Report No. FAA-RD - 74-53

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REMOTE MONITORING OF VISIBILITY IN MOUNTAIN PASSES

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April 1974

FINAL REPORT

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Prepared for

U.S. DEPARTMENT OF TRANSPORTATION

FEDERAL AVIATION ADMINISTRATION

Systems Research & Development Service

Washington, D.C. 20590

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FAA-RD-74-53		

4. Title and Subtitle	5. Report Date
Remote Monitoring of Visibility in Mountain Passes	April 1974
	6. Performing Organization Code
	8. Performing Organization Report No.
7. Author(s) Joseph Czika and Kenneth H. Shreeve	
9. Performing Organization Name and Address Equipment Development Laboratory Systems Development Office National Weather Service National Oceanic & Atmospheric Administration	10. Work Unit No. (TRAIS)
	11. Contract or Grant No. DOT:fA72WAI-244
12. Sponsoring Agency Name and Address Department of Transportation Federal Aviation Administration Systems Research and Development Service Airports Division, Weather Data Branch Washington, D.C. 20590	13. Type of Report and Period Covered Final Report March 1972 to April 1974
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This report describes the work accomplished and results obtained during an experimental program that evaluated television and slow-scan video transmission techniques as a means to remotely monitor visibility in mountain passes. The purpose of the program was to demonstrate the practicality of this technique to provide VFR pilot advisories in remote mountain passes.

Experimental television equipment was installed at Stampede Pass and Boeing Field, Washington, interconnected to transmit pictures via slow-scan techniques over telephone lines from Stampede Pass.

17. Key Words	18. Distribution Statement
Television Visibility Slow-scan system	Document is available to the public through the National Technical Information Service, Springfield, Va. 22151

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	58	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

REPORT SUMMARY

This report describes an experimental program that evaluated television and slow-scan bandwidth compression, with video picture transmission on telephone lines as a means to monitor visibility conditions in a remote mountain pass.

The report is in three parts corresponding to the work plan:

Phase I - Test site evaluation, detailed system design, and proposed experimental test plan.

Phase II - Performance of the experimental test program and its evaluation.

Phase III - Performance specification for future equipment (Appendix).

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PHASE I

INTRODUCTION

Review of problem and proposed solution.

Unreported low stratus and fog conditions in a mountain pass frequently prevent a pilot, flying under Visual Flying Rules, from completing his mission. Because of the remoteness or rugged terrain of the pass, it is often undesirable or even impossible to station a qualified human observer at the site. The flying public and industry have suggested that television techniques could be used to provide reliable information about visibility conditions in such areas.

In order to render a solution to the simple question of whether the pass is open or closed to VFR pilots, the Federal Aviation Administration undertook evaluation of a closed circuit television (teleview) system. This system should enable a Flight Service Station briefer to make a sound judgment on the basis of the televised data. Further development of this type system may yield more detailed weather information on visibility, ceiling, etc.

The goal of this investigation was to demonstrate experimentally the usefulness of the teleview system in sensing visibility conditions. The investigation is divided into three phases. Phase I consisted of site selection, detailed system design, and the establishment of a test plan. Phase II consisted of equipment procurement and installation, test operation for 5 months, and system evaluation. Phase III consisted of generating specifications for procuring future systems on a competitive basis. This specification is given in the Appendix.

TABLE 1. EVALUATION FACTORS FOR THE POTENTIAL SITES

Pass	VFR Traffic	Marginal VFR Weather	Power Availability	Phone Line Availability	Weather Observer Availability	Access to Site	Availability of Maintenance Service
Stampede Pass, Washington	Moderate	Frequent	Very good (at site)	Very good (at site)	Trained observer on duty at field site	Restricted during snow season	Available from Seattle
Snoqualmie Pass, Washington	Moderate	Frequent	Moderate (estimate few miles)	Moderate (estimate few miles)	No trained observer	Good to pass, possible snow restricted at site	Available from Seattle
Donner Pass, California	Moderate	Frequent	Moderate (estimate few miles)	Moderate (estimate few miles)	No trained observer	Good to pass, possible snow restricted at site	Available from Sacra-mento
Banning Pass, California	Heavy	Infrequent	Good (estimate under 1 mile)	Good (estimate under 1 mile)	No trained observer	Easy	Available from Los Angeles

