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VISUAL CONFIRMATION OF VOICE TAKEOFF CLEARANCE (VICON) OPERATIO--ETC(U)
FEB 81 J J MAURER, B CASTLE, E DOWE, B HUGHES

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LEVEL II

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VISUAL CONFIRMATION OF VOICE TAKEOFF CLEARANCE (VICON) OPERATIONAL EVALUATION: VOLUME I

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FEDERAL AVIATION ADMINISTRATION TECHNICAL CENTER
Atlantic City Airport, N.J. 08405

FINAL REPORT

FEBRUARY 1981

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16. Abstract

An operational evaluation was conducted at Bradley International Airport, Windsor Locks, Connecticut, to test an experimental visual (light) system which would confirm the voice takeoff clearance issued by the controller. The effort was in response to the tragic incident which occurred in March of 1977 on Tenerife Island where two Boeing 747's collided because of an apparent misunderstanding of air traffic control verbal instructions. This experimental system called Visual Confirmation of Voice Takeoff Clearance (VICON) consisted of a cluster of three PAR56 lamps with green lenses which were installed at all departure points on the airport with the activation of each cluster controlled by the air traffic controller.

Results indicated that the VICON system equipment and components operated in a highly reliable fashion during the entire evaluation period. Data collected and analyzed by a contractor indicated that VICON was technically feasible; however, VICON did not demonstrate that it enhanced safety.

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METRIC CONVERSION FACTORS

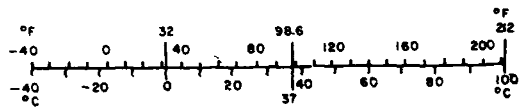
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in ≡ 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

This document is Volume I of the Visual Confirmation of Voice Takeoff Clearance (VICON) Operational Evaluation. This document contains the background; data collection and analysis; summary of the operational evaluation; results and conclusions. It is expected that this volume will be the publication most frequently consulted.

Volume II contains working drawings, schematic diagrams, and detailed maintenance and operational procedures for the VICON system as installed at Bradley International Airport. It is expected that Volume II will be consulted when considering future implementation or design modifications of the VICON system.

This evaluation was conducted by the Air Traffic Control (ATC) Applications Branch, ACT-210, of the Systems Simulation and Analysis Division, and the Visual Guidance Branch, ACT-410, of the Airport Development Division, under Federal Aviation Administration (FAA) Technical Center Program Document 07-213. It was conducted in response to a letter from the Director of the Systems Research and Development Service, ARD-1, to the Director of the FAA Technical Center, ACT-1, dated June 29, 1977, to support Agency 9550 Requirement No. ATF-77-2. The subprogram managers from the Systems Research and Development Service (SRDS) were Messrs. George A. Scott, ARD-441, and William Petruzel, ARD-110. The FAA Technical Center Program Manager was Mr. Felix F. Hierbaum, Jr., ACT-210.

Appreciation is expressed to Mr. Donald G. Hepler, Chief, Bradley Air Traffic Control Tower (ATCT); Mr. Fred Merrick, Deputy Chief, Bradley ATCT; Mr. George Langdon, Operations Officer, Bradley ATCT; all the controllers of the Bradley ATCT; Mr. Thomas Ewing, Chief, Bradley Communications Unit; and all the Technicians of the Bradley Communications Unit who assisted in the evaluation of the VICON system at the Bradley International Airport. Thanks are given for the courtesies, assistance, and cooperation provided to the FAA Technical Center Visual Confirmation of Voice Takeoff Clearance (VICON) team personnel while on site during the evaluation.

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PURPOSE.

The overall purpose of this evaluation was to determine if a visual signal confirming a voice takeoff clearance is feasible and if it will provide an added measure of safety.

PROJECT OBJECTIVES.

This effort, because of its scope, was accomplished under three separate projects, each having their own specific objectives. Projects were divided into three categories: (1) hardware and interface equipment related to specific locations on the airport, (2) control panels and associated interfaces located in the control tower facility, and (3) the operational evaluation of the VICON system.

The specific objectives for these projects were: (1) design, install, and modify the VICON system at Bradley International Airport as required for operational testing and to maintain and perform technical evaluation of the VICON system during the operational evaluation, (2) develop and test VICON control display panels, provide technical assistance to Airway Facilities Service, as required, to establish specifications for air traffic control tower (ATCT) equipment and to evaluate the reliability of the VICON control display panels used in the operational evaluation, and (3) evaluate the feasibility of utilizing a VICON system in an operational environment.

BACKGROUND.

In March 1977, one of the most tragic airport accidents in the history of aviation occurred on Tenerife Island when more than 580 persons lost their lives. The apparent probable cause of the accident was a simple verbal misunderstanding of air traffic control (ATC) instructions between the pilot of the departing aircraft and the airport tower controller. Other accidents and near-accidents occurred between 1972 and 1976, and analysis has indicated that the probable causes involved controller and pilot misjudgments of runway usage in takeoff, landing, and runway crossing operations. At present, runway utilization generally involves a single aural stimulus for the pilot receiving ATC instructions: namely, hearing a voice instruction on the aircraft radio.

In some of the occurrences mentioned above, the probable cause statements included a reference to "the pilot not clarifying ATC instructions." This tends to indicate that present voice (radio) confirmation of runway usage instructions, when not clearly understood by the pilot, can lead to undesirable and unsafe operations. It is questionable whether additional voice confirmation of runway utilization instructions would be as effective in gaining the attention, and hopefully eliminating misunderstanding between controllers and pilots, as the use of a second, independent sensory stimulus to positively confirm the voice instructions.

Regardless of the weather, day or night, or traffic situation, the pilot is expected to use sight as a verification of the voice instruction to ascertain if the runway is clear. Because of weather or darkness, positive visual confirmation to verify the ATC voice instructions prior to proceeding down the runway is not always possible in today's ATC system.

In April 1977, the Systems Research and Development Service (SRDS) initiated a program to develop, test, and evaluate a Visual Confirmation of Voice Takeoff Clearance (VICON) system. In the development of the VICON system, the following factors were considered:

1. The confirmation system shall be used as a standard procedure for all takeoffs (at taxiway intersections as well as end of runway) at airports where there are operational control towers, including single and multiple runway airports.

2. The visual reference shall be conspicuous to pilots of all types of aircraft, other than helicopters, prior to takeoff and shall have minimal impact on pilots of landing aircraft.

3. The use of the confirmation system should have minimal impact on pilot and controller procedures and on airport capacity.

4. For the controller, a means of activating and verifying the activation of the visual signal shall be collocated with, but separate from, other lighting controls and should be readily accessible to the controller.

5. The visual signal shall be distinguishable by the pilot from other visual aids in takeoff and displaced threshold areas and shall meet current airport siting criteria for runway lighting systems.

6. If the takeoff visual confirmation concept proves to be feasible and beneficial, it may be used as a basis for a similar visual confirmation system for runway crossing.

DISCUSSION

METHOD OF APPROACH.

A decision was made by the Associate Administrator for Air Traffic and Airway Facilities (ATF-1) that Bradley International Airport (which serves the Hartford, Connecticut, and Springfield, Massachusetts, area) would be the operational evaluation test site. Bradley International was selected on the basis that it was a relatively busy airport (158,913 airport operations between August 1978 and July 1979) and yet not so busy that testing of this system might infringe upon or interfere with the normal control of air traffic at the airport or in the vicinity of the airport. The operational traffic mix at Bradley International is approximately half scheduled airline (air taxi and commuter service included) and half general aviation and military operations.

Bradley International was also an acceptable location for the operational testing of the VICON system because of its weather environment. It is situated in an area where all types of weather conditions can be expected. The testing schedule was established to conduct the evaluation during October 1979 to March 1980 when all types of weather variations might be expected to occur. The VICON system was designed to be operational in any airport environment likely to be found in the domestic United States.

The in-service operational evaluation was started on October 15, 1979, and was completed on March 31, 1980.

VICON INSTALLATION AND DESCRIPTION.

The VICON system was installed between May and October 1979. Trenching, laying cables, and constructing cement pads for the field equipment were accomplished by a contractor engaged by the New England Regional Office of the Federal Aviation Administration (FAA). All the VICON equipment, including that used for data collection, was designed or developed, purchased or constructed as required, and installed by FAA Technical Center personnel with supplementary on-site assistance from either electrical contractors engaged by the New England Region or from Bradley Airway Facilities personnel.

The VICON system basically was a cluster of three PAR56 lamps with green lenses (figure 1) that were located along the left side of the runways at all takeoff locations. A system control panel located in the air traffic control tower cab provided the means to control each VICON light cluster. These two components are connected by either hardwire or radio control links. A considerably more complete and detailed technical description of the VICON system and equipment or components can be found in Volume II of this report which is the "VICON Operations and Maintenance Manual."

Twenty-one VICON light clusters were installed at all possible departure locations (figure 2). The light clusters were installed at various distances from the departure locations; however, they were always positioned on the left side of the runway. The location of the clusters was described to the users (pilots) as "located in the front left quarter of the aircraft when looking from the cockpit when in takeoff position."

In general, the light clusters at taxiway intersections were placed approximately 400 feet from the center of the taxiway. The light clusters at the runway end takeoffs were placed at various distances. Clusters at the runway ends were not placed at the same distances because (1) equipment adjacent to the runways (such as VASI's) dictated another location; (2) the need to test the use of a single cluster for more than one departure location (such as the light cluster for the end of runway 33 which also served departures on runway 33 from the intersection of taxiway Lima); (3) wide body aircraft utilized the departure points from the runway ends, thereby creating the need for the cluster to be beyond the 400-foot distances used at the intersection departure points; and (4) the need to determine usable distances for cluster placements during times when weather conditions caused reduced visibility. The end-of-runway VICON cluster locations were as follows:

<u>End Runway 06</u>: 650 feet from end of runway.

<u>End kunway 15</u>: 575 feet from end of runway.

<u>End Runway 24</u>: 710 feet from end of runway.

<u>End Runway 33</u>: 1,000 feet from end of runway.

<u>End Runway 01</u>: 550 feet from intersection of center lines of Runway 33 and Runway 01.

<u>End Runway 19</u>: 400 feet from southeast edge of Taxiway Charlie.

The VICON equipment can be classified into three categories: (1) the equipment located in the terminal building, including the control display panel located in the control tower cab and the data collection and interface equipment located in another room in the terminal building, (2) the controlling power equipment, timers, and relays located in a building adjacent to the ASR radar antenna on the airport, and (3) the VICON light clusters, radio equipment, and microwave aircraft detectors located on or adjacent to the runways at each departure location.

Due to the proximity of certain taxiways to each other or a taxiway to a runway end, a test was planned to see if it was feasible for one light cluster to serve more than one departure location. Four such locations were established at Bradley, as follows (refer to figure 2):

<u>Clusters No. 1 and 2</u>: Served Taxiway Alpha and Taxiway Sierra, Runway 06/24.

<u>Cluster No. 7</u>: Served Departure Runway 19 from End Runway 19, Taxiway Golf and Taxiway Charlie.

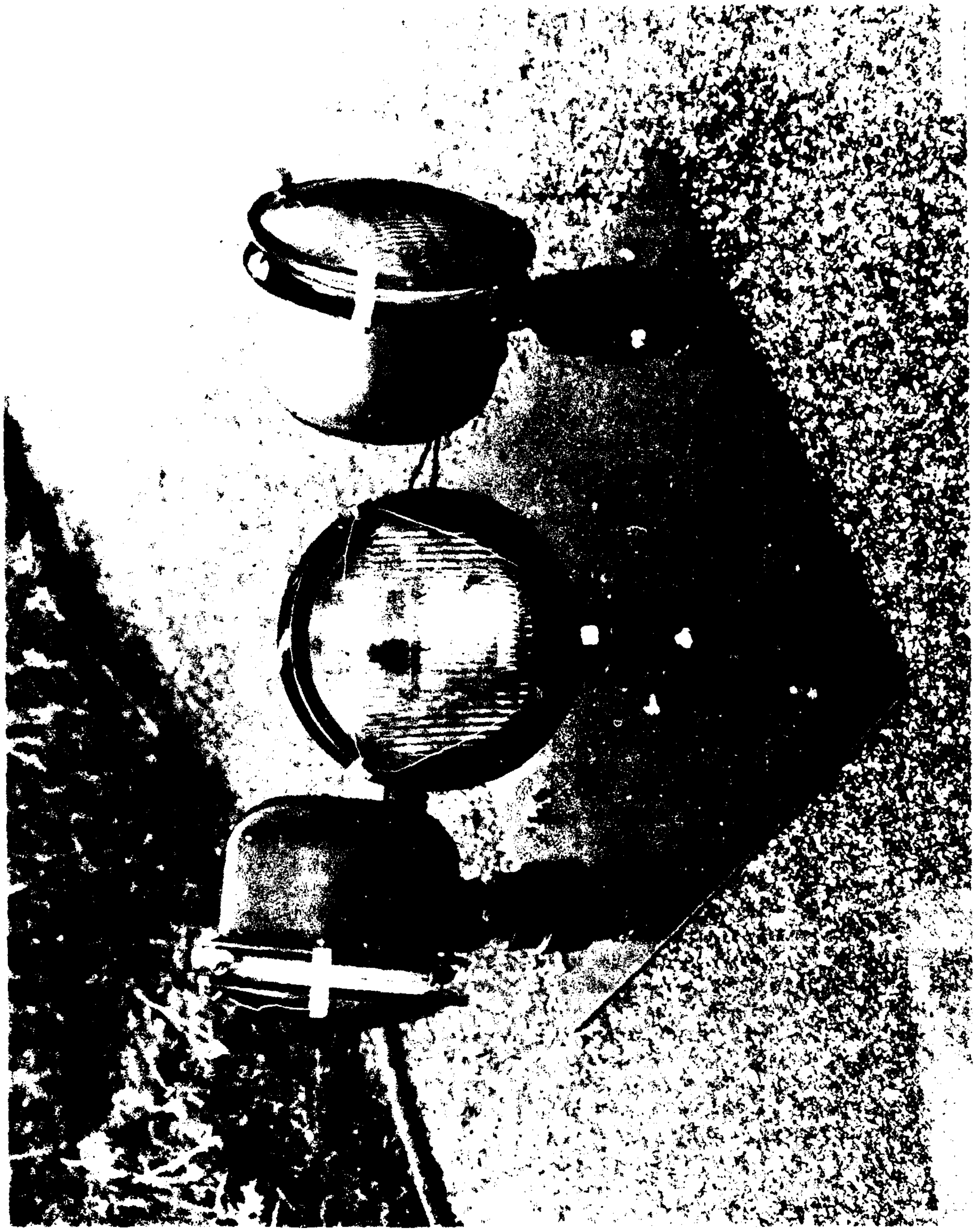

FIGURE 1. VICON LIGHT CLUSTER

VISUAL CONFIRMATION OF VOICE TAKEOFF CLEARANCE

VICON

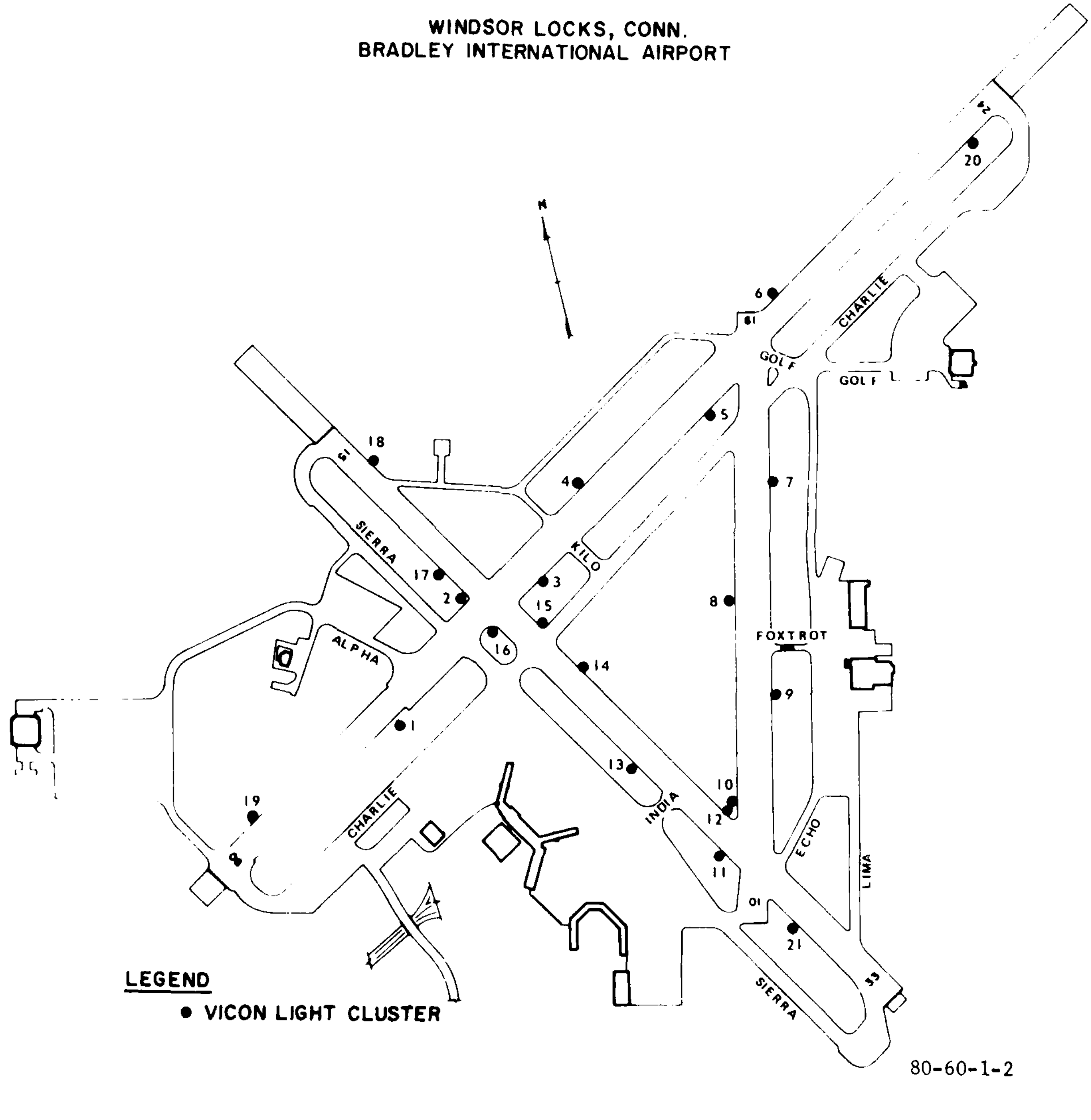

FIGURE 2. BRADLEY INTERNATIONAL AIRPORT RUNWAY AND TAXIWAY DIAGRAM WITH VICON LIGHT CLUSTER PLACEMENT

Cluster No. 10: Served Departure Runway 01 from End Runway 01 and from Intersection Runway 01 and Taxiway Echo.

Cluster No. 21: Served Departure Runway 33 from End Runway 33 and from Intersection Runway 33 and Taxiway Lima.

TEST ASSUMPTIONS.

The operational test was based on the following assumptions:

1. All field equipment and the VICON control display panels were installed and checked out to the satisfaction of the program manager prior to the start of the operational test.

2. The VICON system would be used on a continuous 24-hour basis for all departures (exceptions were touch-and-go traffic, low approaches, and helicopter operations).

3. Prior to the start of the field test, arrangements were made to observe and record operations in the tower cab and to record voice and equipment operations by FAA and contractor personnel.

4. Failure of a system component would receive immediate attention and corrective action would be taken by either local Airway Facilities personnel or the FAA Technical Center engineering group.

PRETEST ACTIVITIES AND TEST PROCEDURES.

The purpose of these activities was to ensure that the total VICON system was, in fact, ready for field testing. Careful preparations were undertaken to ensure system reliability and operational suitability to enhance the chances of a successful test. A discussion of test preparations follows.

SYSTEM SHAKEDOWN. Prior to initiating field testing of VICON at Bradley International, there was a shakedown period. The various equipment components, control display panels, light clusters, hardwire and radio links, microwave aircraft detector system, and electrical switching gear were carefully monitored to determine if they were operating satisfactorily. Descriptions and photographs of the above equipment can be found in Volume II of this report.

Equipment, whenever possible, was tested prior to being installed. For example, the control display panels were tested at the Technical Center by using a simulation device which was developed and built by the electronic technicians assigned to the VICON evaluation team. This device consisted of a large back-lighted display of the Bradley International runway and taxiway layout. This back-lighted display was hung on the wall in the sustaining engineering laboratory of the FAA Technical Center. The display included small green lights placed along the depicted runways in the approximate location where the actual VICON light clusters were placed at the Bradley International Airport.

An interface, or simulation device, was also constructed so that the VICON control display panels and the actual connecting cables could be attached; and the control panels, when activated, would illuminate the appropriate green light on the airport display. This provided the initial testing of the control display panels as well as the cables which were later installed and used at Bradley to connect the display panel and the interface equipment.

During the pretest activity at the Technical Center, the VICON control display panels were also installed and tested in the mockup of a Welton-Becket control tower console which was also located in the sustaining engineering laboratory and provided a realistic testing and training environment.

After installation of the VICON system was completed, further testing was accomplished by the Technical Center VICON team. In order to ensure that the VICON light clusters at each location had the optimum possibility of being seen by departing pilots, the lights were visually checked by the use of vehicles and, when available, various types of aircraft such as the Technical Center's Grumman Gulfstream and a rented Piper Seneca. The elevation angles of the VICON lights were set by using a measuring device (PAR56 Aiming Device AD-1).

Since all types of aircraft utilize Bradley International, from large wide body aircraft to the smallest of the general aviation fleet, it was necessary to ensure that the VICON lights could be seen by pilots of all types of aircraft from various positions on and off the runway. To enhance this objective, each bulb of the VICON light clusters was set at a different angle to the horizontal. The settings were as follows:

1. Bulbs facing 90° across the runway were set at an angle of 12°.

2. Bulbs facing diagonally towards the takeoff position were set at an angle of 6°.

3. Bulbs facing parallel to the runway edge were set at 0°.

These settings were tested at the Technical Center by using a High Ranger (personnel hoisting device) to elevate team personnel 30 feet above the runway along the runway centerline (a distance of approximately 75 feet from the light cluster), which approximated the height of a Boeing 747 cockpit above the runway. Sightings were also made at varying distances (further) from the light clusters, which included sightings from the runup pad adjacent to the end of the runway.

Other tests conducted after installation of the VICON system included a series of live flights conducted by VICON team personnel. These flights were conducted at night to determine if there was a possibility of the VICON lights causing confusion or distraction to the crews of aircraft during their final approach. The VICON personnel aboard the test aircraft had the VICON lights at the end of the landing runways turned on during their approach to observe the effect.

Tests were also made using vehicles during both day and night to determine whether the illuminated VICON light clusters could be observed from locations other than the one intended for that designated takeoff position.

AIR TRAFFIC CONTROLLER TRAINING. The first meeting between the operational personnel of the Bradley ATCT and the operational Air Traffic Control Specialist (ATCS) VICON team members occurred on January 11, 1978. Team personnel briefed both the facility personnel and the Facility Air Traffic Technical Advisory Committee (FATTAC) about the VICON system and its purpose. They also provided preliminary information concerning the initial plans for the installation at the Bradley International Airport.

It was felt that the simplest and most direct contact with the air traffic controller would be through the FATTAC, which is comprised of elected representatives of the controllers within the facility. A detailed briefing on the VICON system was provided describing the purpose and objectives of the evaluation along with as much information concerning the plans for installation as was available at the time. A request was made for participation on the part of the controllers and for an unbiased attitude throughout the evaluation. It was also stressed that controller opinions and comments concerning the

VICON system and the system components were very important; however, it was pointed out that in order to be valid they should be documented in writing. Also, they should be turned in so there could be tangible documentation of their reactions, opinions, comments, and suggestions for improvements.

The FATTAC members were also shown drawings and pictures of a VICON control panel which had been used at the Technical Center for earlier testing. A description of its operation was also provided. Drawings and a mockup of an advanced design were shown along with the proposed operations and functions for the panel. FATTAC was requested to discuss the proposed control panel with their fellow controllers, obtain comments and suggestions regarding the panel and its operation, and assist the Technical Center team personnel in designing the latest version control panels which would be tested at Bradley International.

Suggestions and comments were received from the Bradley controllers which assisted the Technical Center personnel in developing the control display panels that were ultimately built and tested during the evaluation.

An operations document was produced by the Technical Center VICON team which provided instructions, illustrations, and guidance for the use of the control display panel and described the responses of the panel during its use. This guide was produced and sent to the facility for distribution to the controller personnel. In addition, a "Self Study Unit and Test" (see Volume II) was developed by the Bradley Evaluation and Proficiency Development Specialist (EPDS). The Self Study Unit and Test was based upon the operations document.

During March and April of 1979, the "Mimic" and "Matrix" control display panels (figures 3 and 4) were fabricated by the electronic technicians of the Technical Center who were assigned to the project team. As the panels were completed, they were taken to the sustaining engineering laboratory where they were installed in the mockup of a Welton-Becket tower console. They were also interfaced into the simulation device (which has previously been described) and underwent bench testing. Each of the control display panels was subjected to a regime of full testing prior to delivery and installation at Bradley International.

The third VICON control display panel, which was developed and tested during the evaluation, was the "Touch Sensitive" control display panel (figure 5). Because this panel was not completed until December of 1979, full bench testing as was done to the other panels was not possible since the control cables had already been installed in the Bradley ATCT. Testing on the touch sensitive control display panel was, therefore, somewhat limited before its installation.

Each of the three VICON control display panels was to be tested for a period of 45 days. Upon completion of the testing, the controllers were polled to determine which of the three panels was preferred. The preferred panel was then installed in the console of the ATCT and remained in place until the test was concluded on March 31, 1980.

During the month of April 1979, a Technical Center aircraft (Convair 580) was dispatched on three occasions to Windsor Locks to transport Bradley ATCT and maintenance personnel to the Technical Center. During each of these trips, 14 to 18 persons were brought to the Technical Center for the purpose of receiving a comprehensive briefing on the VICON system and the control display panels. After every briefing, the controllers and maintenance personnel were afforded the opportunity to have hands-on training with the control panels through the use of the simulation device.

