instruction, shows that all treatments believed they learned nearly as much or more than in live instruction. Across all these items, there is a pattern suggesting that maximum interest, utility and perceived learning developed primarily in the two-way individual treatment.

Table 4. Affective Responses in Two-way Treatments

	T1 Individual	T1 Group	(z)	T2 Individual	T2 Group	(z)
Log-in Important	84%	64%	(1.67)*	93%	52%	(3.73)*
Compared Scores	68%	74%	(.50)	81%	81%	(0.0)
Compared Answers	76%	74%	(.17)	65%	76%	(1.00)
Satisfied in Seeing Answers Right	92%	88%	(.33)	91%	93%	(.18)
Important to Know Quiz Scores	80%	76%	(.33)	81%	64%	(1.55)+

*$p < .05$
+$p < .10$

Table 5. Comparisons of Instructional Mode with Live Instruction

Compared to Live Instruction	Two-Way Individual T1	Two-Way Individual T2	Two-Way Group T1	Two-Way Group T2	One-Way Paper/Pencil T1	One-Way Paper/Pencil T2	One-Way Covert T1	One-Way Covert T2
a. How interesting?	89	106	88	82	84	82	101	83
b. How useful the questions?	82	85	78	71	64	74	73	79
c. How much learned?	104	104	85	94	101	90	105	90

The Multidimensional Affective Results

The data resulting from over-time administrations of the multi-dimensional affective instrument strongly indicate that by the end of the experiment, participants in the two-way individual treatment more favorably evaluated their profession of firefighting, their TV training experience (by a considerable margin) and the content of the videotapes than did participants in any other treatment. Across the three sets of concepts, at the conclusion of training, participants in the two-way individual treatment consistently reported smaller mean distances for each positive attribute included in the set of concepts. It was anticipated that an effective training program would result in the development of a "positive attitudinal orientation" on the part of the participants toward their profession, the content of the programs and the learning experience itself. While the orientation of participants in the two-way group, one-way paper/pencil and one-way covert response treatments is somewhat inconsistent across the three sets of concepts, we conclude that their orientation is somewhat favorable toward each of the focal concepts, with the orientation of the participants in the two-way individual treatment being considerably more favorable.

Performance

A final assessment of the effect of the training was an evaluation of field performance. After training, the first 28 prefire plan building surveys were scored for accuracy and completion. A perfect score was 100 points. The average score over the 28 surveys was 91 and the median score was 93.

Most of the errors were of omission; a heading or subheading was left blank. Often this occurred where the item was not applicable, but it was not indicated as such. The lessons did not emphasize a standard response to non-applicable blanks on the survey form. Another failure was to neglect the perimeter area, if observation of the perimeter did not indicate major hazards or buildings. The proper procedure, included in the lessons, is to note such perimeter features as railroad tracks and power lines.

Symbols for diagrams, a major element of the training, were consistently correct. Thirty-five symbols were taught, none of which were known at the beginning of the instruction.

Performance on-the-job is perhaps the best test of the training system. In this case, performance evaluation confirmed the generally high learning levels as measured by the posttest. Because of a number of transfers that mixed the treatment groups, no attempt was made in the performance test to differentiate among treatment conditions.

Cost Analyses

This section describes the cost of training all fire station personnel to prefire plan using the two-way cable system and then presents general cost data comparing one- and two-way cable systems.

Training Costs

We calculated training costs as if all of the firefighters were trained by each of our four experimental methods. In addition, we have estimated costs for three other training methods—auto-tutorial, lecture at the Training Academy and lecture at the fire stations. The auto-tutorial method costs were based on a videocassette playback machine bicycled from station to station. The cassettes would be identical to those used in the experimental treatments. The lecture at the Academy is assumed to be a well-designed series with slides and graphic components comparable to those used in the television programs of the experiment. The lecture at fire stations is the same as the lecture at the Academy, except that the lecturer, with visuals and equipment, moves from station to station.

All three of these conventional methods are used by the Rockford Fire Department and constitute the major training alternatives. Overall, the seven training options present a comparison of the more capital-intensive training methods (e.g., two-way individual terminal) to more labor-intensive approaches (e.g., lecture at the stations).