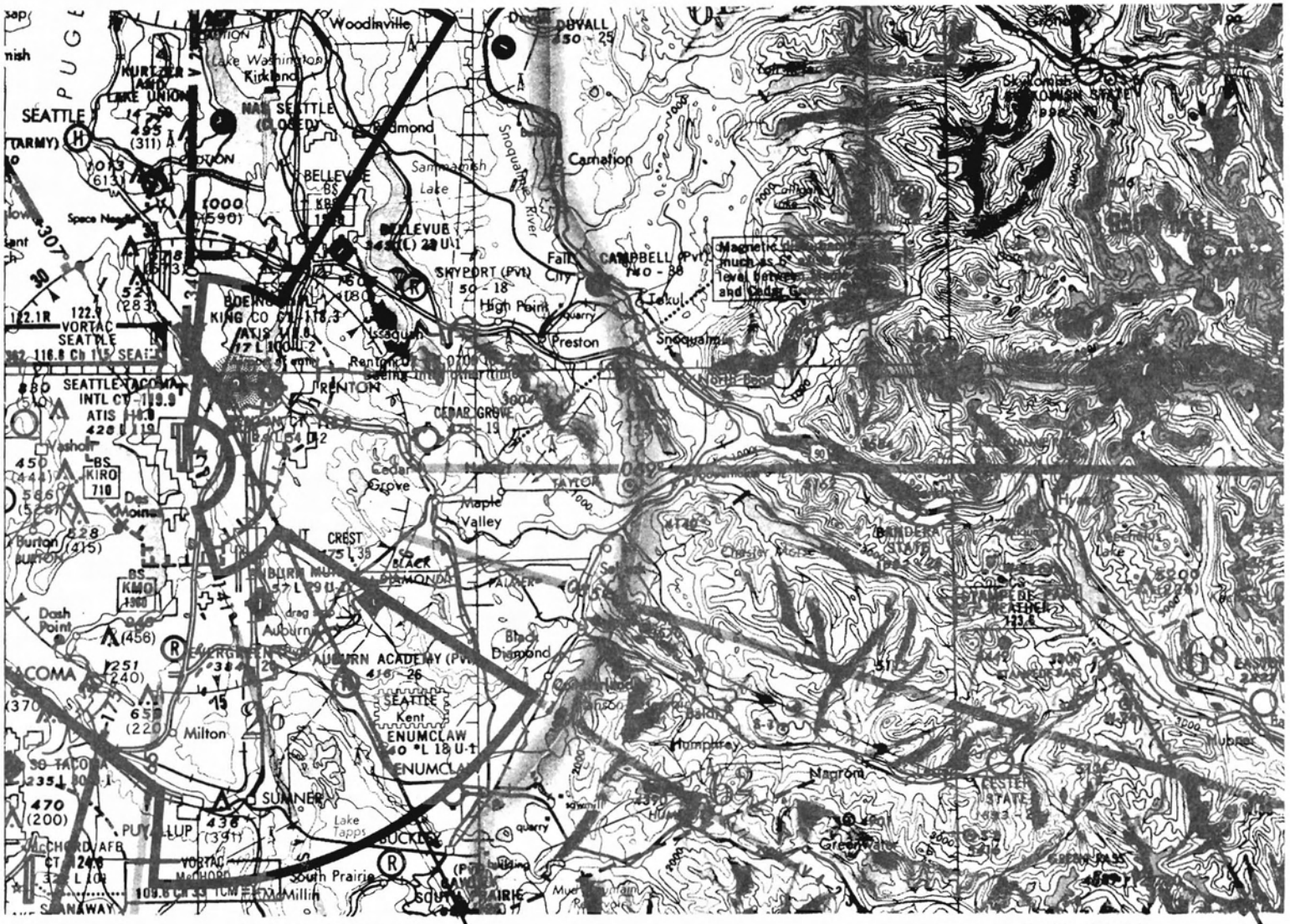

FIGURE 1. LOCATION OF STAMPEDE PASS

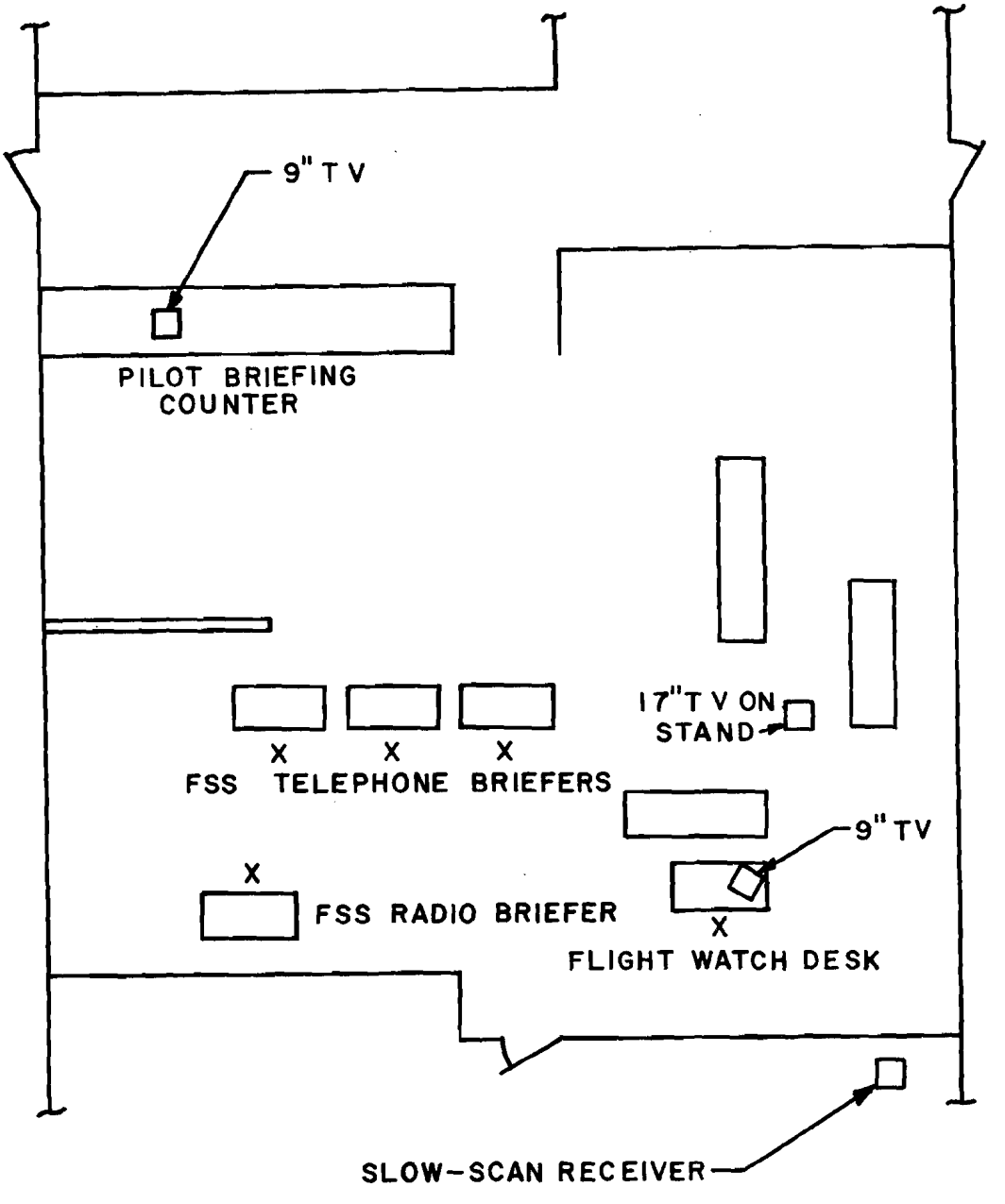

FIGURE 3. EQUIPMENT LAYOUT AT BOEING FIELD FSS

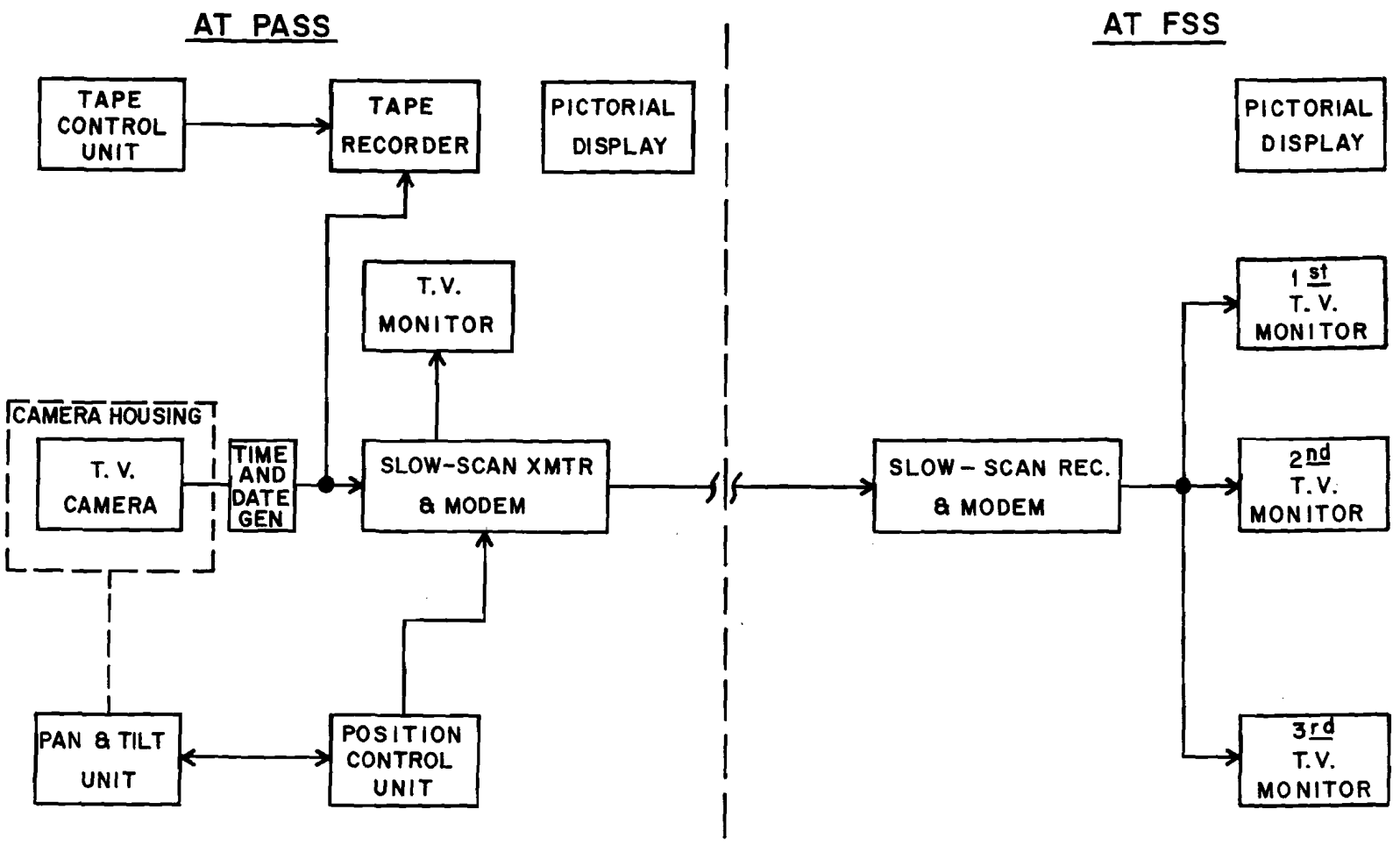

FIGURE 4. EQUIPMENT BLOCK DIAGRAM

9. Slow-scan transmitter - To transmit the video information over commercial phone lines, it is necessary to compress the camera video by trading off frame time for reduced signal bandwidth. The slow-scan unit compresses the video to audio bandwidths necessary for telephone line transmission. The frame scan time should not be more than two minutes.

10. Modem - This unit is a telephone coupling device used to connect audio information into a regular telephone receiver.

11. Slow-scan receiver - This unit performs the inverse function of the slow-scan transmitter; i.e., converting the compressed signal back into standard TV signal format. It also stores the received information until it is overwritten by the next picture.

12. TV monitor - Three FSS monitors were used during this experiment, two 9 inch and one 17 inch.

13. Pictorial display - These are annotated photographic pictures of the reference views (stops on camera sequence) containing the reference points (chosen terrain features). They are the reference views which the FSS briefer uses in his comparison with real time images on the monitor.

B. Physical layout of equipment

1. At the Pass - Figure 2 indicates the approximate location of the teleview components. The camera tower is placed near the NWS observer's house. The exact location depended on light-of-sight determinations which were made at the time of installation. The tape recorder, monitor, and slow-scan unit were in the observer's office.

2. At the FSS - Figure 3 is a floor plan of the equipment layout at the FSS. A TV monitor was placed on the counter top for easy pilot accessibility. The second monitor is near FSS telephone and radio briefers. The slow-scan unit and third TV monitor are adjacent to the Flight Watch briefer.

comparison. All points could be clearly distinguished from surrounding landscape features. Each reference point was identified according to distance from camera and altitude.

C. Pictorial display. An annotated photograph of each reference view was assembled. A set of reference views was available at the pass and the FSS. Included in the notations were:

1. Prominent near-field features to identify the view.

2. Terrain reference features annotated with distance and altitude.

IV. Realtime use of teleview system

The teleview experimental data were taken by two observers, one at the pass, the other at the FSS. At the times prescribed in section II, the pass observer switched on the video tape recorder (it turns off automatically after pan sequence). He physically viewed the pass and classified each reference point as visible or invisible. He decided, not necessarily on the basis of the reference point readings, whether the pass was open or closed. Simultaneously, the FSS observer compared the annotated reference views with the live picture on his TV monitor and classified the reference points as visible or invisible. Solely on the basis of the teleview data, he determined the open or closed condition in the pass.

Both observers were encourage to solicit verbal reports from pilots flying over the pass, especially if visibility conditions were marginal. The observer was asked to note pilot observations.

In the event of system failure, both observers recorded qualitative comments on system behavior and noted weather conditions. The FSS observer had prime responsibility for noting system malfunction and requested the FAA technician on duty to check the system before calling a local maintenance contractor for repair. Other duties requested of observers were:

a. Observer at the pass: Reload tape machine when necessary. Daily check and record the condition of camera face plate and wipe clean when necessary.

b. Observer at the FSS: Check picture quality daily.

PHASE II

PROGRAM SUMMARY