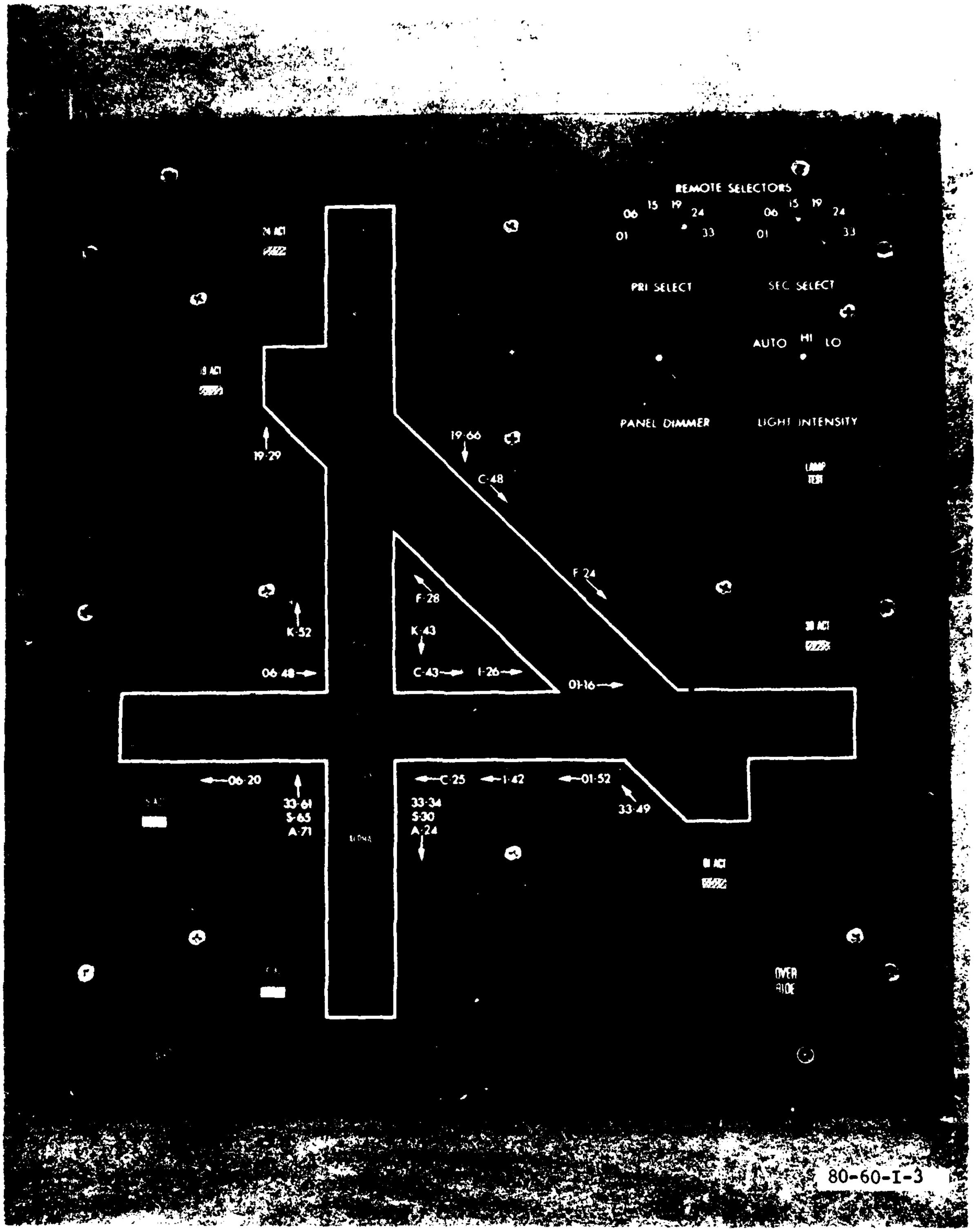

FIGURE 3.   MIMIC CONTROL DISPLAY PANEL

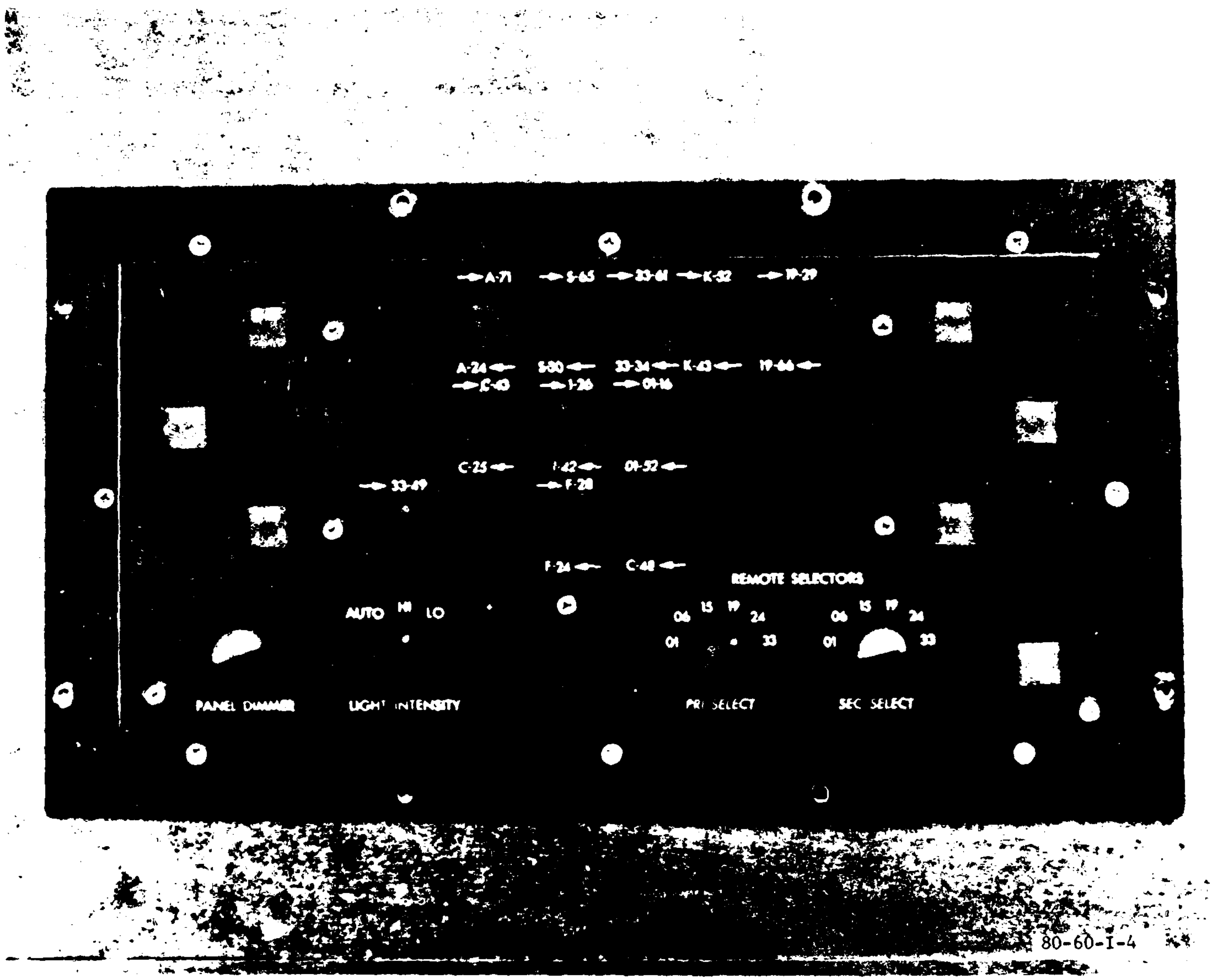

FIGURE 4. MATRIX CONTROL DISPLAY PANEL

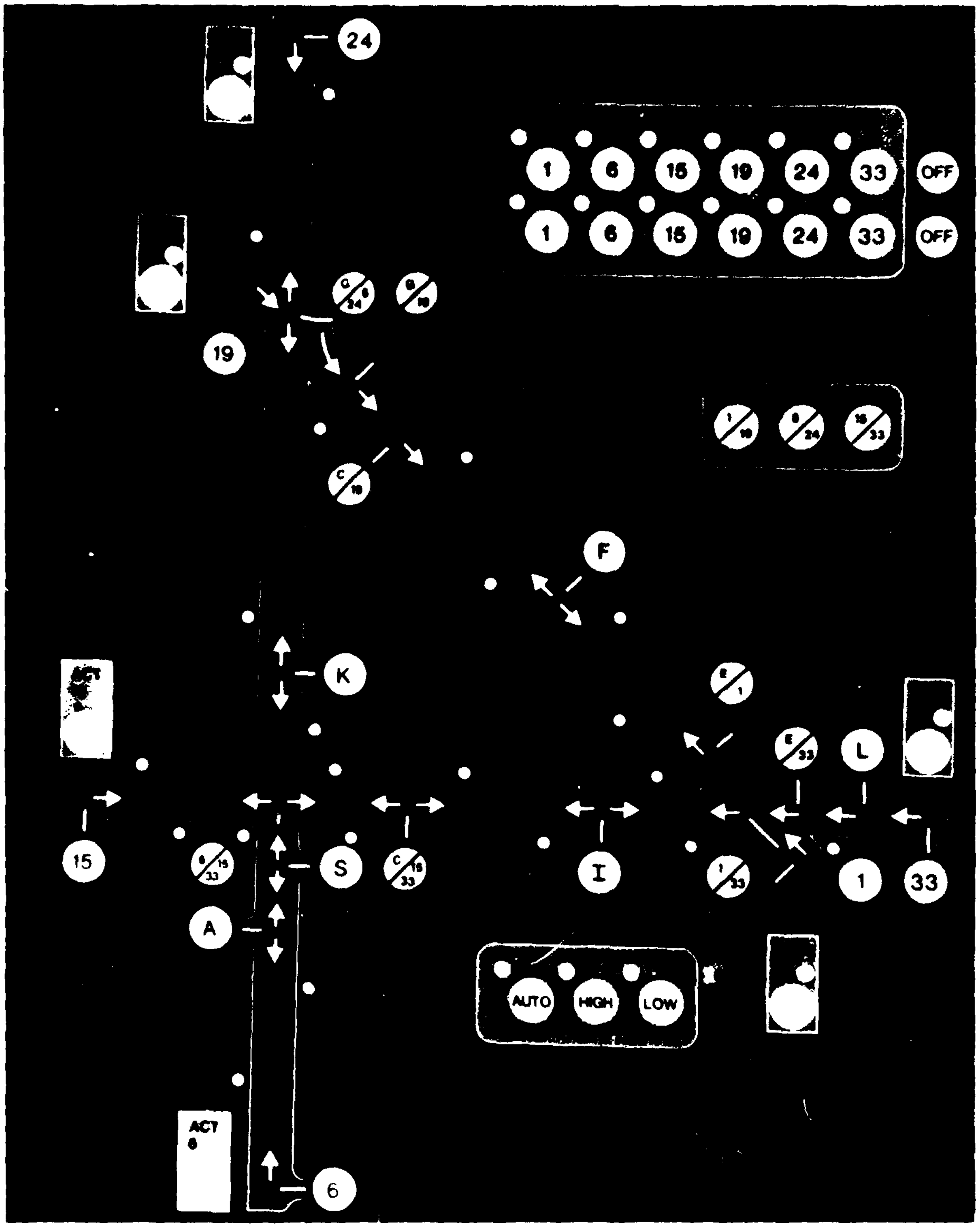

FIGURE [illegible]. TOUCH-SENSITIVE CONTROL DISPLAY PANEL

In addition to the briefing and hands-on training, the controllers also received additional briefings and training from their own facility personnel. A VICON control display panel was provided to Bradley controllers for their familiarization use. Further, the mimic control display panel was installed in the ATCT console during the month of July 1979, and it remained available for training the controller personnel. The control panel provided a realistic opportunity for training and familiarization, however, modifications had been made to the circuitry to prevent activation of the light clusters from the control panel.

The operational instruction guide which was prepared by the Technical Center's VICON team described, in detail, the operation of the VICON control display panels. It also described the procedures for use during the evaluation period, procedures for testing the VICON panels and system (with a suggested time schedule for system checks), and procedures for maintenance notification.

This document was reproduced and sent to the facility for individual distribution to all controller personnel. These operational guides were also to be used as a quick reference in the event a controller had questions concerning the operation of the panels or the system.

The VICON Self Study Unit and Test, developed by the Bradley EPDS, was used in conjunction with the operational instructions and description for the VICON control panels provided by the VICON team. This training was provided by the Bradley training department along with briefings to train the controller personnel in use of the VICON system. (Refer to Volume II for both the VICON operational instructions and the Self Study Guide and Test.)

During the first 5 weeks of the operational evaluation, a Technical Center VICON team member (an ATCS) was on station Monday through Friday from 0800 to 1630. During this period of time, the team personnel offered additional briefings to controllers as they signed on duty at the local control position. The VICON team members were also available to answer questions, offer advice, and provide suggestions during this period of time.

<u>AIRWAY FACILITY PERSONNEL TRAINING.</u> The Bradley Airway Facility personnel were afforded the opportunity to travel to the Technical Center along with the Bradley controller personnel aboard the FAA aircraft provided by the Center. These Airway Facility personnel were provided the same briefing and opportunity for hands-on operation of the control panels as were the controllers.

Engineers and technicians of the Technical Center's Airport Development Division's Visual Guidance Branch, and technicians of the Systems Simulation and Analysis Division's ATC Applications Branch, developed a maintenance manual which described the hardware in detail, provided specific information to assist in troubleshooting, and contained parts lists along with diagrams and schematics of the system and their various components. This manual also included a copy of the operational instructions designed for the controller personnel, so they too would have reference to the operational aspects of the control display panels and the VICON system. This operations and maintenance manual (Volume II) was provided to each member of the Airway Facilities Service located at Bradley International.

Installation of the VICON hardware (except the electrical cabling and cement pads for the VICON equipment) was accomplished by Technical Center personnel assisted by New England Region personnel, electrical contractors provided by the New England Region, and by the Airway Facilities personnel from

Bradley International. Training and knowledge of the VICON system and its components were acquired by the Airway Facilities personnel during their assistance in the installation of the system; after installation they had the responsibility for troubleshooting and performance of minor maintenance as required.

Engineers from the Technical Center were on site at Bradley International during the first 3 weeks of the evaluation period to detect any installation or equipment problems and rectify them. During this period, they also provided additional training to the Bradley Airway Facilities personnel. When not on station, Technical Center engineers and technicians were on 24-hour call, in the event that any major problems arose which could not be handled by the Bradley Airway Facilities personnel.

Bradley ATCT maintenance personnel had the responsibility for checking the VICON equipment daily, recording the switch counter readings, and changing the voice recording tapes as required. Details of this data collection equipment and procedures are provided in detail in Volume II.

PUBLICIZING VICON FOR PILOT INDOCTRINATION. In order to attain the greatest opportunity for success in the evaluation of the VICON system, it was realized early in the program that it would be necessary to obtain the cooperation and assistance of the airport users. Not only would it be necessary for pilots to utilize the system, but it would be advantageous to obtain the pilots' cooperative participation in the evaluation by obtaining their opinions, comments, and suggestions along with answers to specific questions regarding VICON. This section of the report will address the efforts of the VICON team members to publicize the VICON system, to solicite user participation in the evaluation, and to indoctrinate the user on the system and its use.

USER PARTICIPATION. A meeting was held on October 18, 1978, to advise the tenant organizations and users of Bradley International about VICON, to discuss the intended in-service evaluation, and to request cooperation and participation. Personnel from the following organizations were invited:

1. Air Carriers (Those using Bradley International as a regular scheduled stop.)

2. Regional Airlines

3. Air Taxi or Commuters

4. All Cargo Carriers

5. Connecticut Air and Army National Guard

6. The Local Fixed-Base Operator

7. Connecticut Department of Transportation, Bureau of Aviation

8. Bradley Flight Service Station

9. Professional Air Traffic Controllers Organization

10. Pilot and Aircraft Owners Organizations such as Air Transport Association (ATA), Airline Pilots Association (ALPA), Aircraft Owners and Pilots Association (AOPA), National Business Aircraft Association (NBAA)

In addition, representatives from FAA Washington Headquarters, Systems Research and Development Service (SRDS), New England Region, and the Bradley ATCT were invited to attend.

Along with an earnest entreaty for cooperation and participation, a request was made for assistance to distribute VICON information and questionnaires to pilots within each of the represented organizations. Suggestions were obtained to further distribute VICON information.

One of the primary data collection devices was the anonymous, postage-paid pilot questionnaire which asked specific questions and allowed the pilots to make comments and suggestions (figure 6). These questionnaires were approved for distribution and use by the Office of Management and Budget. Tenant organizations were requested to distribute pilot questionnaires through their local dispatch or operations officer.

This procedure was subsequently adopted by most of the tenants. Some organizations included a copy of the questionnaire with other documents which were given to the flight crews before departure.

DISSEMINATION OF VICON INFORMATION TO USERS. The following are approaches which were utilized prior to and during the evaluation of the VICON to acquaint Bradley pilots/users with the system.

1. Video Tape — At the initial representative meeting a recommendation was made by one of the air carrier representatives that a movie or video tape be made about the VICON system and its use. A copy of the movie and tape was to be forwarded to each of the organizations that utilize Bradley International, and each organization could then show this movie or tape to their flight crews during their regular training periods.

This recommendation was accepted and a video tape was produced by the personnel of the Technical Center's audio-visual laboratory, with the assistance of the VICON team. The video tape described the VICON system, its purpose, and its suggested use. The tape also urged participation of the users, requested their inputs through the pilot questionnaires, and described where and how these questionnaires could be obtained. The video tapes were produced both in color and black and white. Tapes were sent to a previously designated contact in each of Bradley International's user organizations and to the pilot or aircraft owners organizations. The tapes were used by these organizations to disseminate the information to their personnel.

2. Briefings — For organizations located on or near Bradley International, visits were made by VICON team personnel to provide the flight crews with a detailed briefing on the VICON system.

The Connecticut Air National Guard was visited prior to the start of the evaluation during their regular monthly training weekend. The video tape was shown, and questions raised by the pilots were answered.

Contractor personnel from Input Output Computer Services, Inc. (IOCS), visited a number of general aviation organizations' monthly meetings, discussed the VICON system and requested their participation filling out the pilot questionnaires.

Fixed-base operators at 11 airports (located in the states of Connecticut, Massachusetts, and New York) were visited by VICON team members, briefed on the VICON system, and requested to urge pilots of their organizations to participate in the evaluation when flying into Bradley International. These fixed-base operators were provided with posters, to be displayed where the pilots would be most apt to see them, and a supply of pilot questionnaires.

The Bradley Flight Service Station was visited, and the personnel were briefed on the VICON system. This was done so the Flight Service Station Specialist would be aware of the system tests and would be capable of answering pilots questions and providing related information. Flight Service Station personnel were requested to remind departing pilots about the VICON system and offer pilot questionnaires to the pilots who had filed flight plans in the facility.

This report is authorized by the Federal Aviation Act of 1958, as amended, sections 303, 311 and 312. While you are not required to respond, your cooperation is needed to make the results of this survey comprehensive, accurate and timely.

INSTRUCTIONS

During the period from August 1979 to February, 1980, an operational evaluation will be conducted at Bradley International Airport, Windsor Locks, CT (BDL) of an experimental light system which is intended to confirm the standard voice takeoff clearance. The non-standard, occulting, green lights are installed at the left front of each takeoff position at BDL.

The intent of this system is not control, but to confirm the voice takeoff clearance by a green light which will be turned on by the tower controller at the time takeoff clearance is issued.

When the visual confirmation (VICON) is observed, it is requested that an acknowledgment be transmitted to the tower. It is also requested that the non-receipt of the confirmation signal be questioned with the tower.

The VICON lights are turned off automatically. They may turn off prior to the start of your takeoff roll, or to your passing the light cluster. This does not indicate that your takeoff clearance has been cancelled. Only the voice instruction from the control tower can cancel the takeoff clearance.

Your cooperation is requested in completing this VICON pilot's questionnaire. If you fly out of BDL from August 1, 1979, through February 29, 1980, please fill in one of these forms after each departure, seal it and drop it in the most convenient mail box. They are post paid. Additional forms are available from the FSS, NWS office and from the BDL FBO.

(1) Fold Back Here

(2) Fold Back Here

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
ATLANTIC CITY, NEW JERSEY 08405

OFFICIAL BUSINESS
PENALTY FOR PRIVATE USE, $300

POSTAGE AND FEES PAID
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U.S. MAIL

VICON Research Project
ANA-210, Bldg. 14
DOT/FAA/NAFEC
Atlantic City, N.J. 08405

PILOT'S VICON DEPARTURE QUESTIONNAIRE

Form Approved
OMB No. [illegible]

ORIENTATION

This questionnaire is intended to obtain pilot opinion of the VICON system described in the current issue of the Airmen's Information Manual. It is expected that the use of VICON will enhance safety without creation of additional pilot workload. Answer this questionnaire only with regard to your latest departure, fold, seal and drop it in a mail box.

IDENTIFICATION AND CIRCUMSTANCES

Your license type ______________ Flight hours ______________

Aircraft type ☐ Air carrier ☐ Military ☐ Air taxi ☐ Business ☐ Other G.A

Aircraft make/model ______________ Date of takeoff ________ Time ________

Departure point at BDL Runway ________ Intersection of Runway ________ and Taxiway ________

How many times, including the present, have you filled in one of these VICON forms?

☐ 1 ☐ 2 ☐ 3 ☐ more than 3

VICON DISPLAY CHARACTERISTICS

Did you see VICON lights? ☐ Yes ☐ No

Please rate the VICON light clusters	Excellent	Good	Marginal	Poor	Bad
Distinctiveness	☐	☐	☐	☐	☐
Perceptability	☐	☐	☐	☐	☐
Location	☐	☐	☐	☐	☐
Intensity	☐	☐	☐	☐	☐

VICON UTILITY RATINGS

Did you ask for VICON lights? ☐ Yes ☐ No

Please rate VICON on the following characteristics, where 1 = made things much easier, 2 = made things easier, 3 = made no difference, 4 = slight impediment, 5 = caused difficulty.

	1	2	3	4	5
Effect on cockpit workload	☐	☐	☐	☐	☐
Effect on clarity and understanding of clearance	☐	☐	☐	☐	☐
Effect on expeditiousness of your departure from BDL	☐	☐	☐	☐	☐

VISIBILITY AT TAKEOFF

☐ Poor ☐ Fair ☐ Good

COMMENT

Please write your comments, descriptions or suggestions for VICON here

FAA FORM NA 7233-12 (2-79)

80-60-I-6

FIGURE 6. PILOT'S VICON DEPARTURE QUESTIONNAIRE

3. Posters — Posters were drawn up and printed (figure 7) which described the VICON system, the in-service testing, and the dates of the evaluation. Pilot participation was requested by asking them to complete a questionnaire and mail it back. These posters were provided to the dispatch or operations offices of all user organizations at Bradley International. The posters were to be placed where they could be seen by flight crews prior to boarding their aircraft or while they were preparing or filing their flight plans. Posters were also distributed to the fixed-base operators at the various airports visited by the VICON team personnel.

4. News Releases — An informative article was prepared for release to the news media through the Technical Center's Public Affairs Office. The article described the VICON system and its operation, the purpose of its evaluation, and the location of the evaluation. The news release requested participation in the in-service valuation by those pilots who fly into Bradley International, by obtaining a pilot questionnaire, observing the system and its use, completing the questionnaire, and mailing it to the Technical Center's project team. It pointed out the postage-paid, preaddressed, and anonymity features of the questionnaire. More than 200 releases were distributed by the Technical Center's Public Affairs Office to aviation-oriented magazines, journals, newspapers, and radio and television stations.

5. Graphic Notices and Supplemental Data — A notice of the operational evaluation was prepared and submitted to the FAA's National Flight Data Center for entry into the Graphic Notices and Supplemental Data publication and also into the Notices to Airman (Class Two NOTAMS). The notices provided information on the evaluation of the VICON system at Bradley International and provided a short description of the system and its use.

The article in the Graphic Notice and Supplemental Data publication included a runway diagram of Bradley International displaying the approximate locations of the VICON light clusters.

This information was printed in these publications from July 1979 until the completion of the evaluation at the end of March 1980.

6. Notice to Airmen (NOTAM) — A NOTAM was prepared by Bradley ATCT personnel announcing the start of the operational evaluation on October 15, 1979.

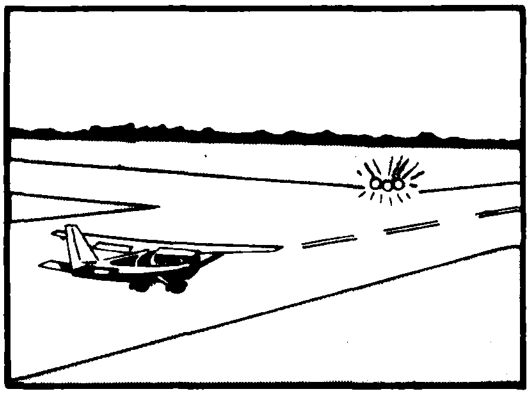
7. Automatic Terminal Information Service (ATIS) — In order to alert and/or remind departing pilots of the VICON system and the evaluation which was in progress, a short notice was placed on and transmitted over the Bradley International ATIS. Technical Center VICON team personnel had suggested that the ATIS information be broadcast for at least the first 2 months of the evaluation. However, a decision was made by the facility management that broadcast of the VICON information after the fourth week was no longer required.

OPERATING PROCEDURES.

One of the primary considerations for the development of the VICON system was that the system would to be simple to use and that minimum added workload would be placed upon the controller, the pilot, and the flight crew.

A system was developed, subsequently, that required a single task for the controller; i.e., that he push a button to activate the VICON signal. The extinguishing of the VICON light cluster was automatic (see appendix 2 of Volume II for complete operating instructions). The requirement for the pilot was that, at the time of receipt of the takeoff clearance, he look for the VICON signal (on the left edge of the departure runway) prior to departure.

FEDERAL AVIATION ADMINISTRATION
NATIONAL AVIATION FACILITIES EXPERIMENTAL CENTER *
ATLANTIC CITY, NEW JERSEY



The FAA's National Aviation Facilities Experimental Center (NAFEC) would like to enlist the participation of pilots in an evaluation of an experimental light system referred to as VICON (Visual Confirmation of Voice Takeoff Clearance) at the Bradley International Airport designed to enhance safety.

The evaluation will be conducted at Bradley International Airport, Windsor Locks, Conn., during the period of September 1979 through March 1980.

VICON consists of a cluster of three green lights installed at all departure locations on the airport. They are located on the left side of the runway at each departure location in line with the runway edge lights.