Costs were calculated for 200 firefighters (close to the number completing the training in Rockford) and for a larger 1000-firefighter unit.

Some basic assumptions were necessary to make the calculations. In comparing the actual costs of cable training with estimated costs for auto-tutorial and lectures, it was assumed that the quality of the lectures and auto-tutorial videotapes were equivalent to the videotapes used in cable-delivered instruction. In the case of auto-tutorial, the same tapes could be used so the development and production costs would be identical. For the lectures, the same investment would be made in researching and writing the lectures as in the preparation of the scripts for television. The visuals—slides, films and graphics—used in the lectures would be essentially the same as those used to make the videotapes; therefore the costs would be the same. The only difference between lecture and cable development and production costs, then, would be the studio and post production costs.

The weakest element of the comparison is in the cost of "response processing, feedback and record keeping." This is relatively easy to calculate for one-way television, auto-tutorial and lecture, but involves the costing of the two-way cable system for the two-way cable instructional methods. Fortunately, Rockford Cablevision has a "System Lease Plan" which prices two-way services. (2) Some of the services involved in the experiments were not priced, since the equipment and the service were unique to the experiments. However, the rationale for pricing service is included in the "System Lease Plan." The lease price for headend equipment is calculated at one-thirty-sixth of the original cost of the equipment per month. The lease price for the terminals is one-eighteenth of the original cost per month. Customer terminal equipment is priced higher than the equipment that remains in the hands of the company.

This is a conventional pricing scheme. However, it assumes that firefighter training would be the only service and provide the only return in the capital investment and operational expense. Other users, and potential users, have emerged who might share in covering these costs, reducing the charge to the Fire Department. Assigning *all* costs to the Fire Department training applications is the most conservative approach.

The results are presented in Table 6.

Table 6. Cost Comparisons in Training Methods

	CABLE						
	Two-way Individual	Two-way Group	One-way Paper/Pencil	One-way Covert	Auto-tutorial	Lecture Academy	Lecture Station
(Cost of cable training 200 firefighters in 10 stations in a 12-lesson series originally produced by the fire department compared to auto-tutorial and high quality, visualized lectures.)							
Total	$78,201	$76,776	$71,762	$70,874	$76,154	$58,752	$60,912
Cost per lesson, per person	$32.58	$31.99	$29.90	$29.53	$31.73	$24.48	$25.38
(Cost of cable training 200 firefighters in 10 stations in a 12-lesson series with purchase of prepackaged materials compared to auto-tutorial and high quality, visualized lectures.)							
Total	$12,679	$11,254	$6,240	$5,352	$10,632	$58,752	$60,912
Cost per lesson, per person	$5.28	$4.69	$2.60	$2.23	$4.43	$24.48	$25.38
(Average series cost of cable training 200 firefighters in 10 stations in a 12-lesson series originally produced by the fire department with six repetitions over a period of 12 years compared to auto-tutorial and high quality, visualized lectures.)							
Total	$20,599	$19,174	$14,160	$13,372	$18,552	$13,935	$14,007
Cost per lesson, per person	$8.58	$7.99	$5.90	$5.53	$7.73	$5.81	$5.84
(Average series cost of cable training 200 firefighters in 10 stations in a 12-lesson series with purchase of prepackaged materials with six repetitions over a period of 12 years compared to auto-tutorial and high quality, visualized lectures.)							
Total	$9,679	$8,254	$3,240	$2,352	$7,632	$13,935	$14,007
Cost per lesson, per person	$4.03	$3.44	$1.35	$ .98	$3.18	$5.81	$5.84
(Cost of cable training 1,000 firefighters in 50 stations in a 12-lesson series originally produced by the fire department compared to auto-tutorial and high quality, visualized lectures.)							
Total	$84,901	$77,776	$75,218	$71,162	$103,802	$101,312	$112,112
Cost per lesson, per person	$7.08	$6.48	$6.27	$5.93	$8.65	$8.44	$9.34
(Cost of cable training 1,000 firefighters in 50 stations in a 12-lesson series with purchase of prepackaged materials compared to auto-tutorial and high quality, visualized lectures.)							
Total	$19,379	$12,254	$9,696	$5,640	$39,280	$101,312	$112,112
Cost per lesson, per person	$1.61	$1.02	$ .81	$ .50	$3.19	$8.44	$9.34
(Average series cost of cable training 1,000 firefighters in 50 stations in a 12-lesson series originally produced within the fire department with six repetitions over a period of 12 years compared to auto-tutorial and high quality, visualized lectures.)							
Total	$27,299	$20,174	$17,616	$13,560	$46,200	$61,319	$72,119
Cost per lesson, per person	$2.28	$1.68	$1.47	$1.13	$3.85	$5.11	$6.01
(Average series cost of cable training 1,000 firefighters in 50 stations in a 12-lesson series with purchase of prepackaged materials with six repetitions over a period of 12 years compared to auto-tutorial and high quality, visualized lectures.)							
Total	$17,195	$9,254	$6,696	$2,640	$35,280	$61,319	$72,119
Cost per lesson, per person	$1.36	$ .77	$ .56	$ .22	$2.94	$5.11	$6.01