The results from the experimental Phase II demonstrated the feasibility of providing adequate VFR visibility information using television techniques. A comparison between observed visibility at Stampede Pass versus visibility viewed on TV monitors at Boeing Field show good correlation. Statistically, 88% of all observations agree (see data evaluation section for details). It is important to understand that only features with well-defined contrast, compared with clouds, were used, e.g., forested ridge lines. Two siting features are mandatory for successful TV operation: 1) Presence of distinct terrain features at known distance and elevation with typical high contrast compared to clouds. In weather with reduced visibility conditions, these features provide estimates of visibility and ceiling. As a result the highest ridge line determines the highest ceiling specifically identifiable. 2) Similar reasoning can be applied to visibility estimates. Therefore, the camera location must not be far removed from the surveillance area or it may be obscured by intervening clouds. Although this experiment took place in a forested mountain pass, the results can be extrapolated to evaluate application in other regions. Three examples are: 1) An area with heavy snow covering all vegetation provides little contrast and would not be suited for this equipment. 2) An arid region with little vegetation providing only varying shades of light brown or gray would also produce marginal results. This case would be especially bad in haze or smog conditions. 3) Any pass or gorge area with at least modest vegetation and distinctive terrain such as the Columbia River Gorge would provide a good viewing subject.

The television equipment used in this experiment was assembled mainly from off-the-shelf commercial equipment. The reliability was good considering that the equipment was not designed specifically for the severe weather conditions experienced. The worst problem encountered during the experiment was communications over the rented telephone line. (See Equipment performance.) At FAA recommendation, the system scan resolution was doubled (to 400 lines) and transmission bandwidth reduced. This greatly improved the picture quality but doubled the picture transmission time to 2 minutes. As a result, the latter part of the experiment produced superior results demonstrating the feasibility of using this equipment for remote VFR visibility monitoring.

Not all the equipment or techniques used in this experiment are recommended for field implementation but the knowledge gained allowed writing general performance specification for suitable equipment. For example, it is desirable to simplify or remove the need to pan and tilt the camera.

EXPERIMENTAL TEST PROGRAM

Experiment Objectives

The Phase II part of this program consisted of installing, testing, and evaluating an experimental TV system in an operating field environment. The goal of the program was to successfully demonstrate the use of the TV system as a VFR visibility monitoring device in a remote mountain pass. The knowledge gained during this experiment provided the basis for writing equipment procurement specifications for operational use.

Equipment Description

Equipment used in the experiment closely follows that described in the Phase I section. Figure 4 shows the equipment layout in block diagram form. The TV camera, enclosure, and pan-and-tilt unit are mounted on a self-standing tower overlooking Stampede Pass. A time-and-date generator adds this information to the raw video signal from the camera. The slow-scan transmitter, modems, and receiver permit narrow-band transmission of television pictures over the phone line. The position control unit and the pan-and-tilt unit function together providing automatic positioning of the camera for different views. In this slow-scan transmission scheme there is no "freeze-frame" capability. In this case the camera must hold still during transmission of each new frame. With the position control unit interconnected to a slow-scan transmitter, the camera is held still during picture transmission. At the end of the first frame the camera is positioned to the next view and slow-scan transmission is started. At the pass a TV monitor was provided to continually monitor the TV camera and the slow-scan transmitter. A video tape recorder and control unit provided an automatic taping sequence for each hourly observation taken by the observer. The taping sequence was initiated manually by the observer. At Boeing Field Flight Service Station (FSS), three television monitors displayed the slow-scan relayed pictures. Pictorial displays annotated with range and elevation of selected check points were used in the picture transmission comparison. Figure 5 (a through g) shows several pictures of the experimental equipment installed.