The intent of this system is not to control, but to "CONFIRM" the voice takeoff clearance by the green light and will be turned on or activated by the control tower operator at the time takeoff clearance is issued. The "VISUAL" confirmation of voice takeoff (VICON) signal, will always be the pulsating green light. When the visual confirmation is observed, it is requested that an acknowledgement be transmitted to the tower. It is also requested that a non-receipt of the confirmation signal be questioned with the tower.

The confirmation lights are turned off automatically by a timer or other electronic devices. The lights may turn off prior to the start of the takeoff roll. The light going out does not indicate your takeoff clearance has been cancelled. Only the voice instruction from the control tower will cancel the takeoff clearance.

Your assistance in this evaluation is requested by filling out a questionnaire available at the BDL FSS, Weather Station Fixed Base Operators Office and Airline Flight Operations. Questionnaires are also available by writing: VICON Project Office, ANA-210, FAA/NAFEC, Atlantic City, New Jersey 08405.

80-60-1-7

* Name changed to Federal Aviation Administration Technical Center

FIGURE 1. PUBLICITY POSTER

The operating procedures for the controllers for use of the VICON system during the in-service operational evaluation were as follows:

1. Clear the departure for takeoff according to the instructions specified in Air Traffic Control Handbook, FAA Order 7110.65B.

2. *Concurrently with, or immediately* after issuance of the voice takeoff clearance to the departing aircraft, depress the appropriate VICON light cluster activation switch.

Pilot procedure was as follows:

1. Receive the voice takeoff clearance from the control tower.

2. Look for the VICON light signal (left side of the departure runway — left front quadrant of the aircraft when in departure position).

3. Acknowledge receipt of the departure clearance *and, also acknowledge seeing* the VICON light. This can be accomplished concurrently.

4. If no VICON light was observed by the flight crew, request confirmation of the departure clearance prior to applying power.

DATA COLLECTION.

All data collected during the entire evaluation period at Bradley International were protected using various measures to ensure complete confidentiality of individuals (both FAA and non-FAA) and aircraft.

There were four major factors included in planning for the operational evaluation.

First, there is no substitute for testing VICON in an operational environment in a field facility. Exposure of VICON to around-the-clock, 7 days a week, live operational use under variable conditions of visibility, weather, and traffic levels provided a realistic test of the strengths and weaknesses of VICON, and provided the opportunity to examine the level of user acceptability by ATCS and by pilots.

Second, the VICON testing at Bradley International was structured so as not to disturb the operation of the facility. Tower observers performed their functions unobtrusively, without interfering with the operational environment in the tower cab. Magnetic tape data recording equipment and VICON switchcounter recording devices were installed in the fourth floor equipment room to ensure that controllers need not be disturbed.

Third, user inputs during the evaluation were deemed to be important. To realistically evaluate the feasibility of VICON, it is essential that the pilots and controllers who use the system provide their first-hand reactions to real, as well as imagined, operational benefits and problems. Furthermore, their opinions, suggestions, and recommendations are valuable inputs.

Fourth, to assure that the appraisal of the operational evaluation was unbiased, a technical consultant, IOCS, was selected by the Technical Center. This company is not an equipment manufacturer, designer, or sales distributor, and does not have a vested interest in the outcome of the operational evaluation. Furthermore, it is reasonable to assume that pilots and controllers would be more at ease and more candid in discussing their personal experiences with VICON if they talked to non-FAA interviewers. Finally, a pledge of anonymity was provided to pilots and controllers during all aspects of user data inputs, including interviews, questionnaires, reports, tower observer assessments, data tapes, and switchcounter readings.

The following nine data sources were used to obtain the maximum range of subjective and objective information about the functioning of VICON and the personal reactions, comments, and suggestions of its users, both pilots and controllers: Pilot Questionnaires, Pilot Conference Sessions, Controller Reports, Controller Interviews, Tower Observers, Data Tapes, Switch Activation Counters, Weather Reports and Traffic Logs, and Maintenance Logs.

1. Pilot Questionnaires. The questionnaire was designed by the FAA to encourage a wide population of pilots departing from Bradley International to convey their frank opinions of the VICON system by providing checkoffs to seven sets of scored answers relating to display characteristics and utility ratings. The bottom of the form offered the pilots space to add their comments, suggestions, or opinions about VICON. The top of the form asked a minimum number of reference questions about their departure to allow analytical study of the scored answers and comments.

2. Pilot Conference Sessions. Three series of pilot interviews were conducted by IOCS to provide the opportunity for individual pilots, and representatives of specific pilot groups to discuss three broad questions — three different questions with scored answers — and to offer comments, suggestions, and opinions.

During the interview, the pilots were given a copy of the pilot interview form so that they could follow the line of questioning that the IOCS interviewer was developing.

The interview format sought responses as to the greatest benefits (and shortcomings) of VICON; any unusual personal experiences when using VICON; an assessment of personal difficulties or annoyances; the value of VICON to the National Airspace System; and any comments, suggestions, or opinions.

3. Controller Reports. The controllers report form was designed to provide a convenient means for the controllers using VICON to voluntarily and anonymously disclose their experiences, provide a count of the number of times each of six different situations may have occurred during their shift, and offer comments or suggestions for improvement of the VICON system.

4. Controller Interviews. Three interview sessions were conducted by IOCS staff members during controller break intervals. The questions were developed to obtain information about the controllers' attitudes and experiences with VICON and to generate discussion about their personal experiences with the system. Finally, the opportunity was provided to solicit their comments, suggestions, and recommendations.

At every interview, the interviewer explained the purpose of the session and gave the controller a copy of the controller interview form so that they could follow the line of questioning that the IOCS interviewer was developing.

The interviewer sought information by asking several broad questions as well as questions that required scored answers, and attempted to bring forth comments, opinions, and suggestions.

5. Observers. Observers were stationed in the ATCT to achieve firsthand, closeup observations of the operations of the VICON system and its effect on other ATC functions. The observers worked in pairs under the direction of a supervisor; all were IOCS staff members.

An observer's worksheet and report was used to allow each observer to provide scored reports (completed every half-hour) of controller workload, additional workload caused by VICON, the contribution to safety by VICON, and details of specific VICON occurrences, as well as comments, opinions, and recommendations about the VICON system operations. In addition, a departure log form was used to supplement the observer's report form to record certain time intervals during takeoffs.

Finally, at the end of each daily data collection period, the tower observers were interviewed by their supervisor to obtain the benefit of their experiences, reactions, and opinions. A tower observer interview checklist form was developed for this purpose.

A sampling plan was devised (see appendix B) to determine the basis for scheduling the observers. This was done to ensure that adequate samples would be obtained to allow the analysis of those variables which might impact the VICON operation. The important variables included weather, traffic level, traffic mix, aircraft type, runway use configuration, and night versus day.

6. Data Tapes. The Technical Center staff designed, fabricated, and installed a data acquisition system to record voice actuated data on a continuous, 24-hour-a-day, unattended basis throughout the entire evaluation period. High quality magnetic tapes recorded local control, ground control, VICON signal activation tone by location, and continous digital time readout.

Time was recorded to the nearest second in Greenwich Mean Time; the days of the year were numbered consecutively. The tape reels were replaced every 3 days, on the average. An alarm system was provided to alert maintenance in the event that a malfunction had occurred in the data acquisition system.

7. Switch Activation Counters. The data acquisition system included an array of switch activation counters designed to provide a total count of the number of VICON control panel individual switch movements as well as the override or cancel switch movements. On a daily basis throughout the evaluation, counter readings were recorded by maintenance personnel on forms developed for this specific purpose by Technical Center personnel.

8. Weather Reports and Traffic Logs. The standard National Weather Service data reports were obtained as when required for the tower observer data collection intervals. The data used included hourly observations of visibility, ceiling, wind, and other related meteorological information.

Facility traffic data that is regularly compiled and reported on FAA Form 7230-12, were also obtained on a daily basis during the data collection periods to provide a basis for comparison of actual traffic levels with those determined in the data sampling.

9. Maintenance Logs. The facility maintenance logs (FAA Form 6030-1) were used as a record of equipment failures, system downtime, and times necessary to restore failures.

DATA ANALYSIS.

The evaluation and analysis of the data was performed by IOCS staff at their offices in Waltham, Massachusetts. Data forms, interview reports, questionnaires, and magnetic tapes were sent every few days to Waltham. The Technical Center provided IOCS with a functional duplicate of the appropriate components of the Data Acquisition System that was installed in the ATCT Equipment Room to facilitate the readout of the four separate channels of data contained on the tapes.

Refer to appendix B for details as to the specific analytical approach that was used for treating each element of the data collection inputs. However, in general, certain analytical approaches were common to all forms of data inputs.

For structured data (where responses are scored from 1 to 5, for example, on questionnaires) frequency distributions were calculated and correlated with weather conditions and traffic levels by time period. Trends were identified by comparing the results of succeeding time periods.

The unstructured subjective statements, on the other hand, were categorized and quantified where possible, and response patterns and distributions were prepared. Correlations were determined for weather, traffic level, and time periods.

The statistical techniques used are defined in appendix B.

EVALUATION OF IN-SERVICE TESTING

GENERAL.

Consultants, under contract to the Technical Center, were utilized to perform the data collection, reduction, and analysis to assure impartiality in the evaluation. Because of this, the test data and the test results are separated in this report. The main texts of the consultants' reports are located in the appendices. An evaluation of tests conducted by the Technical Center's VICON team personnel and a summary of results are documented within this text.

IOCS was the contractor designated to accomplish the data collection and analysis of the primary data during the evaluation period. The report of IOCS's efforts can be found as appendix B of this report.

Vitro Laboratories Division of Automation Industries, Inc., was the contractor designated to perform a predictive reliability study of the equipment and components of the VICON system that were initially installed and used during the evaluation period.

The Vitro reliability study can be found as appendix C to this document. Appendix A, "Availability Predictions and Minimal Cut Sets" and appendix B, "Fault Tree Diagrams" of the Vitro report have not been reproduced for inclusion in this report; however, they will be held at the library of the Technical Center, and will be available for examination by interested parties. A copy of the diagrams and printouts will also be made available for inclusion in the final technical data package if a determination to implement VICON is made.

SUBJECTIVE EVALUATION.

The subjective evaluation was based upon four factors: (1) information collected by IOCS from the pilot questionnaires, (2) feedback from the tower controllers, (3) monitor tape recordings, and (4) miscellaneous suggestions and information gathered by the tower observers. Certain technical problems were encountered during the evaluation process with regard to the system and its components. Whenever these problems could be corrected on location, they were. However, there were instances of reported problems of such a nature that corrections were not feasible because of cost, time, or disruption to the facility.

PILOT FAMILIARIZATION. An extensive publicity program was initiated to familiarize user pilots with VICON and its operation. This involved the dissemination of information about the VICON system — how it should be used, its purpose, and its evaluation at Bradley International. However, it was found during the evaluation that there were still a great number of pilots who were unfamiliar with the

VICON system or its use. The greatest majority of the unfamiliar pilots was in the general aviation group. Though articles about the VICON system and its use were placed in aviation-orientated magazines, in the newspapers in the area, and on radio and television, many pilots still had not heard about the system. Others had heard about it but indicated, through the quesionnaire, that they forgot about it while taxiing out. Even after a visit to fixed-base operators at 11 airports in the vicinity of Bradley International where briefings, posters, and questionnaires concerning the system were provided, there was no increase in the participation of the general aviation population between January 1980 (when the airport was visited by the Technical Center personnel) and March 1980, when the evaluation ended.

It has also been stated by some of the pilots that the intermittent use or activation by the controllers of the VICON system, especially during the months of January, February, and March of 1980, was the reason that some pilots became disinterested in the evaluation, since they were never sure if the light would be turned on or not. This intermittent use also caused some confusion and mistrust in the system among the pilots.

SUNGLARE. The sun shining on the VICON lights sometimes caused confusion. It was difficult to determine whether the lights were on or whether they were reflecting the sun. Appendix A gives a complete evaluation of the sunglare problem, the tests that were conducted to study the problem, and the light modifications that were made in an effort to correct the problem. Three color photographs are included in the appendix to demonstrate the effectiveness of sunglare shields.

Q6.6A/PAR56/3 HIGH INTENSITY SPOT LAMP. During the testing period, efforts were continually put forth to improve the system in one way or another. The ability to command the attention of the pilot to see and take note of the lights during the very busy period when he is taking off is a formidable task. One method tried was to increase the intensity of the one light that should be seen when the aircraft first pulls onto the runway for takeoff. This high intensity spot lamp was installed at the spot for takeoff from runway 33, and the intensity of the lamp was increased from 16,000 to 200,000 candela. It also decreased the beam width from 50° to 12° in the horizontal direction and from 20° to 8° in the vertical direction. The directional spot of this one lamp helped the pilot on the ground to see it while decreasing the possibility of distracting other persons not directly in the beam width of the spotlight. This light was installed during the last month of testing and was considered to be an improvement, when used as noted above, over the normal 200-watt lamp.

MICROWAVE AIRCRAFT DETECTOR. As indicated in the IOCS report (appendix B), there were a number of occasions when the microwave aircraft detector failed to turn the VICON light cluster off after a departure. The report indicates that, in almost all cases, the microwave aircraft detector failed to pick up a small aircraft which apparently was able to become airborne, attain altitude, and pass above the detector beam.

In all cases, except for the detector antenna on runway 15, the antennas were located at a distance of 1,000 feet from the approach end of the runway.

Though the monitor system was working and the control display panel in the ATCT was indicating that the VICON light cluster was still on, this fact is not always detected by the controller. In a number of cases, the fact that the cluster was still on was reported by later aircraft preparing for departure. This occurrence is not operationally acceptable, since it would be confusing to succeeding aircraft that might be taxiing onto the active runway with a clearance from the ATCT to taxi into position and hold. The problem can be solved by the relocation of the microwave aircraft detector antennas to a position closer to the VICON light cluster or closer to the takeoff end of the runway. Care must be taken to place the antenna at a distance far enough down the runway so that large aircraft, when taxiing into position to hold, would still be behind the antennas when coming to a halt. Exact placement cannot be determined since the location of other facilities or equipment (such as the visual approach slope indicators (VASI's)) might prohibit the use of a standard location or placement.

Other than the placement problem just described, the microwave aircraft detector system tested was highly reliable after minor early installation problems had been solved.

USE OF VICON CLUSTER FOR MORE THAN ONE DEPARTURE LOCATION. Due to the locations of certain taxiways with relation to others or to runway ends, an attempt was made, as previously stated, to utilize a single VICON cluster for more than one departure location. These clusters could have been controlled by one activation switch on the control display panel; however, for the purpose of this evaluation, each departure location was provided its own light activation switch. Certain activation switches on the control display panel, therefore, activated the same VICON light clusters.

The locations of the light clusters which were intended for use of more than one departure location are:

1. Taxiways Alpha and Sierra (Runways 06/24)

2. End Runway 33 and Taxiway Lima (Runway 33)

3. End Runway 19, Taxiway Golf and Taxiway Charlie (Runway 19)

4. End Runway 01 and Taxiway Echo (Runway 01)

5. Intersection Runways 01 and 33, and Taxiway Echo (Runway 33)

No datum was obtained during the evaluation which could be used to answer the question as to whether the use of a single light cluster for more than one departure was acceptable. In the opinion of the VICON team members, however, it is felt that this procedure should not be used, if at all possible. Each departure location should have, whenever possible, its own discrete VICON light cluster as well as its individual activation switch. It is reasoned that this would reduce possibilities of confusion on the part of the controller and help keep the number of erroneous activations to an absolute minimum. It is also reasoned that confusion on the part of the pilots would be reduced by the fact that each of the departure locations would have its own light.

LIGHT CLUSTERS VISIBLE FROM MORE THAN ONE DEPARTURE LOCATION. Comments received on the questionnaires and comments made by the controllers indicated that departure aircraft could see VICON lights at various locations in addition to the light for a particular departure. This could present a problem, especially at night, when pilots would not be able to see the VICON light cluster housings and could only see the light cluster which was lit. They could not positively identify that light as the one belonging to a particular departure location. Two aircraft could be preparing for departure at two different locations along the same runway. If those locations were close, and if the departure at the location further down the runway was cleared for takeoff and given the visual confirmation, it would be possible that the crew of the aircraft behind (at the other departure location) could see the VICON light and think the departure clearance was for him. Two aircraft could then be mistakenly on the runway at the same moment.

The VICON system was designed to ensure that the VICON lights could be seen from all possible departure locations where the pilot might be waiting to receive the takeoff clearance from the ATCT. This was accomplished so there would be no need for an agency procedural change for the controller to use the system; the only requirement being for the air traffic ATCS to push a switch to activate the VICON light.

In those cases where aircraft are taxied into position to hold on the runway, the aircraft's final position cannot be exactly predicted because of the aircraft's size, the taxiing speed, maneuverability, etc. In other cases, takeoff clearance is given while still on the taxiway or runup area which affords the crew the option to line up on the runway, to stop and then to takeoff, or to make a rolling takeoff. Because of this variability, it is not possible to really determine where an aircraft would be positioned when it is ready for takeoff. Further, it would not be feasible to design a light signal which would be directional to the point of requiring aircraft to be positioned at certain locations or positions in order to see the VICON light. A procedure such as this would be detrimental to maintaining present levels of operations and would present additional hardships to the controller.

PLACEMENT OF LIGHT CLUSTERS. Numerous comments were received via the pilot questionnaires, pilot conferences, and reports from pilots through the ATCT via radio, with respect to the placement of the VICON light clusters.

The data from the pilot questionnaires and as analyzed by IOCS (appendix B, par. 8.3.2.2) indicated that the rating for "location" of the light cluster appeared to be much lower than the ratings of other display characteristics such as "distinctiveness, perceptability and intensity." It should be pointed out, however, that the number of pilots who answered this question (54 percent) indicated that the location of the lights rated good or excellent, whereas only 29 percent rated the location marginal or worse. The remaining 17 percent either did not answer the question or were ineligible to answer because they indicated they did not see the lights.

Although 25 percent more pilots indicated the light locations were satisfactory, it was obvious to the evaluation team that some of the VICON clusters were too far down the runway from the runway end. Also, many of the pilots who had rated the location as marginal or worse indicated that they felt the light clusters were too far down the runway. This was especially true for the cluster at the end of runway 33 which was located 1,000 feet from the approach end. More complaints were received concerning the location of the VICON at the end of runway 33 than any other departure location. Of the 362 pilot comments received regarding the location of the clusters, 126 rated the location marginal or worse. Of those, 39.6 percent departed from the end of runway 33.

The cluster at the end of runway 33 was purposely placed at that distance since it was being tested as a dual purpose cluster and served departures from taxiway Lima as well as those from the end of runway 33. Ordinarily, two light clusters would have been placed in operation at these locations; consequently, one would have been much closer to the runway 33 end. A recommendation provided in an earlier report for phase I suggested a distance of 600 feet. As stated earlier, other equipment might prevent exact placement of VICON lights for all takeoff locations according to a set standard; however, it is felt that placement should be as close as possible to a distance selected for general guidance.

Few adverse comments were received on the placement of the VICON lights at intersection departure locations. These lights were generally placed at a distance of 400 feet from the centerline of the taxiway serving that departure location.

DISTINCTIVENESS AND PERCEPTABILITY. Although these two display characteristics were rated rather well by the pilots on the pilot questionnaires (appendix B, par. 8.3.2), some comments were received which suggested the clusters should be higher above the ground and moved so they would not be in line with the runway-edge lights.

The light cluster heights were determined by applicable agency regulations which specify allowable heights of equipment with regard to their relationship to the runway. Therefore, unless a waiver is obtained, the VICON light clusters could not be placed higher nor could they be moved closer to the runway.

Even though it was suggested, clusters were not moved away from the runway (during the evaluation period) because of costs to relocate them. This would have required that a contractor pour new concrete bases for the clusters and adjust the cabling. Also, comments were received stating that some pilots confused the VICON lights with the VASI system. Moving the lights further away from the runway and raising them would have placed the clusters more in line with the VASI lights, probably compounding this problem between the two systems. It is not understood why the confusion between the VICON lights and the VASI's took place, since the two systems have completely different colored lights. Other suggestions were received regarding the location of the lights, and they can be found in the IOCS report located in appendix B.

PROBLEM OF UNAUTHORIZED DEPARTURES. The IOCS final report provides data, in the form of comments from personal interviews with controllers and pilots and from comments taken from the pilot questionnaires, that some participants of the evaluation doubt that the problem of unauthorized takeoffs exists within this country. Certain comments received suggested the use of VICON only at airports which regularly serve foreign air carriers.

Current data indicate that the problem of unauthorized takeoffs does exist in this country in spite of comments stating that there is no problem.

In the fall of 1978, the Transportation Systems Center (TSC), which was also involved in studies of the VICON system, traveled to the various FAA regional headquarters in the continental United States. At each regional office, copies of the Air Traffic Controller Interview Questionnaires were left with a request that they be distributed to each ATCT within the region. These questionnaires were returned to TSC, and the data were analyzed.

The first questions on the questionnaire pertained to the number of times aircraft departed without the local controllers' permission, and in addition the number of times they may have witnessed such occurrences. These answers were limited to the previous 3 years. The above information was published by TSC in a final report (reference 1).

The particular questions and the answers TSC received from those facilities which responded to the questionnaire are as follows:

1. How many times, as a local controller, have aircraft departed without your permission? 2,040.

2. How many times have you witnessed aircraft departing without a clearance? 2,058.

A response was not received from each ATCT; however, the data obtained indicate there was an average of approximately 680 unauthorized domestic departures each year between 1975 and 1978.

In addition to the data obtained by TSC, data are also available from the National Aeronautics and Space Administration (NASA) Aviation Safety Reporting System (reference 2). In NASA's Eighth Quarterly Report (January 1 to March 31, 1978) there were 135 reported occurrences of aircraft moving without proper clearance. Of these occurrences, the highest was runway intrusion (or crossings); the second highest was takeoff clearance. The lack of a takeoff clearance amounted to 23 percent, or 31 out of the 135 occurrences. The NASA report also indicated that a pattern was evident in the takeoffs without clearance. The report states, "In 7 of 10 cases, an aircraft took off immediately after a takeoff clearance was delivered to another aircraft. One case involved similar flight numbers, one involved an incomplete clearance, after which two aircraft took off simultaneously on intersecting runways. In the other cases, the reason for takeoff was unknown in one, a probable language problem in a second, a crew member's misinterpretation of a question from the other pilot in the third."

COMPARISON OF CONTROL DISPLAY PANELS.

It was intended that the three control display panels would be installed and tested for a period of 45 days each. At the conclusion of the test of the third panel, the controllers would be queried for their preference, and the preferred panel would then be placed in position and used for the remainder of the test period.

Testing of the Mimic and Matrix type panels was completed on schedule. The touch-sensitive panel, which was the third to be tested, only remained in position for a period of 18 days. It was found that after installation of the touch-sensitive panel, use of the system by the controllers began decreasing. Investigation by IOCS and facility supervisors as to the reason for the decrease in participation by ATCT personnel revealed two primary faults of the touch-sensitive panel: (1) There was no feel to the touch-sensitive switches; consequently, there was no feedback concerning a possible connection being made. (2) The lights in the panel were not sunlight readable.

For these reasons the controllers had difficulty in determining that a connection actually had been made after depressing a switch. At times it required the controller to cup his hand around the lights on the panel or to move over to the panel and get directly over it to observe the lights. These faults were not present in the quick and easy operation of the other two panel systems.

Results of the control panel tests, as taken from the controller interviews by IOCS, can be found in appendix B, par. 9.5. In brief, the controllers preferred the Mimic panel over the others and stated that it was easiest to use because of the map layout and the positive feel of the pushbutton switches. The touch-sensitive panel, even with the faults, was the second choice. The map layout was well liked, and it would appear that this panel was liked because of its aesthetic appearance rather than for reasons relating to the operational usage.

RELIABILITY AND MAINTENANCE OF CONTROL DISPLAY PANELS.

Vitro Laboratories — Predicted VICON System Reliability/Availability. The predicted availability of the VICON System as installed at Bradley International is 99.94 percent, which means that the Bradley VICON can be expected to be capable of performing its defined mission of data collection during 99.94 percent of the 5 1/2-month test period.

The reliability of the VICON system has no bearing on its ability to perform the defined data collection mission. However, it can be noted that the Bradley VICON installation has a minimum reliability of 99.998 percent with respect to the granting of any single VICON configuration.

FAA Technical Center — Control Panels and Interface Electronics.

1. Mimic Panel

a. Alternate action switches — All of the runway activation switches are alternate action types. Two of these switches had to be replaced. The first failure hinted of misuse, although no concrete evidence of this exists. No explanation could be given for the second failure. Contact with the manufacturer was made, and the following reply was received: "After reviewing the problem with our manager of manufacturing, the conclusion was that the problem occurred from two possible actions: (1) relamping the cap and putting the cap back into the body in a position which is not top to top. The cap is marked top and keyed such that this is the only way to get it into position; (2) putting the cap in the indicator body and pushing it like a switch." Subsequent to these failures, tests were conducted at the FAA Technical Center with the Mimic panel engineering model. Twelve-hundred activations of the alternate action type switches on this panel were conducted with no failures. After replacement of the switches in the control panel (at Bradley International) for a 90-day period of testing, no other failure occurred.

b. Momentary Action Switches — All of the light cluster activation and override switches are the momentary action type. For a 90-day period of testing, 17,734 total switch depressions with an individual switch total of 4,651 were recorded with no failures.

c. Switch Lamps — Each switch in the panel contains four T-1 lamps per panel. For the total test period, eight lamp failures were recorded. It is interesting to note that these failures were observed by Technical Center personnel and not recorded as a failure by the user (controller). This occurred because only one lamp per switch had failed and, due to the unique optics system of the switch, no "hot-spot" was observed (i.e., legend maintained uniform brightness). This design affords less downtime per switch due to lamp failure.

d. Panel Overlay Lamps — There is a sum total of 18 lamps within this overlay. For the total test period, no failures were recorded.

2. Matrix Panel

a. Alternate Action Switches — For a 47-day period of testing, no failures of this type switch occurred.

b. Momentary Action Switches — For a 47-day period of testing with 8,197 total switch depressions, an individual switch depression total of 2,868 was recorded with no failures.

c. Switch Lamps — No failures recorded.

d. Panel Overlay Lamps — No failures recorded.

3. Touch-Sensitive Panel.

a. For an 18-day period of testing, no failures of any nature were recorded.