Cost comparisons, 200 firefighter department. For the Rockford Fire Department, or comparably sized departments, training costs for cable and auto-tutorial methods are higher than lectures at the Academy or in the stations when the videotape materials for cable and auto-tutorial are produced professionally in color. However, if these video materials are produced elsewhere and purchased by the Department, the costs of cable and auto-tutorial instruction are only about one-fifth the cost of lectures. When lessons are repeated often (e.g., every two years in these calculations), the costs are substantially reduced for Department-produced lessons, and one-way cable instruction becomes less costly than lectures because "presentation personnel" costs are much lower. When video materials are purchased from outside, the costs of all cable methods and the auto-tutorial method are less than lectures prepared and delivered by Rockford Fire Department personnel.

In all cases, two-way cable instruction costs more than one-way television with the one-way, covert response method least expensive. This last instructional mode, however, was also the least effective teaching method of the four cable methods evaluated in this experiment. Two-way cable is from two to three times as expensive as one-way cable. Nonetheless, for this most effective cable method, the cost is as low as $3.44 per lesson per person. The lowest cost for the lecture method is $5.81. It might be more fair to compare two-way cable to lectures than one-way cable, since the questioning and feedback in two-way cable serves as a substitute for the live instructor.

Two-way cable with individual terminals for each trainee is only slightly more expensive than two-way cable with one terminal per station. Although learning was not affected by this difference, the clear preference of firefighters for the individual terminals might justify the small additional expense.

Cost comparisons, 1,000 firefighter department. For the larger fire department, with 1,000 firefighters, even with the cost of producing video materials internally for use on cable, the cost is about one-third less than lectures. The cost relationships between two-way and one-way are about the same as in the smaller department, but the costs of two-way cable instruction were as low as $.77 per lesson per person.

Cost comparison between one-way and two-way cable. It is pertinent to the cable operator, and to the cost analysis of two-way cable, to determine the cost differential between a cable system with two-way capacity (amplifier housings capable of accommodating modular additions of return amplifiers and filters) and a cable system with the on-line hardware (return amplifiers and filters) in place. We will call this latter case a "two-way ready" system. The two-way ready cable system is capable of two-way communication with terminals of some sort in the feeder system and a scanning and processing system at the headend. This cost analysis (reported in Volume II) suggests that: (1) larger cable systems are more likely to find the initiation of two-way service profitable than are smaller systems ; (2) the costs of operating a two-way cable system are more likely to impede initiations of two-way services than are the costs of construction; and (3) over time, new two-way services such as per-program pay cable present the potential to generate profits in excess of those which could be earned by one-way systems.

Public Policy in Two-Way Cable

The study of two-way cable technology in public service applications has identified a number of public policy issues to be faced as two-way services expand and develop. This section presents the background of existing policy in two-way cable communication, identifies definitional problems, suggests policies for the implementation of two-way service and outlines some of the responsibilities of local franchising authorities unique to two-way services, particularly in the area of upstream spectrum allocation.