Detailed specifications of the equipment used are given below:

1. Television camera - Diamond Power, Model LL-55[1] with 25 mm lens and automatic iris, and 2:1 interlace option.

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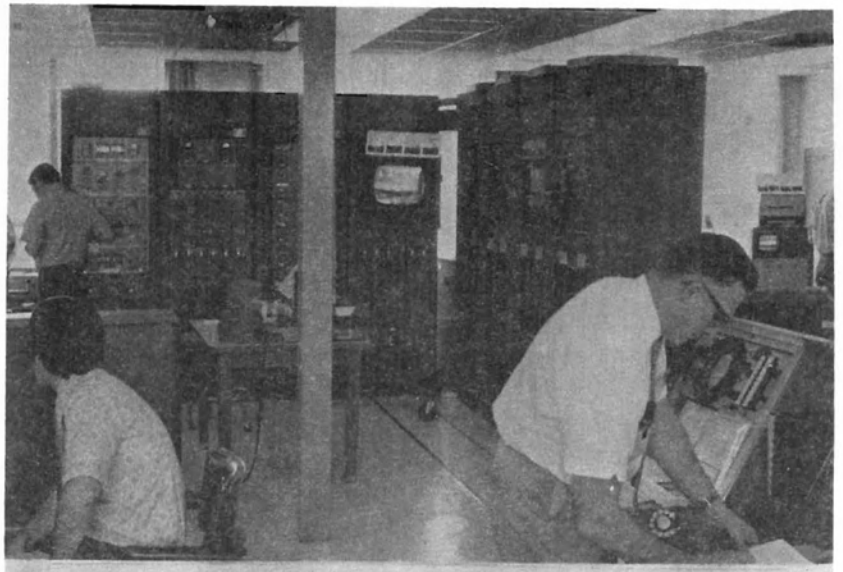

Fig. 5(c) TV monitor for telephone and radio briefers at the FSS.

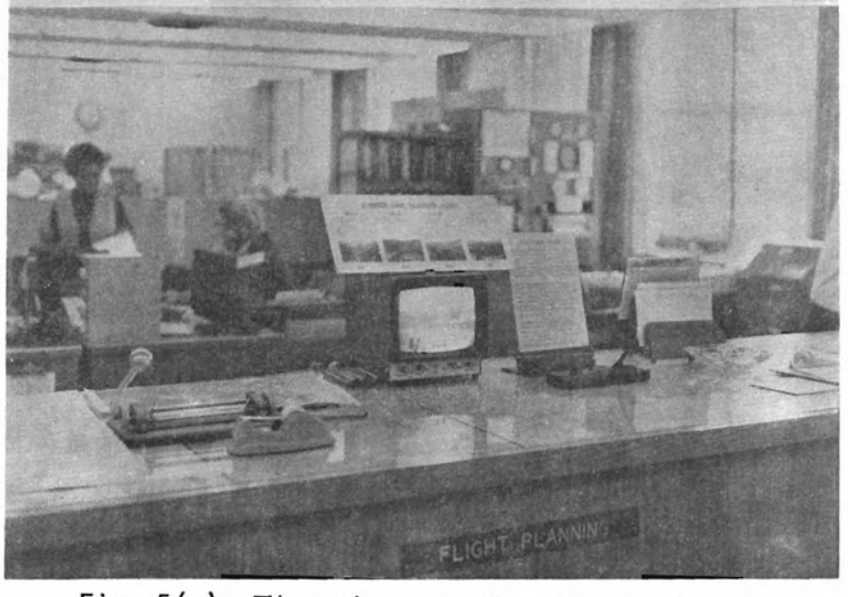

Fig. 5(e) TV monitor at the FSS pilot briefing counter.

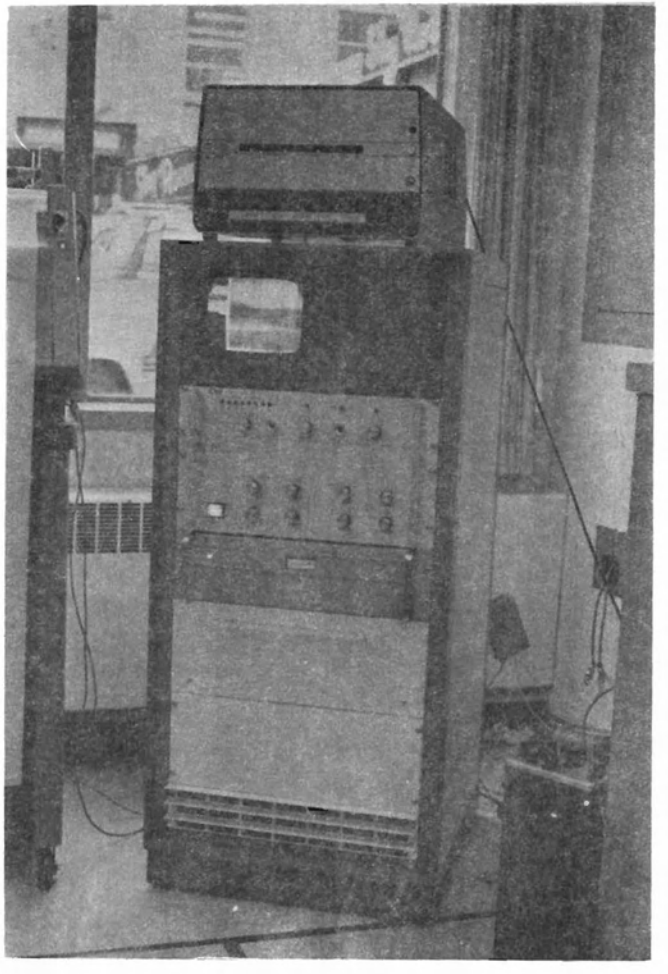

Fig. 5(d) Slow-scan receiver, TV monitor, and hard copy unit at the FSS.

2. Camera housing - Pelco Sales, Inc. Model EH-2 built with the following options: windshield wiper, thermostatically controlled fan motor, thermostatically controlled 300 watt heater, and mounting cradle. This unit was modified by the Equipment Development Laboratory providing an 18 inch sun shield overhanging the face plate.

3. Tower - Constructed with "Uni-Strut", 25 feet tall, approximately 3.5 feet square, with side ladder, work platform, and additional bracing members for rigidity. A camera mounting plate was bolted across the top railing.

4, Time and date generator - Built by Impossible Electronic Techniques, Inc., Model VTG-32.

5. Pan-and-tilt unit - Pelco Sales, Inc. Model PT-1050-L with 1,000-ohm position potentiometers, and thermostatically controlled low temperature heaters.

6. Pan-and-tilt control - EDL custom designed.

7. Nine-inch television monitor - Miratell, Model TE 9RR.

8. Video tape recorder - International Video Corporation, Model IVC 700.

9. Tape control unit - EDL custom designed.

10. Slow-scan transmitter and modem - Colorado Video Corp., Model 260, video bandwidth compressor, modified for 400 scan-line resolution.