The total of switch activations equaled 5,424. Individual switch activation total equaled 1,426. The low usage (18 days) of this panel was due to a major man-machine interface design problem. The controllers disliked this nonfeedback (nontactile) condition of the switch and found poor to zero visibility (washout) of the return signal during daylight hours. This panel design used the membrane type switch with visual (illumination) feedback; and if it could not be seen, there was no verification of switch activation. This was a major problem, and it adversely affected user attitude toward continued participation in the test program.

4. Equipment Cabinet.

a. Time delay relays — For the total period of 167 days, two failures of this type relay were recorded. Again, these failures were noted by Technical Center personnel and not recorded as outages by the user. Examination showed that the relays would "start-time;" however, they would not "time-out" (failure of a component within the circuitry). Use of the system was still available by depression of the override switch which would then reset the relay. No other hardware in this cabinet failed.

TECHNICAL OPERATION OF HARDWARE. The "Operations and Maintenance Manual" (volume II of this report) and the "VICON Test Plan for Hardware During Phase II" will provide complete documentation of how the entire VICON system operates and how it was tested. Both before and during phase II, the system was subjected to environmental tests at the Technical Center, and a VICON reliability analysis was performed contractually by Vitro Laboratories. During the 5 1/2 months of operation at Bradley International, further operational and reliability data were obtained. Actual operation proved that the system was very reliable and capable of operating with little maintenance for long periods of time. Information, as detailed below, was obtained from the facility maintenance logs and from the pilot questionnaires.

1. Control Lines.

The control lines, located between the control tower and the VICON building, and the power lines to each light cluster were tested for proper operation before the operational tests started, and no failures were recorded during the 5 1/2 months of testing.

2. Relay Control System.

The entire relay control system located in the VICON building (which included the auxiliary pilot relay cabinet, the timer relay cabinet, the power relay cabinet, the power distribution cabinet, the monitor relay cabinet, the pulser assembly, and the photocell intensity control system) operated without any problems. The only exception was that twice during the 5 1/2 months of testing two of the monitor relays had to be adjusted.

3. Radio System.

The radio system of controlling the VICON runway end lights at 15, 33, 06, and 24 was successfully tested at the Technical Center for proper operation before installation at Bradley International in an environment of temperatures between minus 10° C and plus 50° C and with humidity up to 90 percent (in accordance with specification FAA-G-2100/1b). Once installed and debugged, the system worked without a failure. It was found after some operating time that, because of its design, the radio system could miss a signal from the override button if the button was activated for less than 75 milliseconds. This problem was alleviated by installing a pulse stretcher in that circuit.

The associated relay system used with the radio system also was successfully environmentally tested, as described above, at the Technical Center. It was installed at Bradley International where one failure occurred during the full testing period: A fuse holder at the 06 end of runway 06/24 developed a loose connection which had to be tightened, and the problem was corrected.

4. Microwave Aircraft Detector System.

The microwave aircraft detector (MAD) system installed with each radio system was first tested at the Technical Center under the same environmental tests as noted above and, in addition, tested against an in-pavement inductive loop system for 80 days during March through June 1978. After installation, three problems occurred that required attention: (1) The MAD systems that were located close to the radio systems were being triggered by the radio station. Radio frequency interference (rfi) shields had to be installed between the radio equipment and the MAD systems which alleviated the problem. (2) The power supply for the MAD system at the end of runway 33 developed a problem and had to be replaced. (3) It was found that small aircraft would quite often, during takeoff, climb high enough to be over the top of the 20-foot beam of the MAD system and thereby not shut off the light.

5. Lamps and Associated Hardware.

The 21 light clusters, consisting of three PAR56 lamps per cluster and associated hardware, were installed and tested at Bradley International. After the initial connection problems, no troubles were encountered with the hardware during the 5 1/2 months of testing. Two lamp clusters, however, were damaged by trucks during snow removal operations in February. The locations of these light clusters and the visibility and/or distinctiveness of the clusters was a design problem that was frequently mentioned by the pilots. It should be mentioned that all runway edge lights were routinely marked (by the operating agency of the airport) with small red flags which normally (with the exception of very deep snow) would protrude through the snow and mark the location of the edge light. No such flags or markers had been placed near the VICON light clusters.

6. Data Acquisition System.

The data acquisition system used was primarily a documentation system for the VICON system operational tests and will probably not be included in future installations. A few minor problems developed in this system, such as the failure of a trigger to the tape alarm system and the failure of some test lights. This required replacing some springs and lights during the operational tests. Timely replacement of the tapes seemed to be the major problem with the data acquisition.

7. Solid-State Controller.

During the operational testing of VICON, an effort was made to develop an electronic controller system that was even more reliable and simple to operate than the one initially installed at Bradley. The results of this effort produced a solid-state controller (Struthers-Dunn, Model 3001 Director) that was tested to the FAA-G-2100/1b specification for operation under high and low temperatures and at humidities up to 90 percent (appendix D) and then installed during the last month of the operational tests. This solid-state controller proved to be reliable, programmable, smaller and more cost effective than the system initially installed at Bradley International. It can be programed to do anything that can be accomplished with electromechanical relay switches. The solid-state version replaced all of the pilot relays, the intensity relays, all of the timer relays, and the pulser circuit from the monitor relay cabinet. If all of the light clusters were being activated by the hardwire system, it would (1) prevent opposite ends of the runways from being activated simultaneously; (2) prevent more than three light clusters from being turned on at the same time; and (3) provide a count of the number of times each light cluster was activated. A contract was awarded to provide solid-state high power output cards which will eliminate all of the cabinets except a portion of the power supply cabinet in the VICON building. These output cards can furnish direct high power outputs to the light clusters, monitor the light cluster filament current (yes or no), provide individual current settings for each light cluster, and require only one variable autotransformer instead of the presently required seven. This microprocessor-based system utilized a light erasable read-only memory (LEROM) that requires programing by keyboard changes to the program. The separate programer unit suggests that one programer could be located at a central point and, by typing exclusive programs onto individual LEROMS, could tailor the program to fit every airport in the country. The LEROM would then be mailed to that particular airport for plug-in installation. If changes were needed, a revised LEROM would be shipped to the site and installed. The incorrect board would be shipped back to the central point, erased by ultraviolet light, and filed away for future use. From February 26 to March 31, 1980, the solid-state director operated without a single problem. An operations manual on this director is included in volume II of this report.

Reliability (Field Tests). Vitro Laboratories of Silver Springs, Maryland, performed a predicted reliability analysis of the system as installed, and that report is included as appendix C of this report. The report concludes that the system is 99.94 percent reliable or "available" under the definitions of the analysis. It suggests that certain items should have redundancy. For example, where only one item is provided that could shut down the system (such as the critical power supply), an auxillary supply should be made available. Such conclusions are valid. Five and one-half months of operation have proved that the system can operate for that length of time with few problems. In addition to the reliability report, most of the equipment was required, prior to installation, to pass tests for temperature and humidity standards in accordance with specification FAA-G-2100/1b, entitled "Electronic Equipment, General Requirements." This specification generally calls for proper operation of the equipment during temperature ranges from minus 10° C to plus 50° C and in humidity up to 90 percent. A report concerning the environmental tests performed at the Technical Center on the solid-state controller is included as appendix D.

Design Considerations. The following design problems surfaced during the VICON testing at Bradley International, and they will require close study and further corrective action in order to achieve an optimum system:

1. The problem of distinctiveness of the lights on the field is by far the most mentioned pilot user problem and is one that will be evident as long as the lights are located on the field. With familiarity of the system, a reduction in pilot confusion would be expected.

2. The second most mentioned problem involving the hardware concerns the problem of not turning off the VICON

light at the proper time. If extinction is timed, it will be inappropriate sometimes; if the microwave detector is used, it will also be incorrect sometimes. This specific problem might be eliminated if the indicator were placed in the cockpit and then controlled by a timer; however, sucn a solution is neither feasible nor cost effective.

3. Sun reflection from the light clusters is only a problem before the lights are turned on. Once the lights are on, the difference in intensity makes the fact obvious. Sun shields were installed which appeared to solve this problem, although the time necessary to accomplish extensive testing was not available.

LOGIC ANALYSIS OF SEQUENTIAL VICON OPERATIONS.

Refer to figures 8 and 9 which depict operational scenarios that can realistically be expected to occur with or without VICON. VICON was created to attempt to reduce the frequency of the two types of unsafe/illegal takeoffs that occur as shown in figure 8.

Because VICON is a confirmation signal of the controller's verbal departure clearance delivered to the pilot, VICON provides no benefit (i.e., makes no difference) if the voice clearance is given by the controller and is understood by the pilot. Further, for this condition, there exists the probability of the inadvertent random introduction of undesirable and unwanted events to disturb this condition of complete understanding between the controller and the pilot: (1) the controller inadvertently activates the wrong light button on the control panel, (2) an electromechanical fault occurs in the VICON system, or (3) another departure aircraft mistakenly assumes that VICON light is for him. Finally, VICON might create two sets of circumstances that could lead a pilot to make an illegal takeoff (refer to figure 9).

In condition I, the pilot does not receive a verbal takeoff clearance (he may think that he has for some reason(s)) but sees a green light and takes off, assuming that the green light is his clearance.

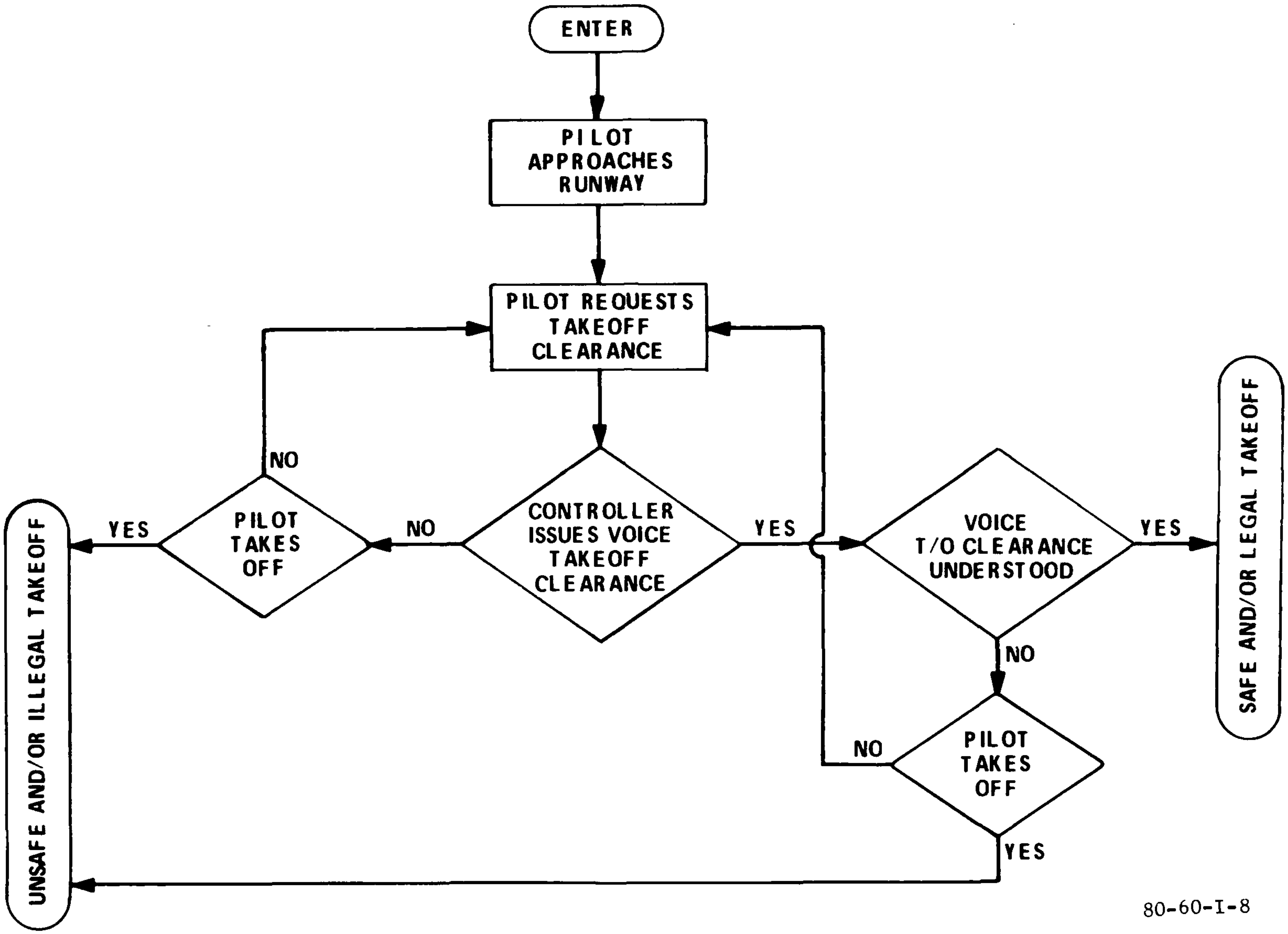
In condition II, the pilot receives but does not understand his verbal clearance, sees the VICON light, and takes off. This is potentially dangerous if the clearance contained additional instructions; the controller assumes the entire clearance is understood, but the pilot has missed the added information.

It should be pointed out that in the real world operational environment, the primary cause of unauthorized departures is that pilots think that they heard and understood a clearance intended for them. So it can be argued that a visual confirmation of the spoken clearance (i.e., VICON) can provide a benefit because it is designed to confirm the departure clearance.

VICON PROJECT PILOT COMMENTS.

The project pilot had the responsibility to support, assist, recommend, and report on his reactions to the VICON concept. To accomplish this, the VICON lights were viewed from the cockpit of a Seneca II, G-159, CV-580, and a B-727 in conditions of darkness, ordinary daylight, and bright sunlight. Unfortunately, the opportunity to view the VICON lights in marginal visibility did not occur. The following comments were made by the project pilot:

1. The VICON lights did not increase the cockpit workload in the test aircraft to any significant degree. Workload, however, was slightly increased when a delay occurred between the controller's verbal takeoff clearance and energizing the VICON lights. This workload was additionally increased when the aircrew had to request the lights. Also, it was not a



80-60-I-8

FIGURE 8. FLOW CHART OF TAKEOFF SEQUENTIAL ACTIONS — WITHOUT VICON

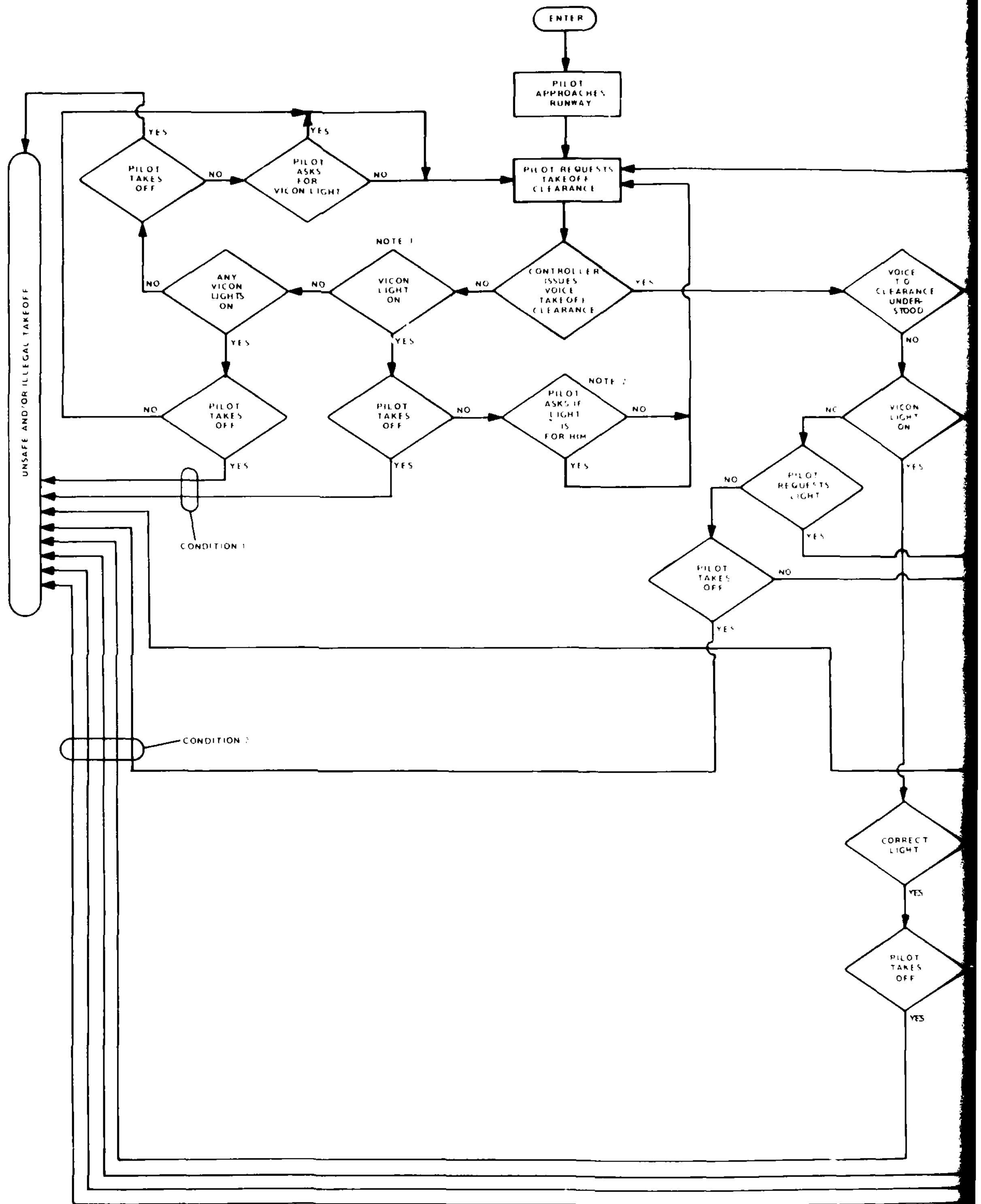
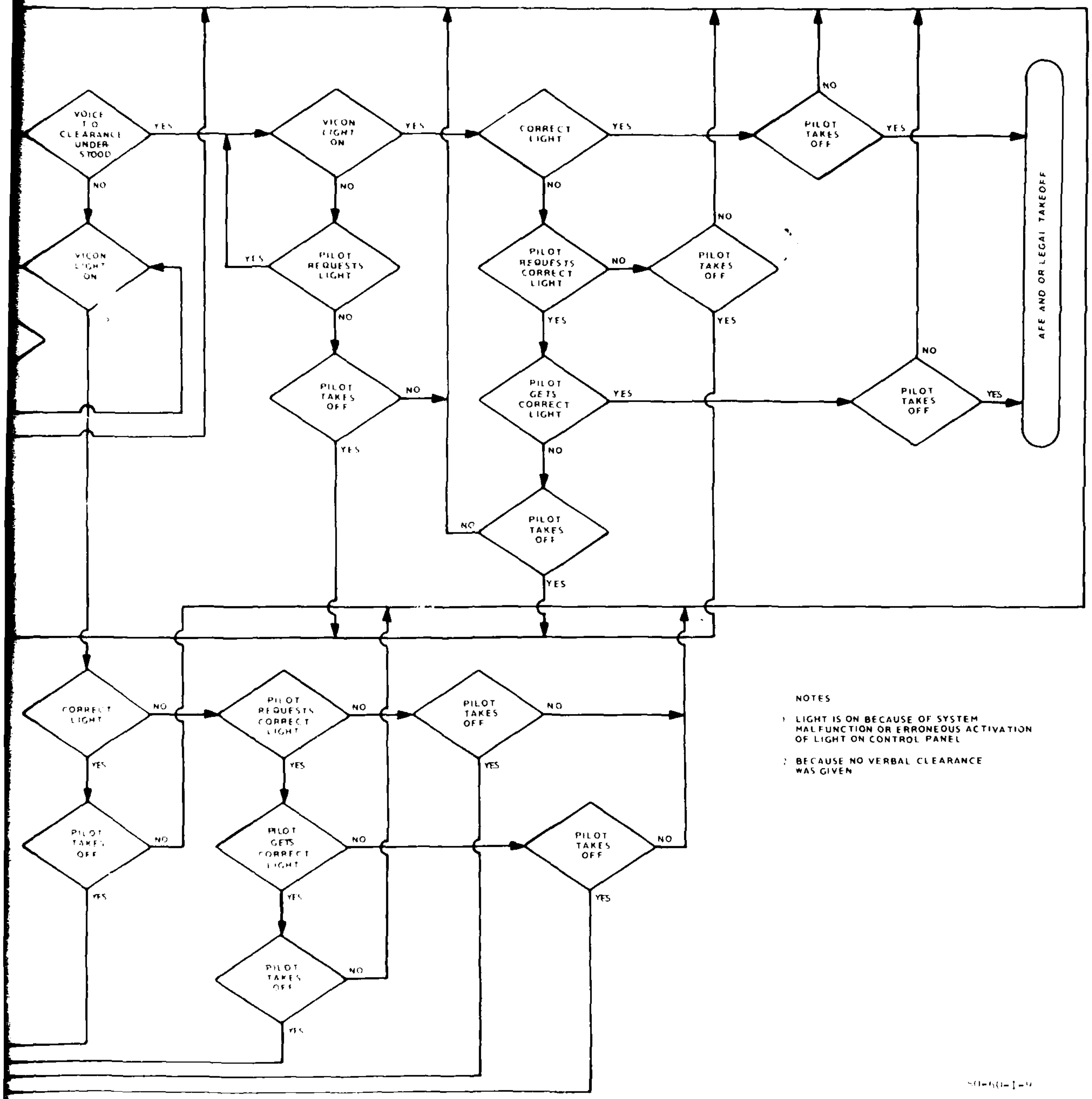


FIGURE 9. FLOW CHART OF TAKEOFF



OF TAKEOFF SEQUENTIAL ACTIONS — WITH VICON hand- or foot-type (physical) workload but, more importantly, a mental detractor from a critical aspect of flight — the takeoff.

2. In the weather conditions mentioned (night, day, bright sunlight) there was little problem locating and recognizing the VICON lights. Naturally, they were more visible at night than in bright sunlight; however, in the conditions viewed, their message was readily discernable.

3. The location of the VICON lights for the test conducted at Bradley International was adequate (other pilot users differed here). The cockpit reaction varied with the size of the aircraft. For example, pilots of large aircraft preferred a more distant location for the VICON light fixture, and pilots of small aircraft preferred the opposite.

4. VICON lights impacted safety. Most pilots when cleared on the runway would (or should) widely scan the approach lane to the runway for landing aircraft. This includes not only the tower controlled aircraft, but also the uncontrolled aircraft at towered airports (i.e., no-radio aircraft, emergency aircraft, aircraft lined up for landing with the wrong runway, or aircraft landing at one airport and talking to the tower of another, etc.) Looking for the VICON lights detracts from this scan. A pilot cannot effectively scan two areas 90° or more apart without some degree of difficulty.

5. Flight testing was conducted on a clear night utilizing a Piper Seneca II to ascertain whether or not the VICON light cluster at a runway end location, when lit, would be distracting or present a problem to the crew when the aircraft was on a short final approach. Three approaches were made to runway 06 and three to runway 33. The VICON lights were called for when the aircraft was within 1/2 mile from the runway. In the opinion of the project pilot, there was no distraction or problem created by the VICON light. Though the crew was thoroughly familiar with the location of the VICON lights on those two runways, they were difficult to find, or see, until the aircraft was over the runway and near the VICON light cluster location.

SUMMARY OF RESULTS

1. The VICON System was technically feasible. The equipment met the requirements of the program, reliability was excellent, and early problems were resolved. For those problems which were not resolved during the testing period, solutions are available.

2. Controllers were encouraged to use VICON, but its use was not mandatory. As a result, controllers did not use the system all the time. This intermittent use caused some pilots to have doubts about VICON.

3. Although the evaluation of the VICON system was given wide, advance publicity through aviation publications, newspapers, television, Department of Transportation publications, Automatic Terminal Information Service (ATIS) (first 6 weeks), and news and information bulletins of air carrier and pilot-oriented organizations, the results indicated that many pilots were unfamiliar with the VICON system, its use, and the testing at Bradley International. Many pilots ignored VICON completely. The majority of the pilots unfamiliar with VICON were those in general aviation. Pilot interviews were very poorly attended. Those representatives who attended or provided comments by phone or mail showed little enthusiasm for the VICON system.

4. Subjective controller opinions indicated that VICON might have a slightly negative effect on safety. Their view was that VICON use increased the probability of a hazardous situation (due to distraction and added workload)

more than it decreased the probability of a hazardous situation (due to unauthorized takeoffs). Observers found that the observable workload required by the constrollers to operate VICON was very low. Controllers also indicated that VICON caused delays and was incapable of preventing runway intrusions. Data collected by the observers and the analysis of magnetic data tapes indicated that there was no evidence of delays attributable to the VICON system.

The most common controller comments were that VICON does not achieve its objectives; the system serves no useful purpose; and the money could be better spent on other equipment.

5. Pilot questionnaires asked respondents to rate the utility of the VICON system effect on cockpit workload, on clarity and understanding of takeoff clearance, and on expeditiousness of departure. The effect on workload and expeditiousness was rated "Made no difference." The effect on clarity and understanding was rated midway between "Made things easier" and "Made no difference." (Some pilots commented that the VICON system created a distraction to the flight crew at the critical time when they are not only preparing the aircraft for takeoff, but also "looking out the windows" for noncontrolled aircraft or vehicles crossing the runway.)

6. Pilot questionnaire analysis indicated that of the four questions, with regard to display characteristics, location of the VICON lights rated the lowest. However 54 percent of the respondents rated the location good or excellent, while only 29 percent rated the location marginal or worse. Seventeen percent did not answer or were not eligible to answer since they indicated they did not see the lights. Of 126 pilot questionnaire ratings of light cluster locations that were marked as being marginal or worse, a majority departed from the end of runway 33 where the VICON light cluster was located 1,000 feet from the runway end. This particular cluster was deemed to have been installed too far from the runway end and would be a candidate for relocation. Night flight tests conducted by the VICON project pilot indicated that the VICON light clusters, when lit, did not present a distraction for flight crews on final approach.

7. Light aircraft departing from runway ends occasionally were able to attain sufficient altitude to pass over the microwave beam causing the VICON cluster at the location to remain lit, necessitating the controller to have to override the system to turn the light off. This is correctable by simply relocating the microwave antennas.