Need for Clarification of Two-Way Capacity

Two-way *capacity* is treated by the FCC as something less than active two-way *service*. Unless this distinction is clearly understood by franchising authorities, the promise of two-way capacity may be misleading. The FCC view of capacity does not require that the cable system be *operational* in the return mode, but only that it be *capable* of furnishing two-way, non-voice services. This necessitates installation of "certain passive equipment in the system's distribution network and the use of downstream amplifiers which possess minimum second order distortion characteristics." The downstream amplifiers must be contained in a dual housing unit, built to receive a second amplifier, for upstream communications. The second amplifier is not actually installed. (3) Installation of the upstream amplifier would render the system active to transmit two-way communication assuming the installation of subscriber and headend terminal equipment.

Under existing federal rules, due to omission of explicit instructions, each government and cable system is left with the responsibility for making the transition from two-way capacity to active two-way services.

Introducing Provisions for Two-Way Cable

The nature of two-way cable communication is now clear enough so that some guidelines may be suggested for franchising authorities and cable companies anticipating a two-way system.

If it is the intent to write a two-way communication requirement into a franchise agreement, the nature of the two-way communication technology demands that the communication service or services to be provided be specified carefully. Each type of service makes unique demands on the character and technical capacity of the system—at the home terminal, in the distribution plant equipment and at the headend.[1]

If a franchise authority wished to develop particular two-way services, specification of such services could enter the agreement with the franchisee in at least two ways. One way would be the simple requirement that such a service be available on completion of the construction schedule (or as the system is turned on after each stage of construction). Such a franchise clause would seem to be appropriate for consumer- or institutional-private services where the service specified has been tested operationally and where market experience or projections would assure sufficient revenues to keep the two-way service from becoming a burden to the system or its subscribers.

If a two-way system were required exclusively for government services, the capital cost of the two-way system also could be viewed as socially desirable for the community and treated as a cost of acquiring the privileges in a franchise or as a direct cost to the government. In either case, the potential public benefit of the service would still be weighed against the costs, wherever assessed, in determining whether to include the service in the franchise.

When two-way service relates directly to both consumer and public welfare, special problems are presented. In alarm communication, for example, the general public welfare is enhanced and cost of government service reduced, if alarm communication is available through two-way cable. At the same time the consumer realizes personal benefit. If the alarm communication service is mandated by the government, the franchise or ordinance must contain the two-way provision. If the desire is only to make the service available to those citizens who wish it, then the questions of marketability, cost and general public benefit all weigh in the decision to require a two-way system.

1. To the extent that the household terminal and the headend equipment can be made modular, new services may be added to those specified with minimum cost.

If investigation by the franchising authority identifies general value and also seems to indicate a desired consumer benefit, greater public welfare and/or increased government efficiency, writing a two-way service clause into the franchise would be appropriate. On the other hand, in the absence of strong evidence of the benefits of a service, the franchise could stipulate a field test. This would provide an opportunity for both the operator and the franchising authority to evaluate the benefit of the service without the high cost of completing a two-way system. Although many of the headend costs for a two-way system are fixed, distribution plants in many systems have been built to accommodate a two-way retrofit. The necessary switching hardware within the distribution plant can be added after construction. Thus such a field test would require modification of only a part of the cable system.

Although a minimum-cost field test could not provide a random sample of households or geographically dispersed institutional sites, the test area could be designed to provide an economically feasible representation of a potential universe of users. Such a field test has been written into the Syracuse, New York, franchise. Smoke alarms and ambulance and police call buttons will be tested in 1,000 households. (4) The franchise appears to leave the ultimate decision to extend the service to the entire franchise territory to the franchising authority. (5) This is perhaps the best policy, since the franchisee will certainly provide a major input to the evaluation process. To be most cautious, an arbitration arrangement could be specified to resolve differences in interpretation of field test results.

If a franchise authority is reluctant to impose even an experimental field test on a cable franchisee, it might include a "state-of-the-art" clause in the ordinance or franchise agreement which could require two-way service prior to the end of the franchise period. Criteria by which state-of-the-art technology and service are judged may be hard to come by; however, the burden of establishing two-way cable technology as the state-of-the-art has been eased somewhat by the FCC requirement that systems have two-way capacity. The FCC Rules suggest that two-way service is important and imminent enough to warrant system design to accommodate it. A practical demonstration of a two-way service in other systems should provide impetus for suggesting the activation of the existing capability.