11. Slow-scan receiver and modem - Colorado Video, Inc., Model 261, video bandwidth expander, modified for 400 line resolution.

12. First 9-inch television monitor - Miratell Model TE 9RR.

13. Second 9-inch television monitor - Miratell Model TE-9.

14. Seventeen-inch television monitor - Conrac Model SNA17, with yoke and 4 foot stand.

Equipment siting

Siting is an important aspect of this experiment. It is equally important for the evaluator to have a good mental picture of the equipment and its

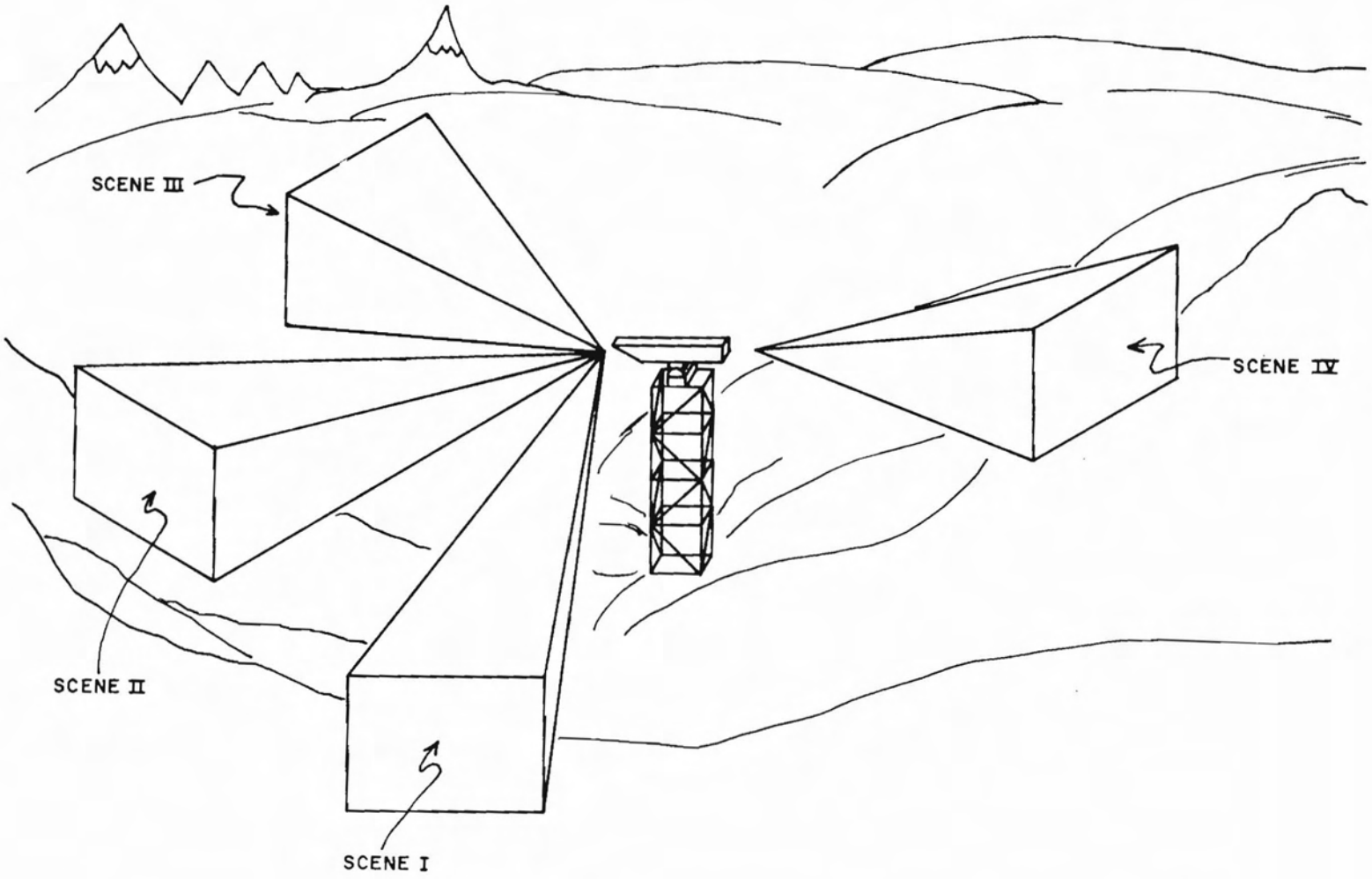

FIGURE 6. ILLUSTRATION OF STAMPEDE PASS CAMERA VIEWS

general aviation pilot benefits from its results, it always seems realistic to encourage pilots to participate in the experiment.

Besides the general data taking requested of the observers and briefers, all participants were encouraged to comment freely on the proposed use, suggest changes, and evaluate the equipment for its intended use. In a number of cases these comments have resulted in changes in the proposed equipment and siting requirements. An example is the addition of a strong infra-red filter used to compensate the characteristics of the silicon matrix camera tube. This problem is discussed further in the hardware section under Camera and lens.

Data evaluation

During the field evaluation several kinds of data were taken and analyzed to measure the system's ability to determine visibility conditions in Stampede Pass. Scene-by-scene checksheets were filled out by Stampede Pass weather observers and the FAA briefer at Boeing Field. These sheets were used to make hour-by-hour comparisons between actual visibility conditions and those viewed at Boeing Field via the slow-scan system.

A video tape recorder at Stampede Pass was set to record 5 seconds of each scene directly from a television camera for comparison with the checksheets. During analysis of the checksheets the video tapes provided additional insight into comparison discrepancies, especially during marginal visibility conditions.

Probably the most valuable information collected was the general opinion of the FAA briefers as they used the equipment. Leslie E. Ensign, Evaluation Officer from the National Weather Service forecast office in Seattle, spent considerable time working with the FAA briefers using the equipment. He successfully noted their reaction which has provided considerable input to this report.

There were three principal data collection periods: February 26-March 31, April 26-May 21, and November 27-December 31, all in 1973. The first two collection periods used the original equipment arrangement with a picture resolution capability of approximately 200 TV lines. The last data collection period reflects the improvements made by converting the equipment to a higher resolution system. The checksheet data taken with the high resolution equipment does not reflect the user opinion of considerable improvement. The rationale probably lies in the fact that a much higher percentage of bad and marginal visibility days biased this recording period in a negative sense.

TABLE NO. 2. PERCENTAGE AGREEMENT BETWEEN STAMPEDE PASS AND BOEING FIELD OBSERVERS (%/NO. OF COMPARISONS)

Collection period	Type comparison	Visibility category			Percentage by period
		Good	Marginal	Bad	
February 26 to March 31	Point	82%/1443	72%/699	98%/234	81%/2376
	Scene	95%/530	71%/351	97%/100	87%/981
April 26 to March 21	Point	97%/1859	66%/592	99%/318	91%/2769
	Scene	98%/740	67%/236	98%/13	92%/1110
November 27 to December 27	Point	79%/384	71%/591	100%/1540	90%/2514
	Scene	70%/213	61%/161	100%/640	87%/1014
Percentage by visibility category		90%	69%	100%	88%

of the data-phone to transmit picture synchronization. The telephone company's cross-talk between the data and sync channel in the 602C data sets could not be tolerated by the slow-scan system. The problem was solved by exchanging this equipment for a new model just designed by Colorado Video, Inc. (CVI), where the slow-scan system was synchronized automatically from the transmitted video.