8. Data tapes were analyzed on a sampled basis to measure VICON usage, channel loading, and unusual occurrence information. One-hour data samples representing various conditions were selected over a 6-month period yielding 132 sample hours. Analysis of the 132 hours disclosed that VICON was used by the controllers for 60 percent of the departures (983 of 1,626), but the light was acknowledged by the pilots for only 6 percent of the departures (62 of 983) when VICON was activated. The average VICON contribution to total channel loading for the 132 hours analyzed was 0.1 percent. The total channel use was 13.8 percent.

9. A reliability study of the VICON system was performed. It predicted an overall level of reliability of 99.94 percent and a minimum reliability of 99.998 percent for any individual VICON activation. The reliability of the VICON system (including its components) was very high throughout the evaluation period.

10. Primary considerations during design of the VICON system were to determine an optimum method of (1) activating the system, (2) verifying its

activation, and (3) providing accessibility to the controllers. These three design criteria (embodied in the placement and design of the control panels) were successfully demonstrated as having been achieved during the evaluation. The control display panels developed and tested were simple to use. Normal operation of the VICON system required the controller only to depress the proper activation switch at the time of (or immediately after) the issuance of a takeoff clearance. The lights were automatically turned off electronically. The controllers preferred the Mimic panel of the three different types of control panels that were installed. The Touch-Sensitive control display panel was the second choice of the controllers, but it was removed from service because its lights were not sunlight readable and switch activation did not provide "feel" feedback. The Matrix control display panel was the least liked by the controllers. The controllers did not use the remote control unit after the first few weeks of the evaluation.

11. A sunglare problem that caused the VICON lights to appear to be lit was eliminated by the installation of sun shields.

12. The solid-state Model 3001 Struthers-Dunn Director functioned reliably and without outages during the 5 weeks that it was operational. This microprocessor-based director replaced nearly all of the electromechanical relays in the system.

CONCLUSIONS

Based upon the results of this evaluation, it is concluded that:

1. Visual Confirmation of Voice Takeoff Clearance (VICON) was technically feasible.

2. All components of the VICON system installed at Bradley International Airport functioned in a highly reliable manner.

3. Most VICON design problems which could not be corrected during the evaluation have proposed resolutions and can be corrected.

4. VICON did not demonstrate that it enhanced safety.

REFERENCES

1. Coonan, J. R., VICON Deployment and Analysis Strategies Report, Transportation Systems Center, August 1980.

2. NASA Aviation Safety Reporting System, NASA Technical Memorandum 78540, Eighth Quarterly Report January 1, 1978 - March 31, 1978, October 1978.

APPENDIX A

SUNGLARE

General.

After several weeks of evaluation, it became apparent from controller comments as well as pilot reactions, questions, and suggestions that on clear days the sun was causing some of the VICON lights to appear to be lit when in fact, they were not. Efforts to rectify this problem were immediately started at the Technical Center. The following text delineates the various design modifications developed, the tests conducted at Atlantic City Airport, the equipment installed at Bradley International, and the results obtained.

This sunglare effect was reported predominantly on runways 33 and 06 at Bradley. Because of its alignment, runway 01 should have been affected also; however, there were no reports of this specific problem from departures on this runway. Technical Center personnel evaluated the reported problem and agreed with those making the comments that the sunglare was, in fact, causing the lights on the VICON clusters to appear to be lit. During the morning hours, the problem with the sunglare started on runway 33, and as the day progressed, it moved to runway 01 and then to runway 06.

Visual testing conducted by Technical Center personnel showed that, even though sunglare made the lights appear to be lit, when the VICON lights were actually turned on there was sufficient brightness (together with the occulting feature) that there was no doubt about being able to distinguish the difference. Although the lights could be distinguished when actually lit, it was felt that the glare and appearance of the lights being lit (even though steady and not occulting) was, in fact, a serious problem in that pilots could be confused and, therefore, could misinterpret the glare as the light being on.

Technical Center personnel developed two sun shields (figures A-1 and A-2) in an attempt to eliminate the glare problem. These shields were louvered with horizontal rather than vertical louvers. The horizontal louvers retained the light beam width and prevented the lights from becoming highly directional (as was the case with shields having vertical louvers, which were tested earlier at the Technical Center during the phase I testing). The primary difference between the two shields was the size of the visor; one visor was 10 inches in length, and the other was 5 inches in length. Both sizes of visors were eventually installed and tested at Bradley International.

The first sun shield that was fabricated was installed on the light cluster at the end of runway 33 along with a different type of bulb. The bulb and sun shield were installed on the light, which was aligned parallel to the runway and towards the runup area. When the other five sun shields had been completed, they were installed on the remaining lights at the end of the runway 33 cluster and on the light cluster at the end of runway 06.

Testing was also conducted at the Technical Center to examine the effect of a visor on the sun shield and the possibility of the visor restricting the view of crews in aircraft with extremely high cockpits (such as the Boeing 747) and preventing them from seeing the lights. A "High Ranger" (personnel hoisting device) was utilized to place observers at various distances from the VICON light cluster and also at various heights above the ground.

For the first test, the High Ranger bucket was set at a distance of 75 feet from the light cluster, simulating an aircraft with the cockpit centered on the centerline of a 150-foot-wide runway. At a height of 30 feet (the approximate height of the cockpit of a Boeing 747), the VICON lights with the 5- and 10-inch visors were visible with no restriction from either the shield or the louvers (figure A-3).

For the second test, the bucket of the High Ranger was positioned at a distance of 50 feet from the light cluster at a height of 30 feet. At this point, there was a slight restriction in visibility of the light, more so to the shield with the 10-inch visor (figure A-4, left light) than that of the shield with the 5-inch visor (figure A-4, center light); however, the observer indicated that the amount of light and the visibility of the VICON signal was still more than adequate. The observer in the bucket during these tests was an Air Traffic Control Specialist (ATCS) and a member of the VICON evaluation team.

At the 50-foot distance, observations were made at various heights above 30 feet (figure A-5). The observer reported that the presentation of the light from the lens with the 10-inch visor became unacceptable to him at a height of 36 feet and the lens with the 5-inch visor became unacceptable at a height of 38 feet. These tests were conducted on a clear day in bright sunlight. Not only ATCS's, but also electrical engineers and technicians, were present.

A check of the pilot questionnaires, which were received after installation of the sun shields, indicated only one adverse comment regarding sunglare on the VICON lights. Unfortunately, the pilot did not provide his departure point; therefore, it could not be determined if he had used a departure location where the sun shields were being utilized or one of the departure points which had no sun shield. These tests indicated that both sunglare shields successfully eliminated the glare problem, and both were visible from all types of aircraft unless the aircraft cockpit was 36 feet or higher above the ground and 50 feet or less from the VICON light cluster. This would accommodate most runways which would be utilized by wide body aircraft. Since both sun shields were found effective in eliminating the glare during the test, it would seem feasible that the shield with the 5-inch visor be recommended for use in the future.

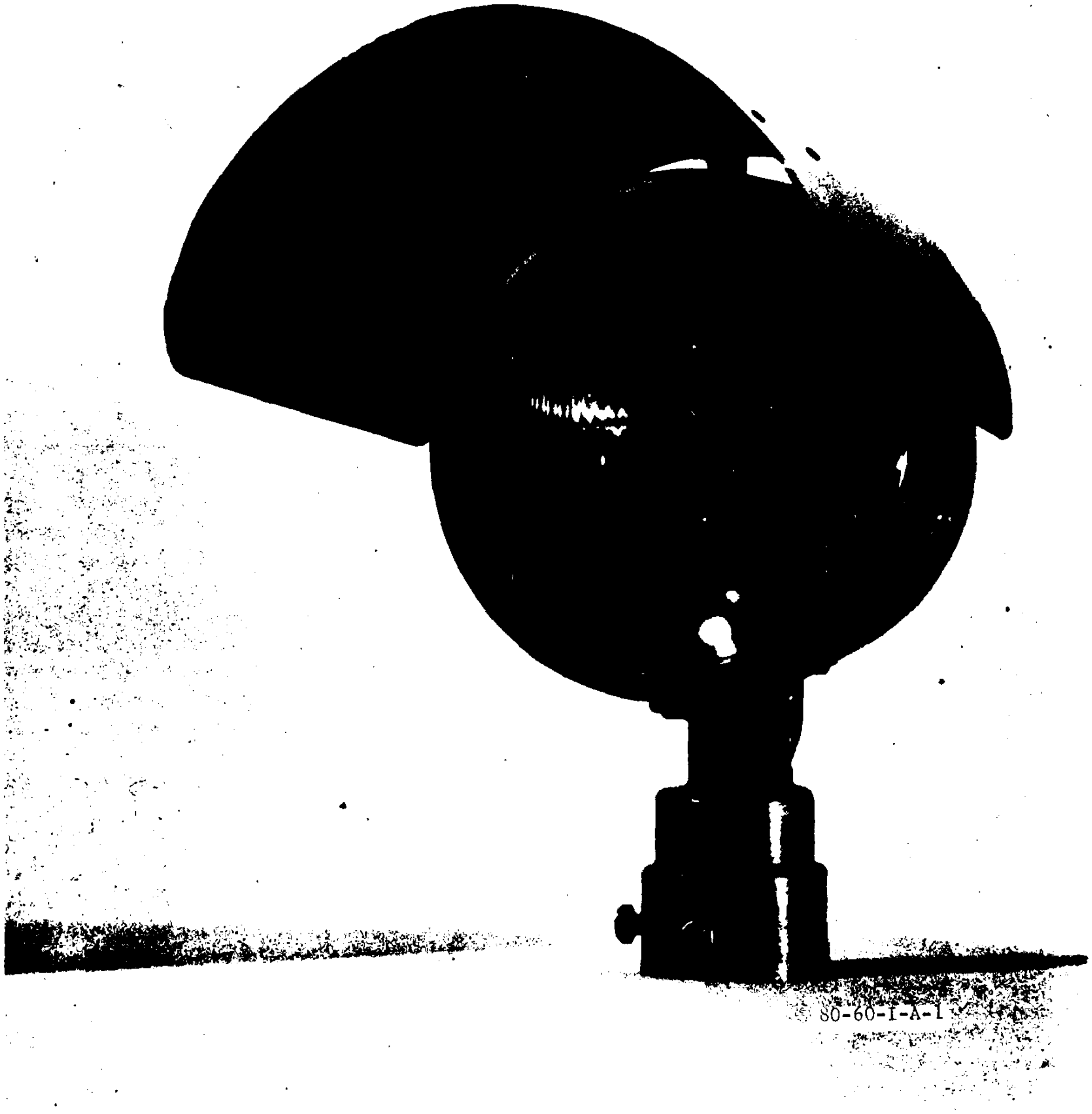


FIGURE A-1. LOUVERED SUN SHIELD (10-INCH VISOR)

FIGURE A-2. LOUVERED SUN SHIELD (5-INCH VISOR)

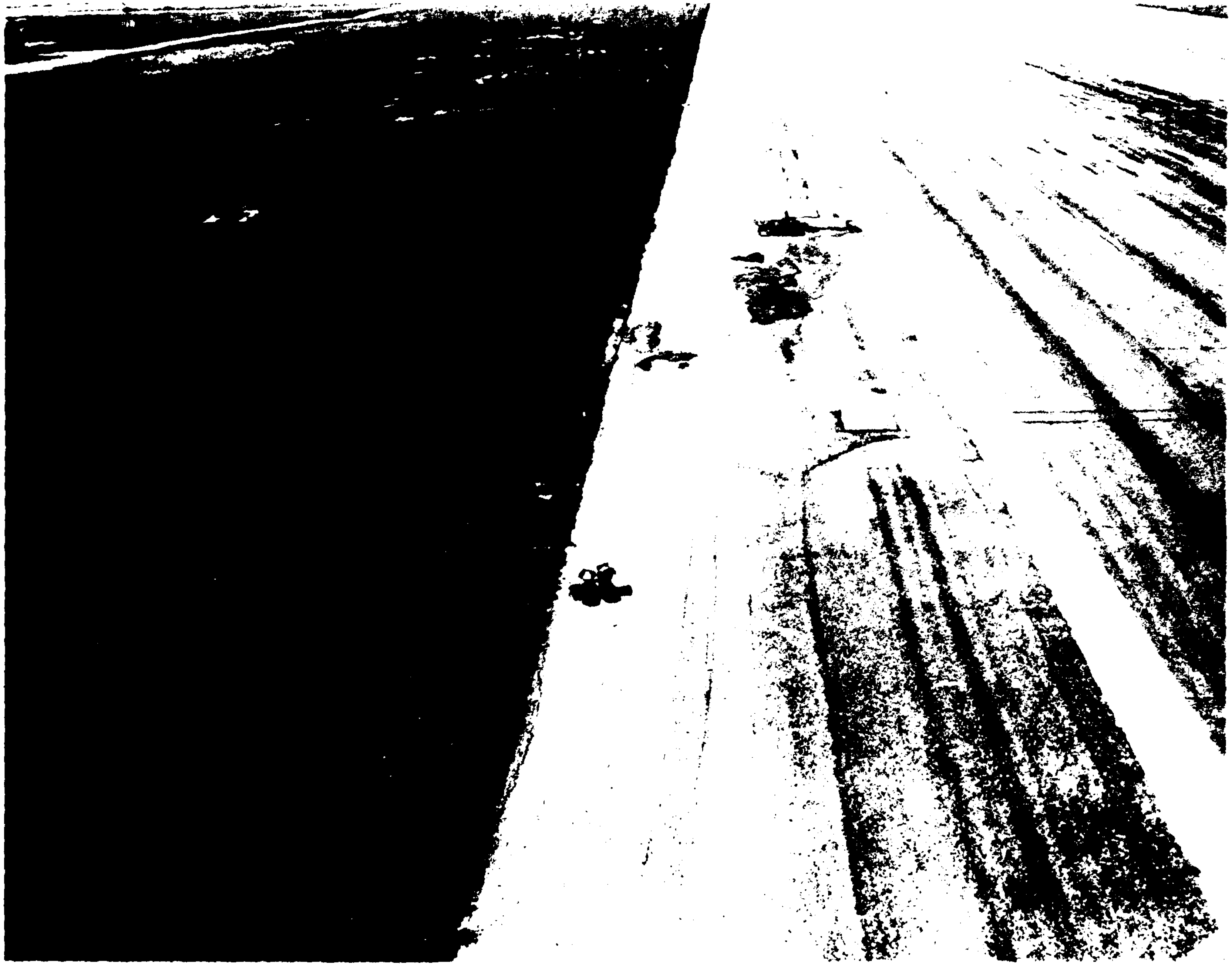


FIGURE A-3. VICON LIGHT CLUSTER (DISTANCE 75 FEET 30 FEET ABOVE SURFACE)

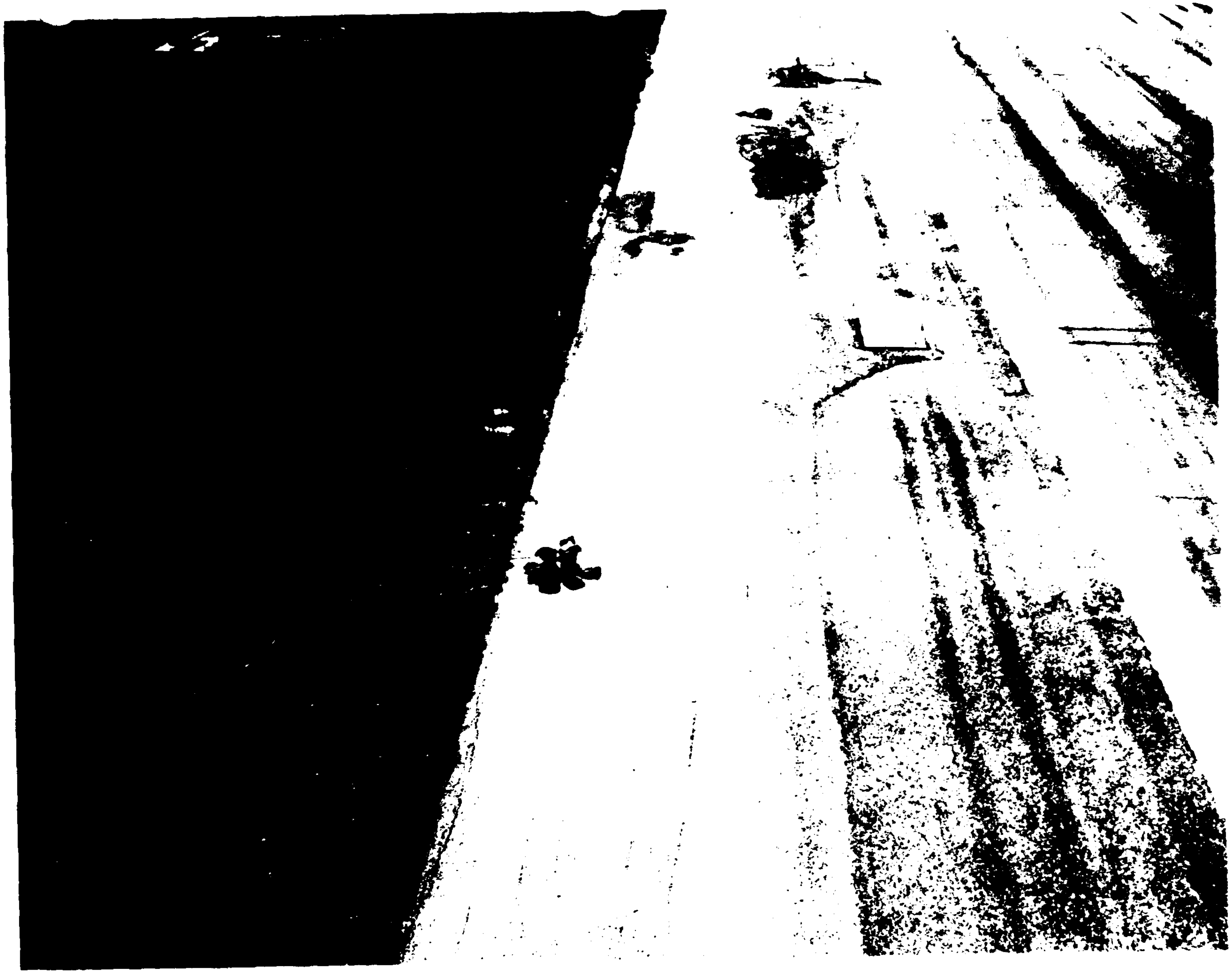


FIGURE A-4. VICON LIGHT CLUSTER (DISTANCE 50 FEET 30 FEET ABOVE SURFACE)

APPENDIX B

VICON FINAL DATA ANALYSIS AND EVALUATION REPORT (IOCS)

(This document was reprinted in its entirety for presentation in this appendix.)

VICON FINAL DATA ANALYSIS

AND EVALUATION REPORT

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July 1980
Final Report

Prepared for:

U.S. DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
Federal Aviation Administration Technical Center
Atlantic City, NJ 08405

PREFACE

This report was prepared by Input Output Computer Services, Inc. (IOCS) to assist the Federal Aviation Administration (FAA) Technical Center in evaluating the VICON test program conducted at Bradley International Airport, Windsor Locks, Connecticut.

The data collection and evaluation were conducted, whenever possible, to obtain the greatest amount of information. Efforts were dynamic, and were not constrained to the narrow viewpoint of evaluating only the specific installation at Bradley Airport. The reasons behind answers and occurrences were sought, and recommendations for improvements and alternatives to the existing system were encouraged and then investigated, so the findings extend far beyond the evaluation of the specific system tested.

Many people contributed to this effort, from both FAA and IOCS, and their assistance is gratefully acknowledged. Several people, however, made special contributions. Mr. Edward J. Dowe, FAA contract technical monitor, provided technical guidance and other essential help in all phases of this program. Mr. George Langdon, Program Officer for FAA Air Traffic Control Tower at Bradley, gave outstanding assistance for all of our work at Bradley. Mr. Charles L. Erdrich, IOCS Program Manager - Analytical Studies, served as the first project leader, and assisted in many ways throughout the data collection, analysis, evaluation, and report preparation efforts. Mr. Steven J. Pozzi performed all of the statistical analyses, and Mr. Teshome Seyoum was responsible for all magnetic tape data analysis. Mr. George H. Hopper supervised the tower observer team and performed many other tasks needed to successfully carry out the program in the Hartford-Springfield area.

This test program produced some surprises. Certain data could not be obtained as originally planned, and changes had to be made. Because of the subjective nature of much of the data and the different viewpoints of the groups of people involved, there are inconsistencies and even disagreements. The response of the aviation community was different from that which was expected. The test program has been interesting, dynamic, and educational.

Frederick L. Hafer
Project Leader

EXECUTIVE SUMMARY

INTRODUCTION

The Visual Confirmation of Voice Takeoff Clearance (VICON) Signal System provided an independent visual confirmation to the pilot of the voice takeoff clearance issued by the air traffic controller. Because of the limitations of voice communication, numerous unsafe ground operations continue to plague the air traffic control systems of the world. These unsafe operations too often result in aircraft collisions. VICON provided a visual stimulus to confirm or supplement the aural stimulus of the voice clearance, providing a cross-check, and thus a higher degree of certainty of correctly interpreting the takeoff clearance instructions.

The VICON system consisted of four major elements:

- A cluster of three green lights located at each takeoff location, on the left side of the runway.
- A control panel at the local controller's position in the tower which permitted the controller to individually turn on each light cluster.
- A timer or other means of automatically turning off each light cluster.
- The associated relays, cables, etc.

A limited prototype system was installed at the National Aviation Facilities Experimental Center (NAFEC), Atlantic City, New Jersey. This test effort, designated Phase I, provided preliminary system development and initial operational test data. A complete system was subsequently installed at Bradley International Airport, Windsor Locks, Connecticut, for a full-scale operational test, designated Phase II. The Phase II test was designed to evaluate the VICON principle, to provide additional insight regarding pilot and controller response to this principle, and to validate system and equipment design. The Phase II test began on 15 October 1979 and ended 31 March 1980. This Final Report presents results obtained through the entire test period.

OBJECTIVE

The overall objective of the test program was to determine the operational acceptability and technical feasibility of VICON in a field operational environment. This involved answering three key questions:

- Is visual confirmation of voice takeoff clearance technically feasible?
- Can VICON be successfully integrated into the present ATC system?
- Does VICON provide an added measure of safety?

DATA SOURCES

In order to obtain a full range of information about the functioning of the sy ᵐ and the reactions and opinions of the pilots and controllers w use it, the following data sources were established:

- Tower Observers who provided first-hand observations of VICON operation and its effect on other ATC functions.
- Pilot Interviews with pilot representatives and individual pilots.

- Pilot Questionnaires which encouraged pilots to submit their experiences and opinions regarding VICON.

- Controller Interviews which solicited the experiences and opinions of individual controllers.

- Controller Reports which encouraged controllers to report specific occurrences on their particular shift and to submit comments and recommendations.

- Data Tapes which contained recordings of all local and ground control communications, plus VICON system activation and Greenwich Mean Time.

- Hourly Weather and Traffic data obtained from the National Weather Service and the tower traffic log.

- Maintenance Logs in which all VICON system preventive and corrective maintenance was recorded.

EVALUATION METHODOLOGY

In the analysis and evaluation process, the data from each individual source was organized, analyzed, and summarized in its original form of questions and answers, comments, recommendations, and unusual occurrences. These results were then applied to address the three key areas of technical feasibility, system integration, and contribution to safety.

The individual source results were then organized and integrated to provide comprehensive findings. Results from one source were cross-correlated with related results from other sources to confirm or contrast the first results. Occurrences were similarly correlated and checked against all applicable sources to obtain comprehensive findings. The integrated findings were then presented in terms of feasibility, integration, and safety.

TOWER OBSERVER DATA

The Tower Observers were in the tower on six-hour shifts, four or five days per week. Data collection was emphasized during periods of heavy traffic and bad weather, although very little bad weather occurred during the test period. The Observer Report form was used to periodically evaluate the controller workload, the additional workload caused by VICON, and the VICON contribution to safety. The Departure Log was used to log aircraft takeoff time data and identification. Both forms also requested recording comments, occurrences, and suggestions.

The controller workload was rated as Low. The additional workload caused by VICON was rated between Low and Very Low. The additional workload increased as the controller workload increased, but at a lower rate. The contribution to safety was overwhelmingly rated Neutral.

The Observer Report ratings indicated that traffic level did directly affect controller workload and additional workload caused by VICON. There was a statistically significant direct correlation of weather conditions with both controller workload and additional workload caused by VICON.

Significant comments indicated that two-runway operation increased controller workload and that some controllers were not using VICON or were using it intermittently. A number of important occurrences were reported. Light planes did not break the microwave beam to turn off the green light. Sunlight reflections off the green lens caused uncertainty. A number of times an aircraft was cleared for takeoff but did not go, since the pilot was waiting for the green light.

The Departure Logs were used originally to record the times at which clearance was issued, VICON was activated, the aircraft entered the runway, and the aircraft started to roll. The derived time intervals between clearance and VICON activation and clearance and start of roll were expected to indicate delays due to VICON by the controller and pilot, respectively. VICON activation could not be observed (it was recorded on the Data Tape) because of the physical layout of the tower, so controller delay could not be determined in this manner. Possible pilot delays have been checked, but no delay is apparent from this data.

PILOT INTERVIEW DATA

Pilots and Pilot Representatives were interviewed at three sessions to determine their opinions and experiences with VICON. There was little enthusiasm for the system. The objections were: the lights were poorly placed and hard to identify; VICON was not needed as there was no present problem; VICON was too costly for the values received - the pilots much preferred use of funds for other equipment such as VASI, ILS, DME, runway intrusion control systems, etc.; and the system caused distraction and added workload at a very busy time. Pilots felt VICON imposed a minor use difficulty on the pilot and had a slightly negative value for the National Airspace System. The opinions on nationwide installations varied considerably.

In addition, the interviewers attended the monthly meeting of a General Aviation pilots' association. Of 29 pilots, two had used VICON. Of the remainder, one third were aware of VICON but had never seen the lights, and two thirds were completely unaware of VICON.

PILOT QUESTIONNAIRE DATA

NAFEC prepared a printed, stamped, and addressed questionnaire to be given to each pilot departing Bradley. After departure, the pilot was to complete and mail the questionnaire; 432 questionnaires were received.

Display characteristics of Distinctiveness, Perceptibility, Location, and Intensity were rated. Location was rated Marginal-to-Good and the other display attributes were rated Good. The ratings did not improve as pilot use of VICON increased.

The pilots were also asked to rate the utility of the system - Effect on Cockpit Workload, Effect on Clarity and Understanding of Takeoff Clearance, and Effect on Expeditiousness of Departure. The Effect on Cockpit Workload and Effect on Expeditiousness of Departure were rated Made No Difference. Effect on Clarity and Understanding of Clearance was rated midway between Made Things Easier and Made No Difference, but the large spread of ratings indicated that pilots were more uncertain about their opinions.