It is possible to set forth conditions which would lead to implementation of two-way service. The aggregation of a particular number of users for various types of two-way service would be an important condition. In aggregating users, the franchising authority may play a developmental role. This role could be particularly important in broadband communication because operators may not, on their own initiative, seek to develop applications of the technology which involve additional, and unique, public responsibility.

Whether a franchising authority can require activation of two-way capacity during the term of a franchise agreement, where activation is opposed by a cable system, varies from one jurisdiction to another. It seems that if the ordinance or legislative action which authorizes the franchise includes a provision for amendment of the franchise, courts would support reasonable change. If the franchise agreement stands alone without adequate supporting legislation, it may be looked upon as a contractual relationship and change may be more difficult, absent franchisee concurrence. (6)

Responsibilities for Local Government

Two-way cable is inherently a local service. The services to be supplied by such a system may involve agencies of local government (e.g., fire and police departments), entities endowed with a public interest, such as educational institutions, or local businesses.

A local government will have to assume some special burdens as it takes up the issue of cable development. As well as determining the kind of specific services it requires, the community may find it in the public interest to encourage development of community communication services that require advanced technology, a function similar to the FCC responsibility to "study new uses for radio, provide for experimental uses for frequencies and generally encourage the larger and more effective use of radio in the public interest." (7)

A unique responsibility for the local authority stems from the fact that in two-way cable, a variety of public and private services may eventually compete for upstream spectrum space. How the spectrum is allocated to these services is important to all users and potential users. Careful and conservative allocation is more critical as new services are developed and user increase.

At the present stage of development of two-way cable, it is possible to make only a tentative apportionment of spectrum to services. This initial allocation can be flexible, particularly if the transmitting-receiving equipment remains in the hands of the cable system. While the cable system may be in the best position to make the initial spectrum decisions in the developmental period, the franchising authority should reserve the opportunity to review the spectrum plan and lease rates to protect certain public interest users (e.g., in firefighter training, alarm systems, electric power system communication). This is particularly important as competition for upstream spectrum increases.

Finally, the franchise authority and cable system must face the problem of adding new capacity as initial upstream spectrum is fully utilized. This matter is complicated by the high capital cost of changing the split between downstream and upstream signals or adding another cable. In these circumstances, a cable monopolist might forestall the capital cost of adding capacity by controlling demand through the lease rate structure.

The major problem for local authority is how to represent the public interest. On the upstream spectrum allocation and rate issues, perhaps the appropriate procedure is to exercise a right of approval so that a mechanism exists for the franchising authority to become informed of system development and to have the opportunity to express a judgment of public and user interest.

The addition of some two-way cable services (e.g., point-to-point data transmission, electric power system communication) may clearly establish those cable services in a domain which is generally encompassed by the traditional concept of "public utility." In these areas, the state government could be of assistance to local authorities in dealing with some of the complexities of franchise supervision. Although state governments have no previous experience in such areas as spectrum allocation, they may collect information as it becomes available and subsequently advise local authorities.

Postscript

Project Goals

The primary goals of this experiment were to develop (1) a cost-feasible, functional two-way cable system for data return from the feeder system, and (2) to demonstrate applications of this technology in urban administration and social services. More specifically, we sought (3) to design and test an automated instructional system which would provide regular feedback, and still more specifically, (4) to implement a training system in the fire service that provides effective standardized instruction in an administratively efficient manner.

The first three objectives were achieved. To some extent, the system developed in these experiments has already become a model on which other systems will be patterned. Warner Cable Corporation hopes to be able to adapt the automated, interactional instructional system to the Columbus QUBE System. (8) The Syracuse, New York, two-way alarm system will use hardware and software developed for Rockford. (9) TOCOM, Inc. is using some of the Rockford concepts in its two-wing systems and has employed one of the original Rockford two-way project staff members.

Reports of the project have been made to national conventions of instructional communications technologists (10), computer specialists (11), firefighters (12), public power operators and engineers (13), associations of cable television operators in the United States and Canada (14,15) and other groups. This is only the beginning of necessary dissemination activities, but indicates an interest in the interface of telecommunications and computer technologies in various applications.

The fourth objective, to initiate a practical training method in the fire service, and more generally to improve fire department communication, has also been achieved to the extent that the limited post-experiment experience indicates.