The Tektronix hard copy unit was installed to facilitate recording samples of the received picture at Boeing Field. The resultant picture had an apparent resolution and gray scale totally inadequate for good reproduction of the received picture. No attempt was made to substitute better equipment.

The first pan-and-tilt control unit for the camera at Stampede Pass as easily false triggered and did not provide stable operation. The scene control circuit board was redesigned, resolving the problem.

The environmental housing for the camera provided sufficient protection for the camera circuits but the 18-inch sun shield did not adequately keep snow from frosting the face plate several times during the experiment. Usually the 300-watt heater in the camera would slowly clear the face plate within an hour after severe freezing, blowing snow conditions. This technique is not considered adequate for the proposed field system.

Through most of the experiment the resolution of the slow-scan system was approximately equivalent to 200 TV lines. With good telephone lines the 200 line resolution produces a satisfying picture. With noisy telephone lines, doubling the resolution of the system to an equivalent 400 lines made an amazing improvement in the picture quality. This increased transmission time from 1 to 2 minutes but the improved picture quality justified the change.

The CVI slow-scan system does not incorporate a "freeze-frame" technique. It is simply assumed that the camera does not move, and consequently the scene is constant. With a constant scene, the picture can be scanned directly as it comes from the TV camera. This requires that the TV camera remain very stable during wind buffeting. The first tower used with the system was not sufficiently stable, and a second was installed.

Few actual equipment failures were experienced during the field test period. Most of the equipment has been running 24 hours a day from September 1972 with only a few down periods. The major failures consisted of (1) a filter capacitor in the TV monitor at Stampede Pass, (2) the pan-and-tilt control unit failed several times leading to the redesign of the view positioning circuit board, (3) the power supply failed twice in the pan-and-tilt control unit and was replaced with a different design, and (4) the slow-scan receiver failed once, requiring integrated circuit replacement on the demodulator board.

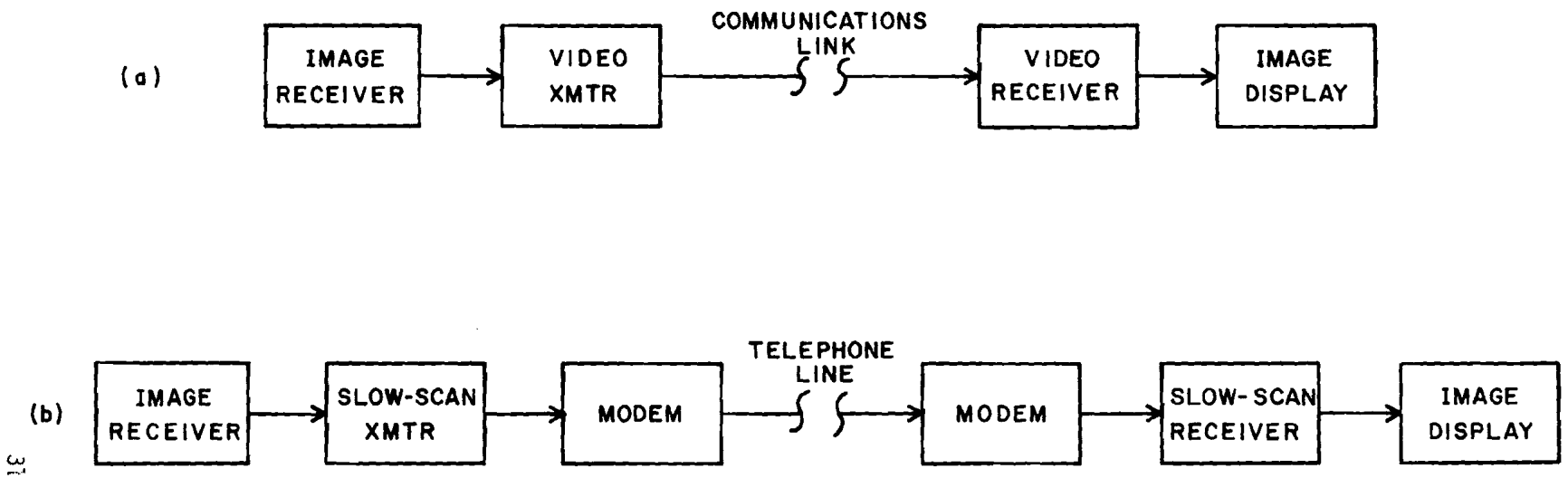

FIGURE 9. GENERALIZED BLOCK DIAGRAM OF A REMOTE TV SYSTEM

Table No. 3. Artificial Target Size (feet square)

	Lens Focal Length and 200 TV Line Resolution			Lens Focal Length and 350 TV Line Resolution		
Lens / Dist.	2X 25 mm	4X 50 mm	8X 100 mm	2X 25 mm	4X 50 mm	8X 100 mm
1 n.m.	61	30	15	35	17	9
2 n.m.	122	61	30	69	35	17
3 n.m.	182	91	46	104	52	26
4 n.m.	243	122	61	139	69	35
5 n.m.	304	152	77	174	87	43

For a camera using a 25 mm format image tube and assuming a reasonable resolvable target size equals four times the TV line pair resolution:

$$T = \frac{(4)(L_0)(D)}{(L_1)(R)}$$

T = Target lineal dimension

L_0 = Reference lens focal length, 25 mm

L_1 = Focal length of lens used

D = Distance to target, ft

R = TV system line pair resolution

Camera and lens

Many companies make reliable off-the-shelf television cameras suitable for this work. The major features that affect cost are environmental operating range, reliability, automatic light range, and optional features, e.g., 2:1 interlace, crystal control synchronization, etc. The general features of a camera suitable for this application are listed below.

- Resolution: The standard 525-line television system with an equal or greater horizontal line resolution is more than adequate since most slow-scan systems preserve only 350 to 400 lines.

- Sweep circuits: 2:1 interlace with EIA RS170 synchronizing format preferred.

- Synchronizing circuits: The question of crystal control versus line lock synchronization is a question that must be considered. Some slow-scan systems require one of two things, either (1) both ends of the slow-scan system receive commercial power tied to the same phase grid, or (2) a TV camera can be crystal controlled and line synchronizing information must be transmitted over the slow-scan system.

- Gray scale enhancement: Both the peak white clipping and gamma correction should be employed to help maintain the gray scale over the wide dynamic range required.

- Camera tube: The silicon matrix camera tube is presently the best choice since it provides the required sensitivity and is not burnt by viewing direct sun. Strong infra-red filtering must be added in the camera optics to correct for the infra-red response. In this experiment a KG-3 Schott filter from Fish-Schuman Corporation of New Rochelle, N.Y., was used. This filter did not totally remove the effect but proved an adequate solution for the experiment. A still stronger filter is recommended for operating system hardware.

- Automatic light compensation: The camera and its associated lens should operate over a 100,000:1 dynamic light range. This light range seems to handle everything from the bright sun conditions to twilight. The automatic light level control on the experimental camera proved adequate, but the mechanical iris and neutral density filter arrangement should be reviewed from a reliability standpoint.

directions. In this situation certainly 2, 3, or more views are required. Operating the system continuously 24 hours a day or even during daylight hours requires special mechanical design if reliability is to be attained. Alternate methods should be considered on a cost performance basis such as (1) multiple cameras electronically switched between views, or (2) a horizontal rotating line-scan camera.