There was no change in the utility ratings with either increased VICON usage or different visibility conditions.

Comments were grouped into five subject areas - favorable, unfavorable, neutral, equipment, and procedures. Favorable comments (15%) stressed the improvement in safety created by the redundant, backup check and confirmation provided to the pilot when he is very busy; this is especially important when visibility is bad. Unfavorable comments (27%) dealt primarily with three concerns. First, the money could be better spent on other kinds of equipment. Second, VICON was not needed as the problem of no-clearance takeoffs does not exist in the U.S. Third, safety was negatively affected because VICON created distraction and added workload at a very busy time. Neutral comments (4%) were submitted only in November and indicated the pilots were unwilling or unable to form an opinion because of a lack of experience with the system.

The largest number of comments (37%) dealt with the equipment. The lights were poorly positioned and were difficult to locate and identify. A number of pilots recommended a red/green traffic light idea. Last, the sun caused problems by blinding the pilot or by making the green light appear to be on when it was not. Procedures comments (17%) stated that the controllers did not use VICON in any consistent manner and the pilots were unsure how they should respond. The pilot check lists did not include VICON and many forgot to use it. Finally, some pilots did not know how VICON operated or how it should be used.

CONTROLLER INTERVIEW DATA

Controllers were interviewed at three sessions to obtain their experiences and opinions with VICON. The Additional Workload Caused by VICON was rated Low at low traffic levels but increased at least as fast as the traffic level increased. Almost half the controllers stopped using VICON at high traffic levels. There was some indication that VICON also affected the ground and departure controllers. In terms of Safety Effect, the average rating was slightly negative, meaning that VICON caused more difficulty than benefits. The only benefit consistently cited is that VICON sometimes improves safety by acting as a double check on the verbal clearance. The most commonly cited flaws were distraction, increased workload, delay, and inability of the system to prevent runway intrusion.

Each interview was concluded by asking the controller for suggestions, comments, and occurrences. The most common items were that VICON does not achieve its objectives, that the system serves no useful purpose, and that the money could be better spent on other equipment. Controllers also favored required readback of the takeoff clearance by the pilot and greater emphasis on standard phraseology.

CONTROLLER REPORTS

The controllers were asked to submit reports of any experience, occurrence or opinion which developed during their shifts. Sixty-eight reports were submitted. The few equipment problems have been discussed earlier and have generally been corrected. Other comments indicated that distraction and increased workload actually reduced safety. The overall tone of the reports was negative.

MAGNETIC TAPE DATA

The tapes were analyzed on a sampled basis to obtain VICON usage, channel loading, and unusual occurrence information. For the 132 hours of tape analyzed, VICON was used by the controllers for 60% of the takeoffs. The light was acknowledged by the pilot only 6% of the times VICON was used. Average use of the local control radio channel was 14%; this is probably greater than the overall use average since the sample hours were largely selected because they covered heavy traffic periods. VICON messages accounted for less than 17% of total message duration. No delays due to VICON were evident.

INTEGRATED RESULTS

The individual results were integrated and cross-checked and were then organized to address the three key questions of technical feasibility, system integration, and enhancement of safety.

VICON was technically feasible. The equipment performed well and met the requirements of the program. Overall reliability was good and problems which occurred early in the test program have been resolved. Some serious design problems existed. The lights were poorly positioned and were hard to locate and identify, and some pilots have suggested a two-color light system like a traffic light. Light aircraft frequently did not break the microwave beam and thus did not turn off the green light; this could be misinterpreted as a takeoff clearance by the next aircraft in the departure queue. There was concern about the effects of snow on the lights in terms of snow removal, masking, reflections, etc. The sun caused problems of reflections and blinding the pilot.

Successful integration into the Air Traffic Control System was not demonstrated. VICON did appear to add to the controllers' workload. There was evidence of distraction and disruption of the local controller. Similarly, there was some evidence of added workload and distraction on the part of the pilot. Pilots and controllers felt the system was not needed. There was no indication of delay or increase in communication channel usage.

VICON had a slightly negative effect on safety. On balance, the ratings and results indicated that the negative effects slightly outweighed the positive effects. If a pilot would not take off without a clearly understood and verbally confirmed clearance, then there was no problem and VICON was unnecessary. However, uncleared takeoffs did occur. If VICON use increased the probability of a hazardous situation due to distraction and added workload more than it decreased the probability of a hazardous situation due to unauthorized takeoffs, then VICON's net effect was negative and it reduced safety. It appeared that this was, indeed, the case.

OVERALL SUMMARY OF FINDINGS

VICON was technically feasible. Design problems did exist but these are correctable.

VICON was not smoothly and fully integrated into the ATC System. The system did appear to increase controller and pilot workload and to cause some distraction.

VICON did not demonstrate that it enhanced safety. The use of VICON seemed to have slightly more negative factors than positive ones.

There was a moderate feeling among both pilots and controllers that VICON was intended to solve a problem that really does not exist.

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1. INTRODUCTION

1.1 STUDY OBJECTIVES

The Visual Confirmation of Takeoff Clearance (VICON) Signal System consists of a cluster of three green lights located on the left side of the runway at each takeoff position on the airfield. Each light cluster is individually activated by a unique push-button switch on the control panel located at the local controller's position in the Air Traffic Control (ATC) Tower. After being activated, the light will remain lit until turned off by a timer or by passage of the departing aircraft through a microwave beam. The control panel also contains an override (turn off) switch. The light intensity is modulated by a rising and falling, bright-to-dim-to-bright pattern to provide identification. This visual system is intended to provide an independent method of visually confirming the verbal takeoff clearance issued by the local controller.

The overall objective of the VICON Signal System In-Service Operational Evaluation was to determine the operational acceptability and technical feasibility of the VICON system. As discussed in the National Aviation Facilities Experimental Center (NAFEC) Operational Test Plan, this involves answering the following:

- Is visual confirmation of controller voice takeoff clearance feasible?
- Can VICON be integrated into the present ATC System?
- Does it provide an added measure of safety?

Note: On 29 May 1980, the National Aviation Facilities Experimental Center was renamed the Federal Aviation Administration Technical Center (FAA Technical Center).

1.2 STUDY APPROACH

A two-phase development and evaluation program was undertaken to answer these questions. In Phase I, which was conducted at NAFEC, preliminary system engineering and initial testing were accomplished. Phase II, the activity at Bradley International Airport, involved the full-scale procurement, installation, testing, and evaluation of VICON.

Data were acquired and subsequently analyzed during Phase II in the areas of system operation, user acceptability, and impacts on safety and traffic movement.

1.3 TEST PROGRAM AT BRADLEY

1.3.1 Test Period and Conditions

The test program at Bradley began on 15 October 1979 and continued through 31 March 1980. This final report presents the full analysis of the data and the evaluation of the test total program.

Approximately ten days before the start of the test, a tornado inflicted serious damage on the east side of the airport. Commercial power lines supplying eastern parts of two runway areas were destroyed; emergency power was used until commercial service was restored about three weeks later. General aviation aircraft parked on the east ramp were all severely damaged or destroyed. The rotating beacon was torn loose and blown away.

1.3.2 Description of Bradley

1.3.2.1 The Airport - The overall arrangement of the airfield is shown in Figure 1-1. The primary runway is runway 06/24,

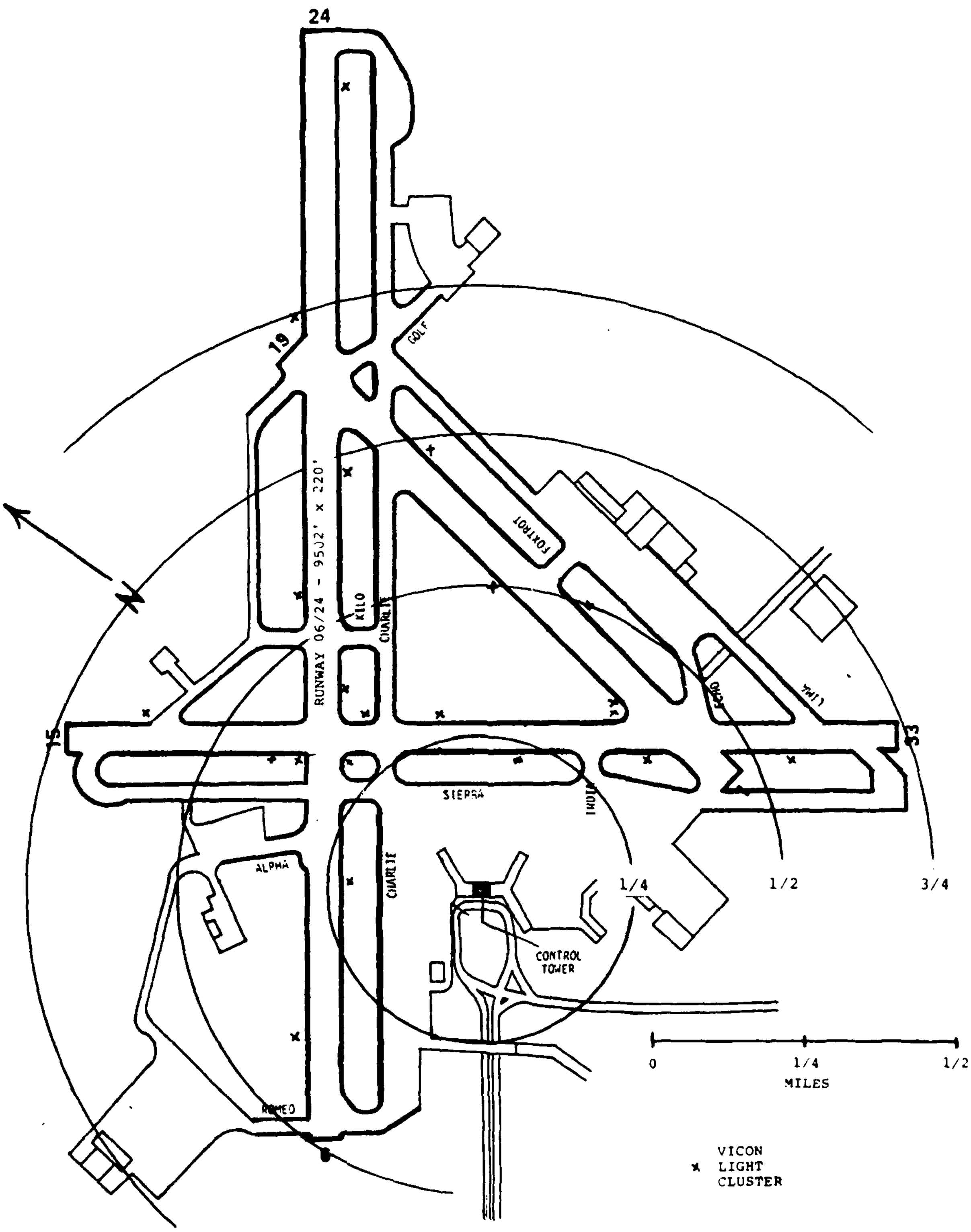


FIGURE 1-1. BRADLEY INTERNATIONAL AIRPORT

which is 9502' long by 220' wide. The control tower is located above the main passenger terminal building; it should be noted that the departure end of runway 06 is about 3/8 mile from the tower, and both ends of runway 15/33 are more than 1/2 mile away. This is shown graphically in Figure 1-1; the distance circles centered on the tower are in 1/4 mile increments. Thus, it is evident that when the visibility drops below 1/2 mile, the tower can see only very limited portions of the runways.

1.3.2.2 The VICON Installation - The VICON System installed at Bradley consists of 21 light clusters, a control panel in the control tower, and the necessary relays, dimmers, timers, cables, and related components. The installation is shown schematically in Figure 1-2. One light cluster is associated with each of the 21 takeoff locations. These are shown as X's in the figure. The lights are located on the left side of the runway in line with the runway edge lights, with the center of the light about nine inches above the ground. See Figure 1-3.

The control panel is the only element of VICON located in the control tower cab. The panel is placed at the local controller's position adjacent to other control knobs and buttons regularly used by the controller. There is a specific button on the panel for each of the 21 takeoff/light cluster positions. A runway master button controls all of the individual buttons associated with a given runway. That is, the Runway 33 button controls the buttons for takeoff locations at the runway end and at intersections Lima, Echo, India and Charlie. When the Runway 33 button is pushed, amber lights are illuminated in the 5 activated location buttons. When one of these buttons is pushed, the amber light in that specific button changes to green and the light cluster is turned on. When the light cluster is turned off, the button light switches back to amber. The panel also contains an override (cancel) button and lights for night use.

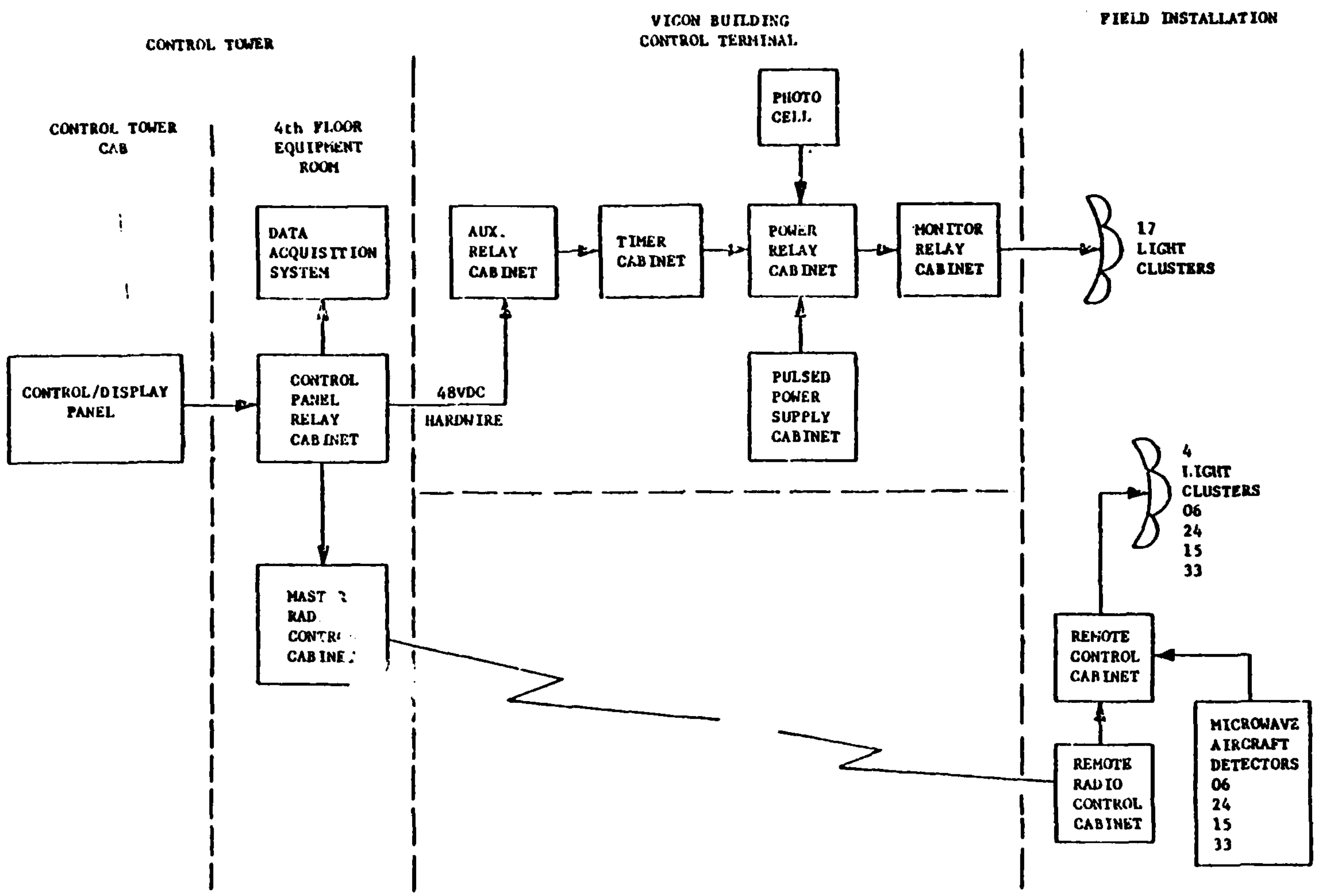


FIGURE 1-2. SCHEMATIC DIAGRAM OF VICON INSTALLATION AT BRADLEY

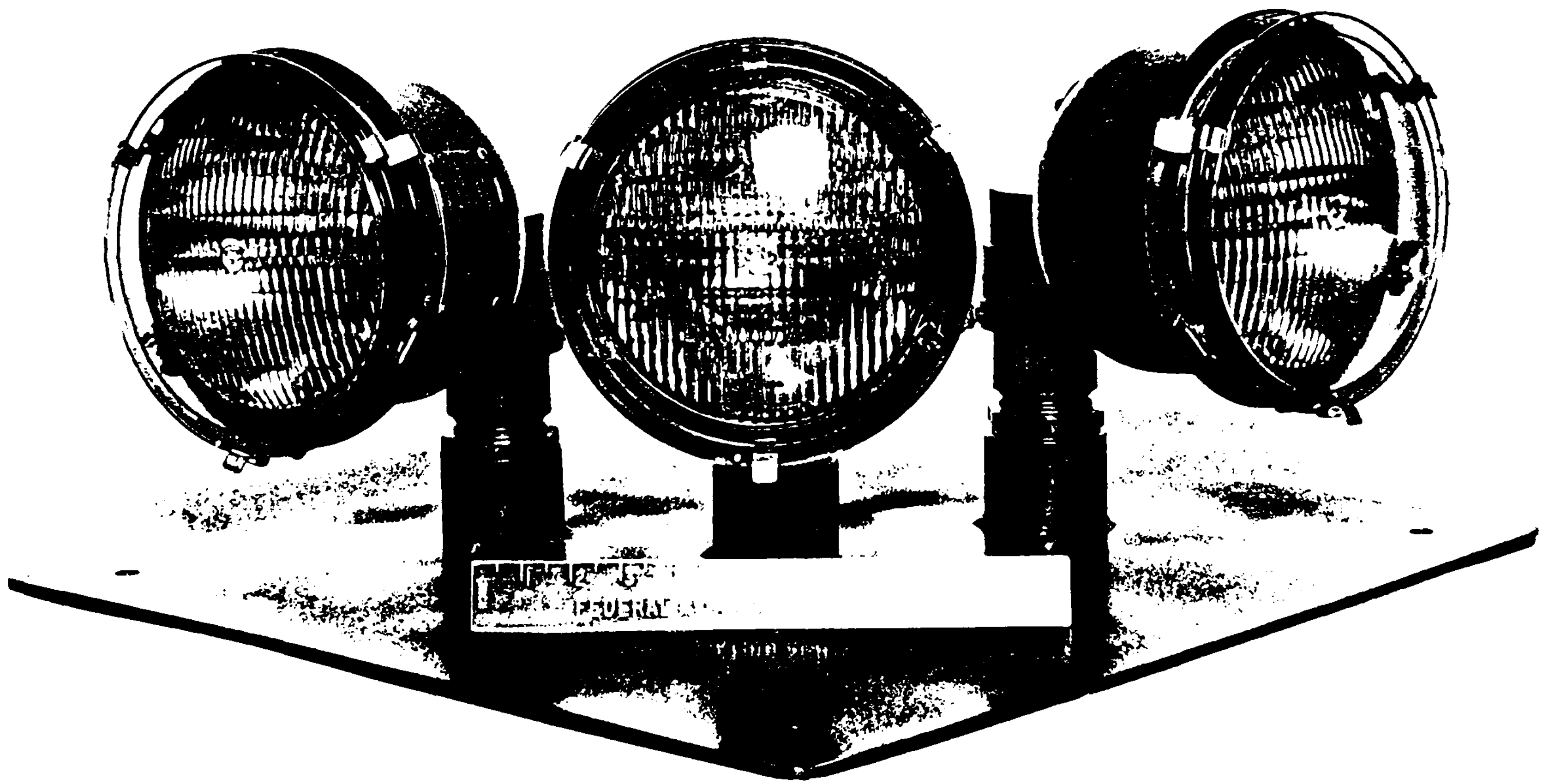


FIGURE 1-3. VICON LIGHT CLUSTER

The green cluster lights are turned off automatically. Microwave beams are installed 1000 feet from the end of runways 06, 15, 24, and 33. When an aircraft breaks the beam on its takeoff roll, the green light is turned off. The other 17 takeoff position lights are turned off by timers.

The remainder of the equipment is installed in a cement block building located near the center of the airfield.

A Data Acquisition System (DAS) designed especially for the test program is installed on the fourth floor of the FAA area in the terminal building. The DAS records the magnetic data tape and light activation counters (Section 11).

1.3.3 Test Period Weather Data

The original test plan called for extensive data collection during periods of bad weather. Since VICON is concerned primarily with enhancing safety during periods of reduced visibility, weather is defined in terms of surface visibility as follows:

Good Visibility:	$v > 3$ Miles
Fair Visibility:	1/2 Mile $< v \leq 3$ Miles
Poor Visibility:	$v \leq 1/2$ Mile

Unfortunately for the test program, the New England winter of 1979/1980 had the smallest amount of snow recorded during the 80 years of keeping weather records. Bad weather testing was therefore extremely limited. Table 1-1 shows the overall weather conditions during the test period.

There was the equivalent of just over thirteen days of bad weather during these five months. Further, much of the bad weather occurred between 7:00 PM and 7:00 AM local time, when the aircraft traffic level is low and the bad weather causes little delay or other negative effects on operations.

For these reasons, the data collected during bad weather was extremely limited.

TABLE 1-1. HOURS OF BAD WEATHER BY MONTH

MONTH	TOTAL HOURS			HOURS DURING BUSY PERIOD*		
	FAIR	POOR	TOTAL	FAIR	POOR	TOTAL
November**	66	16-3/4	82-1/4	31	4-3/4	35-3/4
December	45	29-3/4	74-3/4	38	8-3/4	46-3/4
January	29-1/4	0	29-1/4	13-1/2	0	13-1/2
February	33-1/4	12	45-1/4	23	16	39
March	68-1/4	18-1/2	86-3/4	29-1/4	6-1/2	35-3/4
TOTAL	241-3/4	76-1/2	318-1/4	134-3/4	36	170-3/4

*Busy Period is 0700 through 1900 local time.
**Weather data available beginning 11 November.

1.3.4 Test Period Traffic Data

In addition to the lower than normal amount of bad weather, the traffic level was lower than expected. The reduced level of traffic is attributed to the following factors:

- The tornado destroyed practically all of the general aviation aircraft based at Bradley. Few of these aircraft were repaired or replaced during the test period.

- The price of aviation fuel, both avgas and jet, increased dramatically. Both are presently well over one dollar per gallon, reducing the itinerant general aviation traffic through Bradley.

- The overall economic slowdown, coupled with the fuel price increase, has caused the air carriers to reduce their scheduled flight activity.

- The summer, with longer hours of daylight, better weather, and vacations, etc,. is normally busier than winter.

Table 1-2 shows a summary of the operations count information taken from the Bradley tower operations logs.

TABLE 1-2. OPERATIONS DATA BY MONTH

MONTH	TOTAL OPNS	DAILY AVG OPNS	HIGH DAY	LOW DAY	HIGH HOUR	BUSIEST HOUR	
						BUSIEST TIME	TOT OPS*
November	11,854	395	541	180	78	2100-2200Z	921
December	12,054	389	539	162	56	1700-1800Z	939
January	12,433	401	560	263	61	2100-2200Z	966
February	11,336	391	518	182	49	2100-2200Z	932
March	12,621	407	672	186	71	2100-2200Z	931
Average	12,060	397	566	195	63	2100-2200Z	938

*Total operations during the entire month for the indicated busiest hour.

The total number of operations is 60,298 for November through March. In fiscal year 1978, Bradley recorded 149,674 operations, for an average of 62,364 operations per five months. Traffic forecasts estimated 151,000 operations (62,917 per five months) in FY-79, and 153,000 (63,750 per five months) in FY-80, which overlaps the VICON Test period. Thus, even the 1% growth rate forecasts for FY-79 and FY-80 do not appear to have been reached.

The traffic activity at Bradley shows a rather consistent pattern throughout the day. This daily pattern varies only slightly month after month. The aggregate daily operations pattern for November through March is shown in Figure 1-4. From this data, we have defined the period from 7:00 AM to 7:00 PM local time (1200Z to 2400Z) as the busy period.

However, Bradley traffic activity is not uniform across any given hour. There is considerable variation during short time intervals, even during the busiest hours. When overall traffic is heavy, high levels typically occur over 20-40 minute intervals separated by low level intervals of ten minutes or more. During the high traffic level intervals, arrival and departure queues may develop, but they quickly disappear during the following quiet interval. As overall traffic decreases, the high traffic level intervals decrease in both activity and duration, and the quiet intervals lengthen. Accordingly, the controllers' activity tends to come in bursts.

The traffic activity at Bradley shows a much less consistent pattern throughout the week. Table 1-3 shows selected activity data by day of the week. While it is apparent that aviation operations enjoy a "long weekend" with Saturday - Sunday - Monday activity lower than the remaining "work week," there is considerable variation within the data for each day and month. Thus, the daily activity is much less predictable than the hourly activity.