The field staff for the project has been in regular contact with the Rockford Fire Training Academy over the past three years. All four members of the Academy staff have developed television production skills to a fairly high level. Their current work, independent of project staff assistance, is competent and improving steadily. They are able to script in one- and two-way formats, make videotape on location and in the studio, edit and assemble segments and mix audio. Their preparation of instructional television materials includes the ability to state instructional objectives clearly, and relate plans and scripts to those objectives. In addition to the Academy staff, three members of the Fire Department headquarters have become capable television producers for general and instructional communication purposes.

The Rockford Fire Department has purchased enough equipment to accomplish television production efficiently. The system employs simple black and white television equipment which has required little maintenance. The Training Academy personnel have produced instructional videotapes using the two-way interactive system that was developed through the project. Several people in the Department are now capable of following the Operations Manual which programs the computer to process the two-way lessons.

Since it is time-consuming to produce original materials for instructional purposes, the Training Academy personnel are converting existing instructional materials to two-way videotapes. Academy personnel will systematically convert materials used in conjunction with a 200-hour Advanced Firefighter Training Course to the two-way training mode. This entails adding interactive questions and quizzes to the training materials (slides, films, etc.) at appropriate points, videotaping on a three-quarter inch cassette and preparing the tape for the two-way system. Six of these instructional programs had been made at this writing.

During the experimental 12-lesson prefire planning series, only four of the 10 in-city Rockford fire stations were capable of receiving two-way television. Rockford Cablevision has now completed the conversion to two-way for all stations.

The Rockford Fire Department uses the two-way cable system for its daily briefing, "Update," at 8:30 a.m. and 4:15 p.m. When this system is completely installed the character-generated information will go upstream from the Fire Department alarm office to the headend, and downstream from the headend to the fire stations on channel B. The briefings include vital information such as hydrant reports and street closings. The Fire Department frequently adds a short videotape presenting special information about new programs, equipment and procedures, clarifications of policies, etc. Since the two-way system became operational for the experiment, 24 of these special briefings have been added to the regular daily "Update." Previously these special briefings were presented in person by deputy chiefs to each of the three shifts in 11 stations (33 separate presentations). A survey of viewership of the "Update" program indicates that over 94 percent of the firefighters make use of the character generated bulletin information every duty day. The special television programs following the briefings attracted as many as two-thirds of the firefighters.

In cooperation with the City of Rockford Equal Employment Opportunity Office, the Rockford Fire Department conducted several workshops to prepare applicants for the Fire Department civil service test. One of these workshops was conducted by television on the government cable channel to reach people who were unable to come to workshops in public buildings. The Fire Department Public Affairs Officer made a presentation and then answered questions received by telephone. Twenty-three different individuals asked questions indicating a fairly good audience among persons interested in applying for Fire Department jobs.

The Rockford Fire Department, in association with the Michigan State University project Field Director, produced a 14-question fire prevention test which ran twice daily on the government cable channel during Fire Prevention Week in October. Answer sheets were printed in the newspapers and the cable system Program Guide. The program was run again in December 1977. Eight other programs for the community have been cablecast: "Safe Handling of Flammable Liquids"; "Fire Safety Update"; "Fire Prevention Week Poster Winners"; "Fire Safety, Man-on-the-Street Interviews," Parts I – III; "Christmas Fire Safety Tips," Parts I and II.

Other Users

The University of Michigan has used the two-way system to make in-service professional development materials available to teachers in 14 public schools in Rockford. The schools project ran from 8 a.m. to 4 p.m. weekdays from September, 1977, through May, 1978. The system functioned without major technological difficulties through the entire period. Virtually no special system maintenance was required for the two-way communication.

SwedishAmerican Hospital in Rockford, Michigan State University and Rockford Cablevision demonstrated the two-way system for continuing medical education at the first annual Health in Underserved Rural Areas (HURA) conference in February 1978, sponsored by the Department of Health, Education and Welfare.

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(3) 53 FCC 2d 782, 793-794.

(4) City of Syracuse Franchise Agreement, 1977, Section VI, "Alarm Systems," Section 6.2, "Pilot Programs."

(5) *Ibid*, Section 6.5(a), "Alarm System Testing."

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