Camera tower

The tower must be strong enough to hold a camera, camera enclosure, pan-and-tilt mechanism, and at least two maintenance personnel. The required rigidity of this tower to translational and rotational effects depend on the slow-scan system employed. If the slow-scan system used a "freeze-frame" technique rigidity is not too important. If the "freeze-frame" capability is not provided, the television camera must remain still during frame transmission. It is also important to provide a platform just under the camera where maintenance personnel can stand. Lightning protection for the television camera and slow-scan system is another important consideration. A high fence around the tower is probably necessary to help prevent vandalism.

Slow-scan system

The slow-scan equipment takes the TV camera signal, reduces its bandwidth for transmission over narrow-band radio or telephone communications, then reconstitutes a signal on the receive end. Our recent experience with this experiment demonstrated the need for a quality system that maintains apparent resolution in gray scale to produce a satisfactory picture. For example, there was considerable improvement going from 200 to 400 TV line resolution. Actual determination of picture quality versus resolution in gray scale is subjective and very difficult. The important thing is the apparent picture quality to the human eye, not the actual line by line resolution or gray scale, principally because gray scale dynamic range plays an important part.

The only reason for using a slow-scan transmission system is to reduce the video band width required in the communications line. Communications links such as the telephone line or narrow band FM radio are two primary examples. The slow-scan system must compress the approximately 8-MHz signal from a standard 525 line TV camera to less than 1-KHz for transmission over a telephone line. At the receive end it must reconstitute the 1-KHz signal back as close to the 8-MHz signal as possible if displayed on standard TV monitors.

There are several ways of reconstituting the video picture for display. In the experimental system a video disk was used where the incoming signal was written on the disk at the slow rate and scanned off at a normal TV rate.

consumption assuming use during daylight hours, one day in four, 12 hours per day, results in 32,850 pictures per year or approximately the same paper footage.

Power requirements

The remote site power consumption is important. A good source of power is required principally because of the heating and ventilating required. The most power is consumed in cold weather, where heaters for the camera and pan-and-tilt mechanism must keep the system free of ice and above freezing internally. Ice and snow must be kept from the TV camera face-plate even if a military temperature range camera is used in the system. Heating and ventilation must also be provided the slow-scan electronics unless expensive wide-temperature-range components are utilized.

The electronic load of the television camera and slow-scan equipment probably ranges from 50 to 100 watts with an additional 200 to 300 watts required by the pan-and-tilt unit. In the experimental system 300 watts of heat was provided in the camera enclosure and 150 watts in the pan-and-tilt gearbox.

At present, television cameras and slow-scan electronics are not available in low-power consumption designs capable of battery operation.

Cost considerations

The estimated capital investment for a slow-scan system similar to the one used in this experiment is $15,000 to $20,000 plus installation costs. Another $3,000 to $5,000 for spares (principally because the technician servicing the remote site should have a complete set of duplicate plug-in electronic circuits boards to speed repair under difficult conditions) and approximately $4,000 in test equipment. The recurring costs are those associated with telephone line rentals, electricity, and maintenance. Telephone line rental is a serious consideration because long rural telephone lines can be deceptively expensive.

INFORMATION DISSEMINATION

The general purpose of the remote television system is to provide the current VFR advisories for pilots anticipating flight through remote mountain passes. This information is very perishable especially during marginal weather conditions. Probably the best dissemination of this advisory information is by an en route briefing provided by the flight watch briefer. Next best would be local preflight briefing by FSS radio or telephone briefers.

PHASE III

APPENDIX

REMOTE READOUT TELEVISION SYSTEM VISIBILITY MONITORING

1. SCOPE

This specification sets forth the requirements for a closed circuit television system that provides the ability to monitor the general visibility conditions in remote mountain passes. The system shall be capable of remoting the televised picture from the mountain pass to flight service station facilities over voice grade telephone lines.

The success of the system depends directly on its ability to "see", transmit, and reproduce terrain features with sufficient clarity and contrast to allow accurate determination of the intervening visibility as it would be seen by a human observer.

2. APPLICABLE DOCUMENTS

The following documents of the issue in effect on the date of Request for Proposals form a part of this specification and are applicable to the extent specified herein. In the event of conflict between the documents referenced herein and this specification, the contents of this specification shall be considered a superseding requirement.

FAA-G-2100/1B	Electronic equipment, general requirements; Part 1, basic requirements for all equipments
FAA-G-2100/4B	Electronic equipment, general requirements; Part 4, requirements for equipments employing printed wiring techniques
MIL-STD-454D	Standard general requirements for electronic equipment

Requirement 8: Overload protection
Requirement 9: Workmanship
Requirement 31: Moisture pockets
Requirement 39: Fusing
Requirement 63: Special tools

Copies of FAA or Military Specifications and Standards may be obtained from the Federal Aviation Administration, Washington, D.C., 20591, Attention: Contracting Officer. Requests should fully identify material

white clipping and gamma correction shall be used to help maintain the apparent gray scale over a wide dynamic light range.

3.2.4 Camera(s) resolution. The TV camera(s) shall have a minimum of 600 lines (horizontal-center) at 525 vertical lines per frame.

3.2.5 Camera and lens depth of focus. A depth of focus from 100 feet to infinity shall be maintained without adjustment for all f-stop settings.

3.2.6 Camera lens focal length. 25 mm focal length lens shall be used with a 1 inch format image tube. If a smaller format image tube is proposed, a proportionally smaller focal length lens shall be used.

3.2.7 Scanning system. The system must be capable of sequentially viewing two, three, or four separate views. Although a single camera with panning mechanism would perform the task; multiple cameras or other technique is preferred for maximum reliability. If a scanning camera is proposed, slip rings should be used in preference to flexing cable arrangements. The reliability of the proposed system must be justified in terms of meeting the reliability and maintainability requirements.

3.2.8 Sun damage. The camera system shall be capable of looking directly into the sun without damage to any part or component in the system including the camera tube. For example, a silicon matrix camera tube meets this requirement. If a silicon matrix tube is used, the strong infra-red response must be compensated for by an appropriate filter such as a "Schott KG-3."

3.2.9 Camera system enclosure. A weather-proof enclosure shall be provided that protects the camera(s) and electronics from the elements (see paragraph 5.1, Operating environment).

3.2.9.1 Heated face plate. A heated face plate shall be provided for the camera to look through. Heat will be applied to the face plate when its temperature falls below freezing to prevent strong winds and freezing precipitation from icing up the face plate for extended periods.

3.2.9.2 Sun shades. A sun shade shall be provided to prevent direct sun from shining on the enclosure face plate except when in the camera's direct field-of-view.

3.2.9.3 Maintenance access. The enclosure shall be designed for easy access to the camera and other electronics for maintenance.

3.2.10 Camera system mountings. Tower mounting hardware shall be provided.

the remote and local sites on the same power phase grid. This shall allow operation of the remote site on emergency power without phase or frequency locking.

3.4.6 Test display. At the slow-scan transmitter, a test pattern shall be generated and mixed with the TV camera video allowing easy adjustment and monitoring of the output signal being transmitted over the phone line. This composite picture shall be viewable on the TV maintenance monitor.

3.4.7 Telephone line interface. The telephone line interface shall be provided on both ends with all circuitry necessary to mate directly with a dedicated phone line without need for additional Bell adapters.

3.4.8 Maintenance telephone. At each end of the slow-scan system there shall be a telephone as an integral part of the system that can be used for voice communications in lieu of the picture video for maintenance and emergency communications.