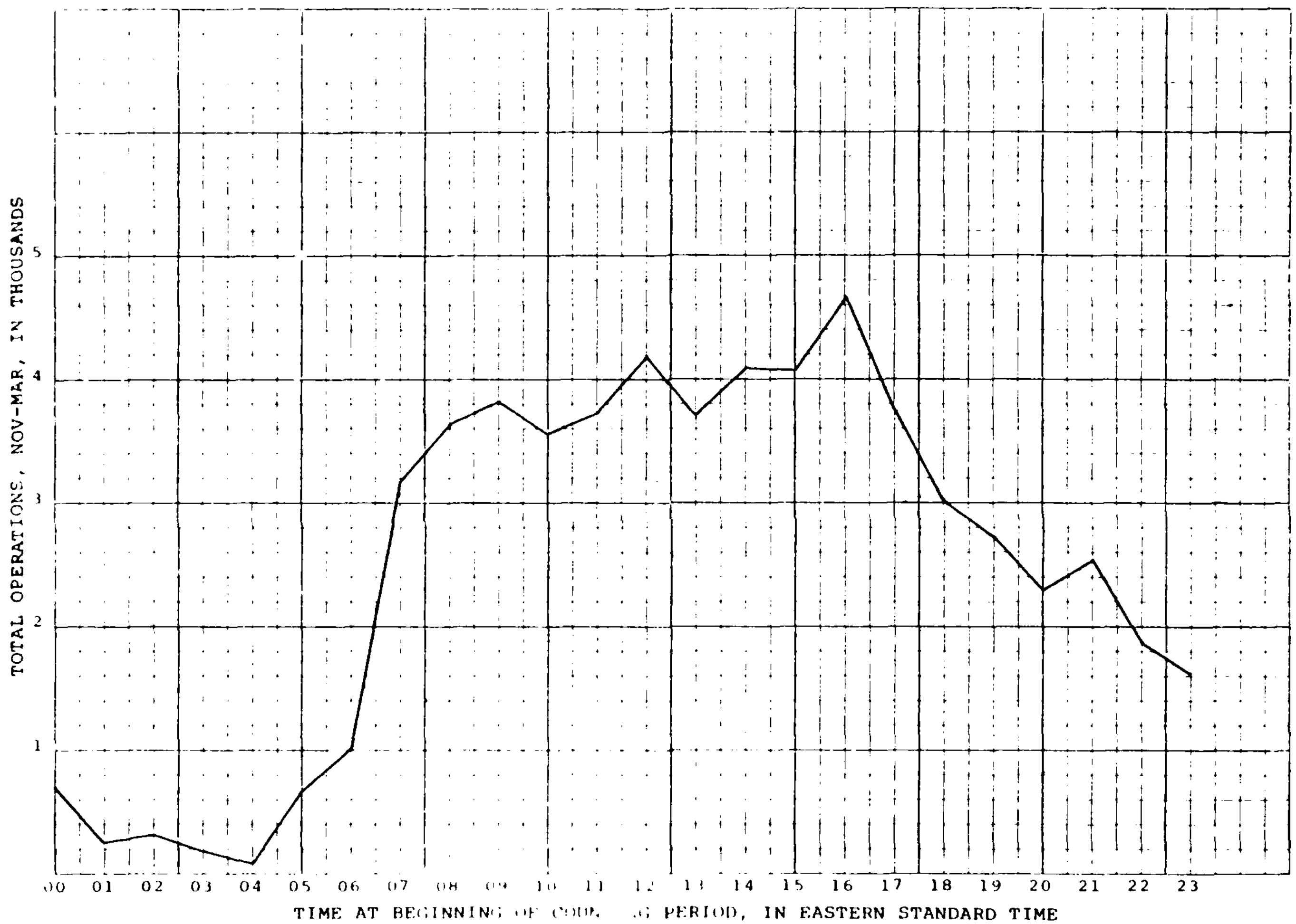


FIGURE 1-4. DAILY OPERATIONS PATTERN AT BRADLEY

TABLE 1-3. OPERATIONS BY DAY OF THE WEEK

		SUN	MON	TUE	WED	THU	FRI	SAT
Nov:	High	408	429	520	541	479	473	492
	Low	254	340	340	420	180	205	212
	Avg	359	386	448	460	402	402	306
Dec:	High	418	464	536	539	504	485	430
	Low	228	193	162	340	305	363	266
	Avg	318	357	420	441	426	438	356
Jan:	High	560	458	473	452	472	482	418
	Low	263	289	341	373	415	408	283
	Avg	416	342	396	408	444	448	341
Feb:	High	378	408	500	481	518	449	372
	Low	260	325	360	402	443	294	182
	Avg	316	376	417	436	480	414	293
Mar:	High	438	586	488	672	641	551	363
	Low	269	355	373	310	484	276	186
	Avg	362	428	412	476	449	393	261

1.3.5 Weather/Traffic Correlation

There is considerable interest in the effect of bad weather on the workload of the local controller. Total workload consists of effort required for each operation summed over all operations. In more practical terms, total workload per hour for the local controller can be determined by multiplying the average workload per operation by the number of operations, with each value referred to the specific hour under discussion.

The effects of decreasing visibility on the workload per operation are discussed in Sections 6 and 9. The effects of decreasing visibility on hourly operations for a five-month period are presented here.

The previous definitions of Good, Fair, and Poor Visibility are used here.

All periods of Fair and Poor Visibility (bad weather) for November through March were extracted from the NWS weather observations for Bradley for the hours between 0800 and 2000 local time. The other hours were not used because the typical number of operations is too low to be meaningful and because the number of operations during this time period is frequently not available on an hourly basis.

During each bad weather hour, the number of operations was recorded. Then, the number of operations during good weather for the same hour and the same day of the week was recorded. The two groups of numbers were compared. For example, in November, the visibility was 1/2 mile during the hour 0900-1000 local time on Tuesday, 20th. The number of operations was 28. This was compared with 30, 19, and 34 operations from 0900-1000 on the other three Tuesdays in November. The results are given in Table 1-4. Note that all data in this table represent the average number of operations per hour for the specified visibility conditions. The table shows that, for all five months, the average number of operations per hour for fair visibility was 16.9, while the average number of operations per hour for good visibility during the same hours of the day and days of the week was 26.8. Therefore, the operations per hour during fair visibility conditions were only 63.0% (16.9/26.8) of the operations per hour under the corresponding good visibility conditions.

It is apparent that the average number of aircraft operations decreases directly as the visibility decreases.

TABLE 1-4. AVERAGE NUMBER OF OPERATIONS PER HOUR FOR VARIOUS VISIBILITY CONDITIONS, BY MONTH

	NOV.	DEC.	JAN.	FEB.	MAR.	ALL	PERCENT
Fair Weather							
Good Visibility Reference	26.9	29.7	24.1	27.0	24.8	26.8	
Fair Visibility	14.0	15.8	24.5	16.5	16.8	16.9	63.0
Poor Weather							
Good Visibility Reference	25.3	24.5	0	25.4	18.5	23.1	
Poor Visibility	16.8	13.6	0	14.0	10.5	13.4	58.0
All Bad Weather							
Good Visibility Reference	26.6	27.9	24.4	26.8	22.5	26.0	
Fair and Poor Visibility	14.5	15.1	24.5	16.0	16.2	16.2	62.2

1.4 DATA REQUIREMENTS

In order to evaluate the overall feasibility of a takeoff clearance signal system, it was essential that the users of the system - pilots and controllers - contribute to the data collection effort. Only in this way could first-hand accounts of operating or procedural problems, user opinions and recommendations, and perceived safety effects be obtained. As a supplement to user inputs, impartial observers stationed in the tower cab were used to collect information regarding impacts on workload, traffic flow, procedures, safety, system integration, and other readily observable factors. User inputs and tower observations were substantiated by voice-data tapes which served both as a back-up and primary data source. All user groups were urged to report deficiencies and recommend improvements.

1.5 FINAL DATA ANALYSIS AND EVALUATION REPORT

This final report has been prepared to provide the FAA with a complete and comprehensive presentation of the VICON test program and the evaluation results.

2. DATA COLLECTION PLAN

The total data collection effort has been presented in the approved Data Collection Plan dated 17 September 1979. This plan is summarized in the following section.

The following sources satisfied the objectives of data collection in a comprehensive and cost-effective manner:

- Tower Observers who provided first-hand, close-up observations of VICON operation and its effect on other ATC functions.

- Representative Pilot Conferences with various individuals and pilot groups, conducted three times over the course of the test period.

- Pilot Questionnaires which allowed pilots to contribute details of individual experiences with the system and to make any desired comments and recommendations.

- Individual Controller Interviews conducted three times over the course of data collection.

- Controller Reports which allowed reporting of experiences and specific VICON occurrences on a particular shift and which encouraged submission of comments and recommendations.

- Voice-Actuated Data Tapes which recorded all voice and signal activity associated with use of the VICON System.

- Supplementary Hourly Weather and Traffic Data obtained from the National Weather Service and tower traffic log (form 7230-12).

The methods and forms used to collect data are given in detail in the Data Collection Plan. Each data form is presented in the data analysis and evaluation section of this report, together with a brief statement concerning the use of the form.

Subsequent to the issuance of the Data Collection Plan, two additional data sources were obtained.

- Facility Maintenance Log (FAA Form 6030-1) which listed by date and time maintenance and modifications performed on the VICON Equipment.

- Light Activation Counter Readouts which presented, approximately daily, the total activations, for the time period since the last readings, for each of the 21 VICON light clusters.

Finally, four of the five regular tower observers were interviewed at the completion of the program.

3. DATA ANALYSIS AND EVALUATION METHODS

Analysis and evaluation of the data were performed by members of the VICON project team at Waltham. Data forms were received once or twice each week. Pilot and controller interview reports were hand carried to Waltham by the interviewers. Upon receipt, all data items were logged in chronological order, and a master index was kept for each type of report. All data forms were reviewed as they were received, enabling IOCS to promptly detect problems, trends, data gaps, etc., and to provide up-to-date results of the test and evaluation effort.

The reports contained two forms of information: structured answers, usually scored 1 through 5, and unstructured comments, reports of occurrences, and recommendations. In addition, they contained date and time, weather, and identification in some selected cases. To comply with the Privacy Act, and to encourage complete and uninhibited reporting of occurrences and opinions, the source of certain information was not identified.

The specific analytical approach was different for each data form and source, and is presented in detail in the discussion, analysis, and evaluation of the information contained on that form. However, certain approaches were common to all forms. For structured data, frequency distributions were calculated and were correlated with weather conditions and traffic levels. Trends were identified by comparing succeeding time period results.

Unstructured, subjective statements were arranged by subject group, categorized and quantified when possible, and response patterns and/or distributions prepared. These were similarly analyzed for weather, traffic, and temporal correlations. In addition, discussions and summaries were prepared which present the findings in each group and category.

Unusual occurrences were analyzed individually to determine the specific conditions of each occurrence, what part VICON did/did not/might have played in the occurrence, the benefits or problems due to VICON, and any recommendations for improvement. These individual results were then aggregated to provide an overall picture, again broken down when possible by weather condition, traffic load, and time period. A simplified Data Analysis Flow Diagram is shown in Figure 3-1.

The structure of this report follows that recommended in the NAFEC Operational Test Plan. Each data source was individually evaluated, and summarized in Sections 6 through 12. These individual analyses and evaluations were then integrated and cross-checked in Section 13 to provide an overall assessment of the VICON System in terms of the three fundamental areas of technical feasibility, system integration, and enhancement of safety.

It must be noted that the analysis and evaluations process was one of organizing, integrating, and summarizing. At each step, large quantities of data items were structured such that they could be reduced to a small number of important ideas and findings. These findings were then evaluated, and the results were again organized and summarized to yield key findings and results. Only in this way could the necessary findings and results be obtained from literally several thousand individual data items.

Finally, this report has been prepared to assist FAA Management in making critical decisions regarding the future of the VICON Program. It has not been prepared to describe the circumstances surrounding every question or the details of each problem or finding. To do so would require such a mass of detail that the report would be difficult to use for its intended purpose. If detail is needed, it should be the subject of a separate report dedicated to the specific problem under study.

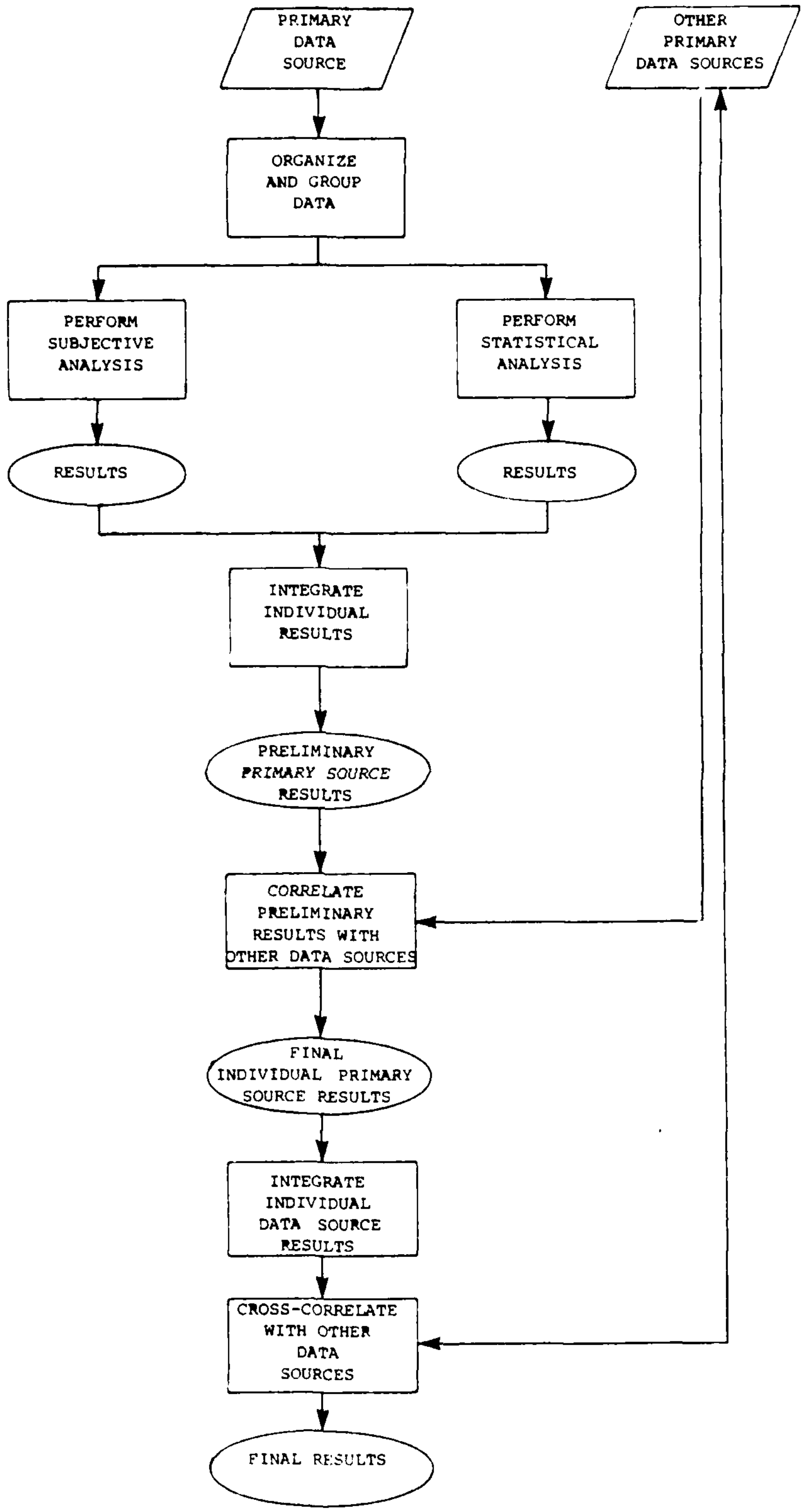


FIGURE 3-1. DATA ANALYSIS FLOW DIAGRAM

4. FLEXIBILITY, FEEDBACK, AND MODIFICATION

In any long-term test and evaluation program, it is possible that original assumptions, ideas, plans, methods, and forecasts may turn out to be less than optimum once actual results become available. Data are analyzed and evaluated on a continuing basis, and results are reviewed frequently. If it appears that the data can be collected more effectively or more efficiently, that data errors, gaps, problems, or inconsistencies exist, or that errors were made in the original plans, then modifications are made promptly to correct the shortcomings or to improve the test results.

For example, after the first week of data collection by the tower observers, it became evident that some data could not be obtained and problems existed. Therefore, the data collection efforts were modified, new forms were designed, and new instructions and methods were instituted. Subsequently, other changes were made in tower observer activity.

Similarly, changes were made in pilot and controller interview material, techniques, and schedule. Additional questions were asked to develop experiences, opinions, and recommendation in greater detail. Two persons interviewed each person or group, and schedules were reviewed to reflect the final test schedule.

In addition, at the recommendation of the FAA Technical Center, additional statistical analyses were performed on the structured data.

Finally, we have held intensive interviews with the individual tower observers immediately following the end of the data collection period.

The overall data collection, analysis, and evaluation effort was dynamic. Results and findings were fed back into the overall effort in order to improve it. The effort was kept flexible so that changes could be made with minimum disruption and cost. The intent was to provide the best evaluation of VICON within the time and resources available.

5. BASIC DEFINITIONS

The three fundamental questions that must be answered are:

- Is visual confirmation of voice takeoff clearance technically feasible?

- Can VICON be integrated into the present ATC system?

- Does VICON enhance safety?

These questions must be restated in more measurable terms so they can be more directly measured. These definitions are taken from Webster's New Collegiate Dictionary, Copyright 1979, G.&.C. Merriam Company, and are used to make this needed restatement.

5.1 TECHNICALLY FEASIBLE

- feasible - capable of being done or carried out; capable of being used or dealt with successfully.

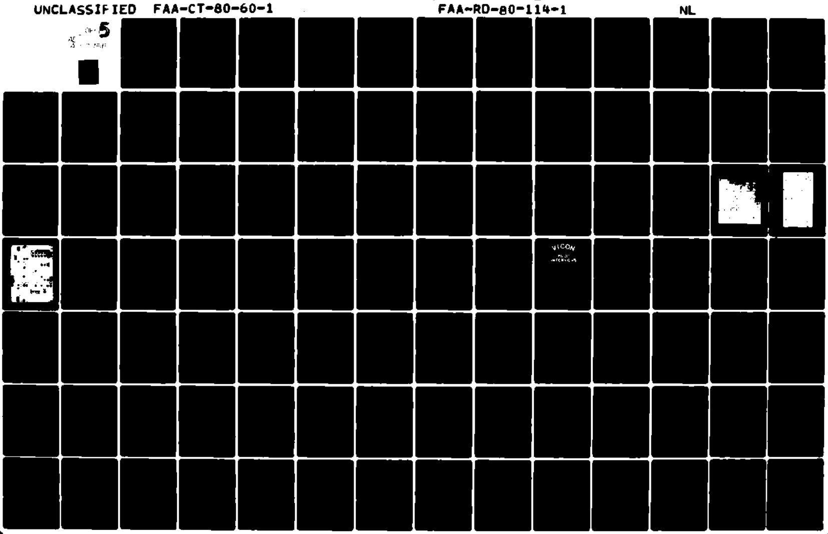
- technical - marked by or characteristic of specialization of, or relating to, a particular subject; especially of or relating to a practical subject organized on scientific principles.

In this case, the definition of technically feasible is: of or relating to a practical subject organized on scientific principles, capable of being used successfully. The first fundamental question can then be restated:

- Can the equipment (hardware) perform the visual confirmation function correctly, effectively, efficiently, and reliably?

AD-A097 756 FEDERAL AVIATION ADMINISTRATION TECHNICAL CENTER ATL--ETC F/G 17/7
VISUAL CONFIRMATION OF VOICE TAKEOFF CLEARANCE (VICON) OPERATIO--ETC(U)
FEB 81 J J MAURER, B CASTLE, E DOWE, B HUGHES

UNCLASSIFIED FAA-CT-80-60-1 FAA-RD-80-114-1 NL



The evaluation looked at equipment performance, and applicable procedures, in terms of the four criteria listed in the question.

5.2 INTEGRATION INTO THE ATC SYSTEM

- integrate - to form or blend into a whole; to *incorporate into a larger unit.*

The second fundamental question can be restated:

- Can VICON be blended or incorporated into the present ATC system so as to create no disruption, distraction, or confusion?

The evaluation looked at both equipment and procedures used by the Air Traffic Controllers and at procedures used by the flight crews, to evaluate the degree of success in incorporating VICON into traffic control procedures. All external effects of using VICON were also evaluated.

5.3 SAFETY

- safety - the condition of being safe from undergoing or causing hurt, injury, or loss.

- safe - secure from threat of danger, harm, or loss.

To enhance safety, we must either increase the likelihood that no harm or loss will occur, or decrease the likelihood of harm. A common approach to enhancing safety is to use an independent, redundant system which will prevent or stop a potentially hazardous action should the primary control system fail. Using such a system strongly indicates an improvement in safety provided the positive factors associated with the system are greater than the negative factors.

Positive factors are to simplify, organize, and expedite the performance of control duties by the controller and the pilot. Reliability and confidence in the system are also positive factors.

Negative factors are to distract, divert, confuse, add work, and delay the performance of duties by the controller and pilot. Unreliability, unfamiliarity and lack of confidence in the system are also negative factors.

The third question can then be restated:

- Does the VICON system have enough positive factors to outweigh any negative factors, so that the addition of the redundant system will indeed increase the likelihood that no harm or loss will occur?

In the evaluation we investigated and weighed all positive and negative factors to determine what overall improvement in safety might have been created by the addition of VICON.

5.4 CAUTION

One note of caution must be added, by way of two more definitions.

- redundant - serving as a duplicate for preventing failure of an entire system upon failure of a single component.

- duplicate - consisting of two corresponding parts.

Since the verbal takeoff clearance serves a <u>control</u> function, and VICON serves a <u>confirmation</u> function, VICON is <u>not</u>, strictly speaking, a redundant system. If the local controller's radio fails, verbal clearance cannot be given and takeoffs cease. If VICON fails, takeoffs continue.

6. TOWER OBSERVER DATA

Observers were stationed in the control tower to observe and record activities pertinent to the VICON test program. The objectives of the tower observation were:

- to note VICON's effects on controller workload and integration with other Local Controller and ATC functions;
- to note differences in and characteristics of the three VICON control and display panels;
- to observe the effects of VICON on safety and traffic movement;
- to note instances of pilot-controller confusion or other problems resulting from the use of VICON;
- to note, first-hand, the effects of key variables on VICON operation;
- to record pilot and controller recommendations and opinions for improved VICON operation, if offered; and
- to record flight operations data for subsequent analysis.

The observers worked in pairs under the direction of an on-site supervisor. One observer was responsible for proper compilation of the forms; the other assisted as requested. Approximately each hour, at a convenient break in traffic, the two observers switched tasks. The supervisor ensured that the equipment was working properly, synchronized the timers, and provided break time for the observers. In addition, the supervisor reported on the overall operation of the VICON system and provided as much information as possible on any unusual occurrences.

The observers were in the tower on six hour shifts, four to five days a week. The supervisor scheduled extra shifts, or changed the shift time, to get as much bad weather data as possible. The regular shifts were scheduled to obtain as much high traffic level data as reasonably possible. The number of shifts and the number of takeoffs observed per month are shown in Table 6-1.

TABLE 6-1. SHIFTS WORKED AND TAKEOFFS OBSERVED

	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	TOTAL
Shifts	8	19	18	23	18	19	105
Takeoffs	472	1,381	1,203	1,402	1,223	1,277	6,958

The NAFEC Operational Test Plan states: "The observer must be unobtrusive; if he disturbs or distracts the local controller, he will defeat the purpose of the evaluation." Further, the FAA management at Bradley required that the observers work on a strict noninterference basis and that they generally stay in the rear of the tower cab out of the way of the controllers. Finally, in addition to the FAA instructions, the observers were instructed as follows:

- You must always be neutral in your actions; you are there to observe, not to influence.

- Record everything which may be of use in evaluating the system, but be extremely careful to make the controllers understand that you are not there to spy on them.

- Ideally, the controllers will be unaware of your presence.

After the first week of observation, it was concluded that the observers could not see the local controller's panel without interfering with the controller. While working, the local controller had his back to the observers, and stood directly between the observer and the VICON control panel. Also, the control panel was mounted almost horizontally, so the buttons and lights were conveniently located for the controller, but could not be seen by the observer standing about 20 feet away. It was therefore not possible to directly obtain any information about the use of VICON and the performance of the system. (The information is available on the DAS magnetic tapes.)

In addition, the controllers were skeptical at first. They apparently felt that the observers were there to spy on them, to report on their individual competence and performance of their duties, and to enforce use of the VICON system. This feeling was reinforced by the presence of the Data Acquisition System which recorded their radio communications and their use of the VICON equipment.

This skepticism was subsequently overcome. Two observers were former controllers who knew many of the duty controllers. All observers remained in the background; when they did ask questions, the questions were objective and neither indicated personal opinion nor implied any judgment. However, the need to remain impartial, impersonal, objective, and unobtrusive was continually stressed.

The observers recorded the data on two forms, the Observer's Work Sheet and Report Form, Figure 6-1, and the Departure Log, Figure 6-2.

The five regular observers were interviewed immediately after the end of the data collection period to obtain their

OBSERVER: ______________________

DATE: ______________________

DAY: ______________________

TIME PERIOD: ______________________ TO: ____________________

WEATHER:

______Good ______Fair ______Poor

TRAFFIC LEVEL:

______High (>16 takeoffs per hour) ______Medium (12-16)

______Low (< 12)

CONTROLLER WORKLOAD:

______Very High ______High ______Medium ______Low

______Very Low

ADDITIONAL WORKLOAD CAUSED BY VICON:

______Very High ______High ______Medium ______Low

______Very Low

CONTRIBUTION TO SAFETY:

______Very Neg. ______Neg. _____Neutral ______Pos.

______Very Pos.

Describe any specific VICON events and rate them according to impact (very unfavorable - somewhat unfavorable - netural - somewhat favorable -very favorable). Include details of each occurrence. Note comments, opinions, recommendations for pilots and controllers. Note suggestions for improvements to data collection process. Use additional sheets if needed.

FIGURE 6-1. VICON OBSERVER'S WORKSHEET AND REPORT FORM

DEPARTURE LOG

DATE: ____________________ WEATHER: ____________________

OBSERVATION PD: FROM: _____ Z TO: _____ Z RUNWAY: _______ TRAFFIC LEVEL: ______

OBSERVER(S): ____________________ TRAFFIC MIX: ________

	OBSN NR	AIRCRAFT I.D. NUMBER	ACFT TYPE	RWY	TIME CLERNCE ISSUED	TIME AIRCRAFT ENTERS RY	LOC ON RWY	TIME ACFT BEGINS ROLL	QUE LGH	COMMENTS
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

FIGURE 6-2. DEPARTURE LOG

opinions and experiences. Also, the supervisor recorded his opinions and experiences in a detailed narrative. This information is presented at the end of this section.

6.1 OBSERVER'S WORKSHEET AND REPORT FORM

6.1.1 History and Development of the Form

The form was suggested by NAFEC, and was modified during the development of the Data Collection Plan. The report consists of four sections: identification, reference information (weather and traffic level), test program observed data, and comments. The original instructions stated that a new report should be filled out each time there was a definite change in any of the reference or observed data items. By the end of December, analysis indicated that two problems were occurring.

- Reports were being filled out on an erratic and irregular basis, which made analysis difficult, and

- There appeared to be biases in the observed data linked to the reference data.