3.4.9 TV maintenance monitor. A self-contained, portable TV monitor (4 to 6 inch diagonal picture tube) shall be housed in the slow-scan transmitter enclosure. This unit shall be easily removed and carried up to the tower for TV camera maintenance. Normally this monitor will be connected to monitor the TV video and overlayed slow-scan signal. A separate power on-off switch shall be provided for this unit.

3.4.10 Power switch and service outlets. AC power on-off switches shall be provided at the slow-scan transmitter and receiver locations that control all power to the respective equipments and their associated electronics. A dual AC service outlet shall be provided at both locations for maintenance test equipment that is not disabled by the above on-off switches.

3.4.11 Radio frequency interference (RFI) immunity. The slow-scan system shall be designed to prevent (except in severe cases) RFI, power line noise, or transients from affecting the quality of the picture transmitted or disturbing normal operation. An example is: preventing local teletype noise from disturbing the system.

3.4.12 Slow-scan transmitter enclosure. A weather-proof enclosure shall be provided for the slow-scan transmitter, TV monitor, and other electronics needed at the remote end of the slow-scan system. This enclosure shall be designed to mount on the lower part of the tower and provide easy maintenance access. The design shall also provide the ability to open the access door and monitor equipment operation during precipitating weather conditions.

3.4.13 Slow-scan receiver enclosure. An enclosure shall be provided for the slow-scan receiver and associated electronics. The equipment chassis

This equipment must operate over the entire environmental range without need for maintenance adjustments either electrical or mechanical.

5.2 At the local site. The local (receive) end of the slow-scan system and display shall operate and meet all specification requirements under ambient conditions of Environment I specified in FAA-G-2100/1B 1-3.2.23.

6. STORAGE ENVIRONMENT.

The system components and assemblies shall be capable of storage without performance degradation in Environment III, FAA-G-2100/1B 1-3.2.23.

7. SOLID STATE CIRCUITRY.

This system shall use all solid state circuitry except the cathode ray tube in the TV monitor(s) and the image tube in the TV camera. The use of integrated circuitry is encouraged but must be a standard catalog item from two or more manufacturers. Plastic encapsulated circuits may be employed with FAA approval.

8. PRINTED WIRING.

All printed wiring shall be in accordance with FAA-G-2100.4, excluding the requirements of paragraphs 4-3.1 and 4-4.1 for compliance to MIL-P-55110.

9. AC SUPPLY LINE, CIRCUIT AND PARTS REQUIREMENTS.

The design of the primary AC supply line circuits shall be in accordance with FAA-G-2100/1B 1-3.6.1 through 1-3.6.7.

10. CIRCUIT PROTECTION.

10.1 Overload protection. Circuit protection shall be provided to prevent damage to wiring and components in case of electrical short circuits or overload in accordance with FAA-G-2100/1B 1-3.7, and MIL-STD-454D Requirement 8. All power supplies shall be protected from overloads by current limiting circuits, e.g., fold-back current limiting circuitry.

10.2 High or low power line voltages. All circuits shall be protected from damage caused by high or low power line voltage as specified by FAA-2100/1B 1-3.3.4, and 1-3.3.5.

10.3 Circuit recovery from overload. In all cases the equipment shall automatically return to normal operation when the power line voltage and loading return within operating tolerance.

13. GROUNDING.

The tower shall have provision for earth grounding for safety. All equipments shall be unaffected by grounding specified in FAA-G-2100/1B 1-3.3.3.

14. DISCHARGE DEVICES.

The circuit design shall provide for discharge devices in accordance with FAA-G-2100/1B 1-3.5.5.

15. CATHODE RAY TUBES.

Personnel protection from CRT implosion shall be provided in accordance with FAA-G-2100/1B 1-3.3.6.

16. MAINTAINABILITY.

The mean time to repair (MTTR) the equipment specified herein after failure of any part shall not exceed 30 minutes from the time the equipment is removed from operating status to the time it is restored to operating status.

Preference will be given to a proposed system designed without mechanical gears, springs, or electro-mechanical servo-mechanisms or the like.

The electrical and mechanical design shall provide for minimum maintenance with all components readily accessible. All circuitry to the greatest extent practicable shall be mounted on plug-in modules or printed circuit cards, facilitating easy replacement. Special effort should be taken to provide plug-in interchangeability at the remote site to effect easy maintenance.

17. INTERCHANGEABILITY.

Any system component, module, printed circuit card, or assembly shall be interchangeable with any other system unit of the same type. The system shall remain within the specified requirements when any system unit is interchanged with any corresponding unit.

18. RELIABILITY.

The equipment shall be designed with a calculated or field proven mean time between failures (MTBF) of 8000 hours.

19. WORKMANSHIP.

Wormanship shall be first class and equivalent to the best standard of the industry in every respect, and the equipment shall be manufactured

20.8 Cooling. Simple cooling techniques based on conduction, radiation, and free convection which utilize the ambient air as the thermal sink, and not requiring external cooling provisions, shall be used to the maximum extent possible, Forced air cooling shall be used only when natural cooling does not provide sufficient cooling or when a significant reduction in overall size and weight can be realized. Exhaust and recirculating fans and blowers shall be driven by brushless motors. Air filters shall be provided for all air intakes to protect internal parts that might be affected by dust and insects. Appropriate shields and/or ducts shall be provided in such a design to inhibit birds and insects from nesting in the air intake and exhaust systems of the camera assembly and slow-scan transmitter equipments.

20.9 Air filters. Filters shall be reasily removable for cleaning without disassembly of the equipment.

21. SELECTED COMPONENTS.

Operation of the equipment within specified limits shall not be dependent upon the use of components having narrower tolerances than those permitted by the applicable component manufacturer's specifications or upon the use of components selected for special characteristics which are not common to all such components meeting the requirements of the applicable component manufacturer's specifications.

22. DERATING OF ELECTRONIC PARTS:

In the application of electronic parts, the parts selected shall be used within their electrical ratings and environmental capabilities (e.g., ambient or hot spot temperature, voltage, current, or power dissipation . Derating shall be accomplished within the operating conditions specified.

23. RANGE OF ADJUSTABLE COMPONENTS.

The overall range of adjustable components shall be such as to insure a reserve in the adjustment range from the normal adjustment setting sufficient to accommodate adjustment during manufacture and subsequent maintenance. This adjustment range shall be sufficient to compensate for composite variations which may develop in the associated circuitry because of changes in part values during the normal life cycle of the equipment. The adjustment range shall also be capable of compensating for variations resulting from replacement with parts within the tolerances specified.

24. SPECIAL TOOLS.

The need for special test equipment and tools for adjustment and servicing shall be minimized. If required, one (1) set for each system shall

30. PREPARATION FOR DELIVERY

30.1 Packing. Equipment items shall be packed in suitable commercial packing to arrive at a destination within the United States, to be specified, without damage.

Discussion, under Scope, describing in more detail the intent of the FAA: to purchase a prototype, or several units for field trials

The height of the required tower(s) should be specified

Allow the contractor to propose exceptions to the specifications provided they are justified and provide significant advantage to the government in terms of improved performance and/or cost.

If this equipment is installed in an area with expected deep snow conditions, a small (6 x 6 foot square) building is recommended to house the slow-scan transmitter and associated electronics. An alternate would be to mount all the remote equipment at the top of the tower.

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