To minimize these problems, new instructions were issued in early January. A report would be completed every half hour of observation regardless of changes, and the reference data would not be filled in. More accurate weather and traffic data could be easily obtained from the NWS weather reports and the departure logs, and biases would be reduced. In later printings of the form, the weather and traffic items were removed.

6.1.2 Data Collection

The observation program was set up in accordance with the referenced Data Collection Plan, and was carried out as discussed above. Observers were initially scheduled as two-person teams; it was felt that close working relationships would develop that would produce excellent data with a minimum of difficulty. However, biases began to appear in the data, so beginning in early January the observer pairs were deliberately scheduled on a rotating, non-team basis.

The completed reports were mailed weekly to the IOCS project team in Waltham.

6.1.3 Data Description and Analysis

As shown in Figure 6-1, the data consists of four types: identification, reference, observations, and comments. The first three types have been analyzed by statistical methods, and the fourth has been treated subjectively.

6.1.3.1 Scored Data - The observer has been asked to provide scored reports on the following variables:

1) Controller Workload
2) Additional Workload Caused by VICON
3) VICON's Contribution to Safety
4) Weather Conditions
5) Traffic Level

From October to early January, the observers were asked to rate the above five variables. However, it was felt that a subjective rating of weather conditions and traffic level might influence the workload and safety ratings. For example, if one believes the Traffic Level to be high, Controller Workload will probably be rated high. In order to safeguard against this possible bias, variables 4 and 5 were deleted by the observer beginning in the early part of January. The analyst was able to measure the Weather variable from the National Weather Service reports and the Traffic Level was measured by the actual number of departures in an observation period.

There were over 700 observer data sheets completed through March 31, 1980, with roughly 550 coming under the revised data collection procedures. The statistical techniques that have been employed were frequency distributions, Kruskal-Wallis Tests, Kendall's Tau tests, t-tests, F-tests and descriptive statistics. The objectives, procedures, and application of these tests are summarized in Appendix A.

6.1.3.1.1 Controller Workload - The first variable considered is Controller Workload. Table 6-2 gives the monthly breakdown by frequency of response. The following point values were assigned to this ranked data:

5 = Very Low
4 = Low
3 = Medium
2 = High
1 = Very High

Interest focuses on whether the ratings differ month-by-month. It is felt that any monthly differences should be attributable to random variation with regard to controller workload. However, normally there is considerable variation at the beginning of a project, then as the observers become more familiar with the system, the ratings of controller workload should stabilize.

The hypotheses were formulated as follows:

Ho: No difference of controller workload rating by month

Ha: Differences exist among months

TABLE 6-2. CONTROLLER WORKLOAD RATING BY MONTH

MONTH	VERY HIGH	HIGH	MEDIUM	LOW	VERY LOW	TOTALS
Oct. & Nov.	6	5	19	25	5	60
December	0	3	6	14	6	29
Early January	0	3	13	50	2	68
Late January	0	10	34	86	36	166
February	0	13	36	113	17	179
March	0	16	47	102	36	201
TOTALS	6	50	155	390	102	703

The Kruskal-Wallis Test (a test concerned with the equality of two or more treatments of ranked data - see Appendix A) was employed and suggests with greater than 99% certainty that differences do exist.

Table 6-3 indicates that the monthly ratings appear to level off and converge closer to an average rating of 4 (low workload) for the observation periods of December through March. The convergence of the average rating since December indicates more consistency from the observers in rating Controller Workload. Another measure which may help evaluate consistency is that of variability. The standard deviations were computed for each period as shown in Table 6-4.

TABLE 6-3. AVERAGE WORKLOAD RATING BY PERIOD

PERIOD	OCT.-NOV.	DEC.	EARLY JAN.	LATE JAN.	FEB.	MAR.
Average Rating	3.30	3.79	3.75	3.89	3.75	3.79

TABLE 6-4. STANDARD DEVIATION OF RATINGS BY MONTH

PERIOD	OCT.-NOV.	DEC.	EARLY JAN.	LATE JAN.	FEB.	MAR.
Standard Deviation	1.08	.902	.583	.809	.725	.830

The combined standard deviation of October and November was 1.08 compared to the latter months of 0.78. It is felt with greater than 99% certainty that the difference is statistically significant. The F-test was employed to test the equality of the variances. This helps reinforce the hypothesis that the ratings since December seem to be homogeneous. Table 6-5 summarizes the number and percentage of actual responses during this period.

6.1.3.1.2 Additional Workload Caused by VICON - A similar analysis was performed for the variable, Additional Workload Caused by VICON, presented in Tables 6-6 and 6-7.

TABLE 6-5. FREQUENCY DISTRIBUTION OF RESPONSES

	VERY HIGH	HIGH	MEDIUM	LOW	VERY LOW	TOTAL
Number	0	45	136	365	97	643
Percent	0	7	21	57	15	100

TABLE 6-6. ACTUAL RATINGS BY PERIOD

PERIOD	VERY HIGH	HIGH	MEDIUM	LOW	VERY LOW	TOTALS
Oct.-Nov.	0	0	5	30	25	60
December	0	0	3	11	15	29
Early Jan.	0	0	2	45	21	68
Late Jan.	0	0	7	96	63	166
February	0	0	13	118	48	179
March	0	2	16	106	77	201
TOTALS	0	2	46	406	249	703
(Percent)	0	0	7	58	35	100

TABLE 6-7. AVERAGE AND STANDARD DEVIATION BY PERIOD

PERIOD	OCT.-NOV.	DEC.	EARLY JAN.	LATE JAN.	FEB.	MAR.
Average Rating	4.33	4.41	4.28	4.34	4.20	4.28
Standard Deviation	0.63	0.68	0.51	0.56	0.55	0.65

The average rating varies over time between Low (4) and Very Low (5), and so the impact of VICON on the controller is deemed to be slight.

The Kruskal-Wallis test was employed to test the hypothesis of monthly differences with regard to the average ratings. The results of this test indicate there is not enough evidence to conclude that differences exist. Also, the standard deviations seem to be equal, apart from random fluctuations. Thus, the ratings of Additional Workload Caused by VICON have remained fairly constant over the test period. One would expect that with more experience with this system the additional workload would decrease, however, the data suggests that familiarity with this system related to additional workload is not a function of time.

6.1.3.1.3 Relationship of Controller Workload to Additional Workload - An important correlation to consider is the relationship that may exist between Controller Workload and Additional Workload Caused by VICON. It is felt that with higher controller workload, the additional workload is also higher, and, conversely, lower controller workload implies lower additional workload caused by VICON. See Figure 6-3.

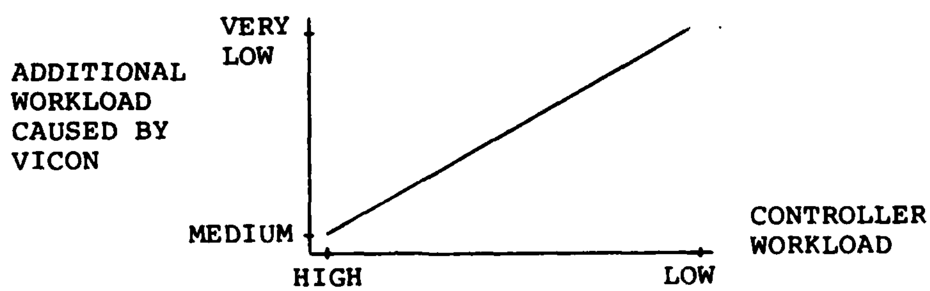


FIGURE 6-3. SUGGESTED WORKLOAD/ADDITIONAL WORKLOAD RELATIONSHIP

The relationship suggested by Figure 6-3 was investigated. Since the data for controller workload was very consistent from December through March, the correlation of the workload variables was based on this data. The sample size is 643, and Table 6-8 summarizes the data. As demonstrated in Figure 6-4, the relationship suggested in Figure 6-3 seems tenable.

Kendall's Tau test was applied to test the validity of the suggested relationship and indicated with greater than 99% certainty that the relationship was valid.

TABLE 6-8. WORKLOAD/ADDITIONAL WORKLOAD RESULTS

CONTROLLER WORKLOAD	ADDITIONAL WORKLOAD				TOTALS
	HIGH	MEDIUM	LOW	VERY LOW	
High	2	23	18	2	45
Medium	0	17	89	30	136
Low	0	1	264	100	365
Very Low	0	0	5	92	97
TOTALS	2	41	376	224	643

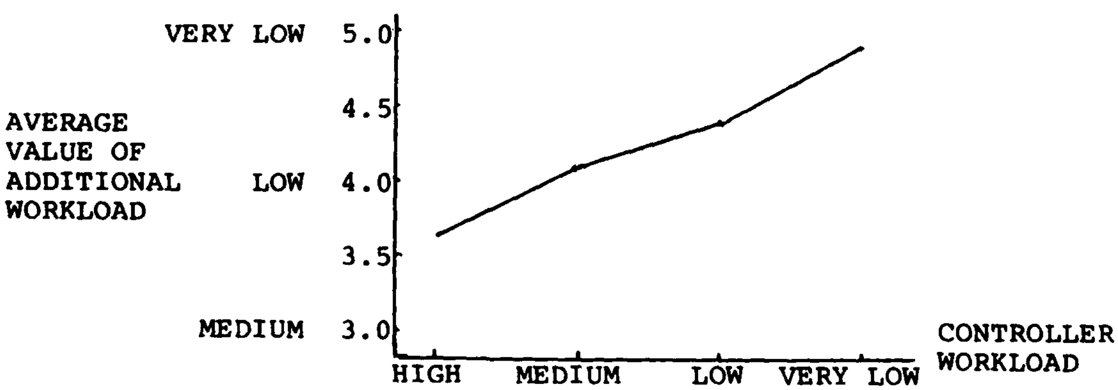


FIGURE 6-4. CORRELATION OF ADDITIONAL WORKLOAD WITH WORKLOAD

Kendall's Tau test was also applied to the five major observers to test the consistency of this relationship. The results suggested that all five tend to believe the assertion of Figure 6-3. Also, this relationship was prevalent across each period from December through March.

The standard deviations were examined at each of the controller workload categories. Table 6-9 summarizes the results.

Variability increases with the increase in controller workload and the converse is also true, suggesting that low additional workload with low activity can be more accurately predicted than high additional workload with high controller activity.

TABLE 6-9. AVERAGE AND STANDARD DEVIATION OF WORKLOAD RATINGS

CONTROLLER WORKLOAD	AVERAGE	STANDARD DEVIATION
High	3.44	0.66
Medium	4.10	0.58
Low	4.27	0.45
Very Low	4.95	0.22

6.1.3.1.4 Contribution to Safety - Another variable that was considered is VICON's Contribution to Safety. Very little could be gained from this variable since about 95% of the responses were judged Neutral. Table 6-10 summarizes the percentage of responses in the five categories.

The observers had very little reason to judge away from the neutral stance on safety. In fact, of the five regular observers, only one was willing to offer non-neutral responses

TABLE 6-10. SAFETY RESPONSES

RESPONSE	NUMBER	PERCENT
Very Negative	3	0.4
Negative	10	1.5
Neutral	656	95.5
Positive	17	2.5
Very Positive	1	0.1

to any degree. However, this amounted to only 25% of this particular observer's response. Due to the predominance of neutral responses, a relationship between controller workload and safety could not adequately be assessed. Similarly, additional workload and safety relationships could not be addressed.

6.1.3.1.5 Effects of Weather and Traffic Level - The other important variables were Weather and Traffic Levels. Unlike the ranked or subjective variables, these two were easily quantifiable. The actual traffic count of departures was recorded by the observer and the visibility in miles was extracted from the weather reports.

The Weather and Traffic variables were scored subjectively by the observers prior to January, and it is felt that inherent biases exist. For example, if one believes the weather to be bad, and records this variable as such, it may influence his/her rating of Controller Workload, Additional Workload Caused by VICON, or Safety. Similarly, a prior belief of the traffic level may bias one's perception of controller workload. Since actual traffic counts and weather reports could be easily obtained, it was felt that a revised observation method could help safeguard against these inherent biases. The new method was instituted in early January and generated over 500 data points. One would suspect that as the traffic level increases, controller workload should increase, and that with low traffic levels, lower workload should result.

This assertion was tested with the Kendall's Tau test. The data highly suggests that this assertion is tenable. Results of the test are shown in Table 6-11. A sample calculation follows the table.

TABLE 6-11. KENDALL'S TAU TEST DATA

TRAFFIC LEVEL (DEPARTURES PER HALF HOUR)	CONTROLLER WORKLOAD RATINGS					
	1 VERY HIGH	2 HIGH	3 MEDIUM	4 LOW	5 VERY LOW	TOTAL
0	0	0	0	1	3	4
1	0	0	5	9	5	19
2	0	0	9	19	12	40
3	0	1	4	32	7	44
4	0	2	10	47	18	77
5	0	2	26	52	17	97
6	0	4	13	47	9	73
7	0	8	19	38	8	73
8	0	5	13	15	3	36
9	0	5	4	9	5	23
10	0	5	7	6	0	18
11	0	7	3	5	0	15
12	0	0	0	1	0	1
13	0	1	0	0	0	1
14	0	1	0	1	0	2
TOTAL	0	41	113	282	87	523

N_c = 22,979 = number of concordant pairs

N_d = 51,038 = number of discordant pairs

n = 523

$$T = \frac{N_c - N_d}{\frac{n(n-1)}{2}} = \frac{22{,}979 - 51{,}038}{1/2(523 \times 522)} = -0.206$$

$$\mathrm{Var}(T) = (0.029)^2$$

$$Z = \frac{T}{\sqrt{\mathrm{Var}(T)}} = \frac{-0.206}{0.029} = -7.10$$

A similar relationship of Traffic Level effect on Additional Workload caused by VICON was investigated by the Kendall's Tau test. Results were as follows:

N_c = 20324
N = 42482
T = -.1629
$\mathrm{Var}(T)$ = $(.0293)^2$
Z = -5.56
n = sample size = 522

Thus, the data indicates as the traffic level increases, the Additional Workload caused by VICON also increases, and conversely, as the traffic level decreases, the additional workload decreases.

The last variable to be considered is Weather, consisting of the visibility in miles. The visibility ranged from 1/16 to 25 miles, with basically good visibility for most of the observation times. Less than 20 percent of the time, the visibility was less than ten miles. One could hypothesize that as the visibility becomes poor, the controller workload would increase and that good visibility would tend to reduce the controller workload. See Figure 6-5.

This assertion was tested with the Kendall's Tau Statistic and the results seem to suggest that as the visibility gets better, the controller workload increases and, conversely, as the visibility decreases, the workload also decreases.

A similar relationship also may exist between visibility and additional workload, as tested by the Kendall's Tau Statistic.

One possible explanation of these results is the idea that flying activity decreases as the weather gets worse. (See Section 1.3.5) As the visibility decreases (especially below about five miles), general aviation activity decreases markedly since many pilots and aircraft are not IFR qualified. Also, air carrier schedules may stretch out as delays accumulate. Thus one can speculate that the workload per operation increases as the visibility decreases, but the level of operations simultaneously decreases, and the net result is that total workload does not increase as the visibility decreases.

Finally, a relationship between Weather conditions and Additional Workload Caused by VICON was investigated. No significant findings resulted and no relationship could be supported by the data.

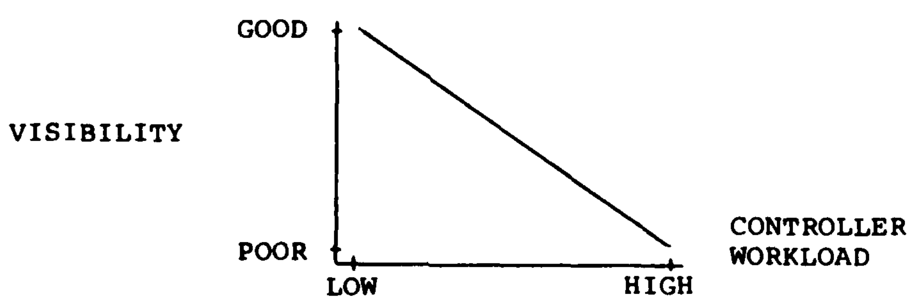


FIGURE 6-5. POSSIBLE RELATIONSHIP OF VISIBILITY TO WORKLOAD

6.1.3.2 Comments and Occurrences - The tower observers were instructed to record any fact, conversation, or event that might be of value to the analysis team in understanding the opinions and reactions of controllers and pilots to VICON. These comments are tabulated in Appendix B, where they have been combined with the comments taken from the Departure Log to minimize overlap and duplication. The Departure Log contained more comments and more specific information - this information is presented in Section 6.2.3.2. The report form comments are summarized here.

It must be emphasized that these comments and occurrences are records of individual events which were jotted down at the time they occurred. Details are not generally available because of the nature of the observing process. Conversations, both on and off the radio, were noted, but only the actual messages could be noted as the observers were barred from entering into the conversation to obtain more information.

For example, suppose a controller commented that he had an equipment failure. If the observer overheard the comment, all he could do was record it; he was not supposed to ask questions. He was required to remain unobtrusive and to not interject himself in any way. However, if the comment was made directly to the observer, then he would try to obtain the details of this failure. Sometimes it was possible to develop details in other ways, such as by analysis of the DAS tapes or through subsequent interviews.

6.1.3.2.1 Comments - The most common and meaningful comments were:

- The most frequent comment by far was that the pilot confirmed the VICON light.

- The next most frequent comment was that the pilot asked questions about VICON. In some instances the controller's reply was vague or inaccurate, indicating that the controller did not fully understand the system.

- The pilot requested the green light. Usually, but not always, the light signal was given.

- Two-runway operation increases controller workload.

- Some controllers are not using VICON, and some are using it intermittently.

- Controllers also stated that other runway lights were to be modified at the same time VICON was installed, but this work was apparently not done.

- A controller suggested changes to the matrix panel layout; the sequence of the buttons should be reversed for runway 15-33.

6.1.3.2.2 Occurrences - VICON-related events and occurrences were:

- Equipment problems and failures caused some troubles. After the October equipment shakedown period, the failures were random and not repetitive except for problems with the Runway 33 location. See Section 12 and Appendix D.

- A number of light planes and one Learjet did not break the microwave beam. On a windy day these aircraft are off the ground before they reach the microwave unit. One large jet apparently did not break the beam as the light did not turn off automatically.

- Reflections of sunlight off the lens was reported for runways 06 and 33.

- There were a number of reports of misunderstood clearances, for which the pilots requested repeats.

- Several times an aircraft was cleared for takeoff but did not go, as the pilot was waiting for the light.

- A controller reported he had pushed the wrong button, used the override, and then pushed the correct button.

- An air carrier pilot in "position and hold" reported having the green light prior to receiving voice clearance. The controller was at a loss to explain this (possibly microwave beam problems). (The event had a very unfavorable impact on the controller).

- There were a number of times when the controllers stated that they would have to accept VICON whether they liked it or not because so much money had been spent on it.

6.1.3.2.3 Trends - There were no apparent trends in the comments or occurrences, except that the rate of comment increased. The increase was most likely due to the increase in the number of report forms submitted after our change in data collection methods, and to the fact that greater skill in recording departure data allowed more time to observe and record other activities.

6.2 DEPARTURE LOG

6.2.1 <u>History and Development of the Form</u>

This form was developed as a companion to the Observer's Report form in order to record certain time intervals in the takeoff process. This form also records the same four types of data, but the specifics are different. Identification and reference information are the same as for the Observers' Report. The test program observed data consists of the logging of aircraft takeoff operations by aircraft call sign and type, takeoff location, and takeoff activity times. Like the Observers' Report, comments are entered to record any matters of interest. The form is shown in Figure 6-2.

The first version of the log included takeoff times, plus other information, in addition to all the data indicated on Figure 6-2. After four days of data collection, it became apparent that changes and simplifications were necessary.

The log had originally been planned to produce two time interval measurements:

- The interval from verbal takeoff clearance to activation of the VICON light. This would give an indication of controller workload and delay caused by VICON.

- The interval from verbal takeoff clearance to start of takeoff roll. This would give an indication of pilot workload and delay caused by VICON.

Because of the physical locations of the observers, the local controller, and the VICON control panel, it was not possible to observe activation of the lights, and this observation had to be deleted. This measurement has been obtained on a sampled basis from the data tapes. See Section 11.2.2.

The modified and redrafted form shown in Figure 6-2 has been used throughout the entire data collection program. The only other change was to instruct the observers to write in the actual Greenwich Mean Time (GMT or Z time) every 30 to 45 minutes.

6.2.2 Data Collection

Data collection was carried out simultaneously with the data collection for the observer's reports, section 6.1.2.

6.2.3 Data Description and Analysis

The primary data obtained from the final version of the log are aircraft identification, aircraft type, the time interval between issuance of verbal takeoff clearance and start of takeoff roll, and observer comments.

6.2.3.1 Takeoff Clearance to Start of Roll Time Interval - Takeoffs are made in one of three ways, depending on the location of the aircraft when takeoff clearance is received by the pilot.

- Position and Hold. In this procedure, the pilot is instructed to taxi into takeoff position and hold there. This procedure is used by the controller when there is conflicting traffic. As soon as the conflict is resolved and safe separation is assured, the holding pilot is issued his takeoff clearance and he departs. Since the pilot is lined up on the runway and has essentially completed his checklist, the time interval between takeoff clearance and start of roll is minimal.

- Number One Position. The pilot has taxied to the edge of the runway and has stopped in position to immediately enter the runway (the number one position). The pilot may now be told to taxi into position and hold, or may be cleared for takeoff. If cleared for takeoff, the pilot may either line up in takeoff position on the runway and briefly stop while completing his checks and then take off, or he may enter the runway and take off without stopping (make a rolling takeoff). The time interval here is longer since the aircraft has a longer distance to travel, and may even stop briefly.

- While Taxiing. When traffic is light, the pilot may receive his takeoff clearance while still some distance from the runway. In this situation, the pilot continues to taxi onto the runway and proceeds as above. This time interval may be very long as the pilot may be a considerable distance from the runway when cleared for takeoff.

Other considerations also influence this time interval. Individual pilot techniques vary considerably. Some prefer to have full engine power before starting to roll, while others gradually increase engine power while moving. Since the engines on a large jet require 8-10 seconds to increase from idle to takeoff power setting, pilot preferences can cause considerable variation in the time interval under study. In addition, ceiling and visibility, crosswind, runway length and braking condition, aircraft weight and other conditions influence taxi speed, rolling takeoff vs. pause decision, and rate of engine power increase. These, in turn, influence the takeoff time interval.

Finally, if the pilot is uncertain about any item of his verbal takeoff clearance, he is required to request a repetition of that clearance from the local controller. This, too, adds to the time interval under study. The takeoff time interval data are shown by aircraft type in Table 6-12.

The spread of time intervals for all types of aircraft, except military, ranged from zero seconds to over 100 seconds. In practically all cases of delays greater than approximately 40 seconds, the apparent delay came about because the takeoff clearance was given while the aircraft was still some distance away from entering the runway. The aircraft received the

TABLE 6-12. TIME INTERVAL IN SECONDS BETWEEN ISSUANCE OF VERBAL TAKEOFF CLEARANCE AND START OF TAKEOFF ROLL

AIRCRAFT TYPE	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.
Small Prop	23	20	19	18	17	18
Large Prop	30	16	28	29	17	15
Military Prop	23	44*	7*	7*	28*	12*
Military Jet	--	43*	--	40*	46*	42
Small Jet	21	22	17	17	20	27
Medium Jet	37	31	42	39	15*	11
Large Jet	24	20	23	23	18	25
Heavy Jet	29	23	27	28	25	24
All Aircraft Combined	25	22	22	22	19	22
Number of Takeoffs	247	606	584	1,014	516	559

*Less than five takeoffs.

takeoff clearance while taxiing, continued taxiing, and then entered the runway and made a rolling takeoff. In a small number of cases, the pilot either requested that the clearance be repeated or stated that the crew had not yet completed the takeoff checklist.

There was no indication of any delay that can be attributed to VICON. A complementary study performed for the Transportation Systems Center, "VICON Signal System Impact Study," indicated that VICON had no significant impact on traffic flow and only a minor impact on runway occupancy time.

6.2.3.2 Comments - The observers were directed to note anything which would be of possible value to the analyst in trying to understand the logs and to evaluate their data. Many entries pertained to local situations which do not apply to the system evaluation. The most pertinent comments are shown in Table 6-13. It is highly possible that a comment recorded on the Departure Log is the same as that recorded on the Observers' Report. This overlap does not negate the value of the report.

There was too small a number of comments to indicate relative importance or trends. However, the pilots continued to confirm the VICON light. Beyond that fact, the other items served to confirm problems and comments presented in greater detail in other sections.

A few specific comments were recorded which are highly informative.

TABLE 6-13. TOWER OBSERVER COMMENTS

	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	TOTAL
Number of observation periods	4	19	18	23	18	19	105
Confirmed VICON light	10	39	37	63	67	38	254
Did not get light	0	4	9	12	1	1	27
Requested light, got it	0	4	3	0	4	3	14
Requested light, did not get	0	1	0	0	0	1	2
Questions about VICON	3	6	3	5	6	5	28
Comments about VICON	0	10	1	6	8	14	39
Equipment problems	1	4	3	1	1	4	14
Light aircraft missed MW beam	0	1	0	3	10	1	15
Sun reflection problems	0	2	0	0	1	0	3
Delay at takeoff by pilot*	2	7	10	3	4	2	28
Delay due enroute saturation	1	1	0	0	2	2	6
Pilot required repeat clearance	0	2	4	10	6	11	33

*Not caused by VICON.

- In poor visibility conditions, the tower observers could not see the runways. Their logging under these conditions was done based on radio conversations or the sound of the engines. Traffic levels are fortunately very low for visibility of 1/2 mile or less.

- There was a lot of discussion among controllers when the system was new, and again when new control panels were installed. The observers' notes do not present details. Personal conversation with the observers indicated most discussions were either educational or sharing of experiences with the system; of the opinions expressed about the system, probably two-thirds were negative.

6.3 TOWER OBSERVER INTERVIEWS

The tower observers' efforts started on 16 October, following a one-day training session held in late September. That first week was devoted to in-tower training. Also, forms and procedures were reviewed and revised based on the experiences of that training period. Data collection started on 23 October and continued through 29 March for a total of 105 observation periods.

Immediately after the end of the data collection period, the five regular observers were interviewed to obtain the benefit of their experiences and opinions. The standby observers were not interviewed as their overall experience level was low. The checklist used for these interviews is shown in Figure 6-6.

The following sections summarize the results of the observers' interviews.

What is your overall impression of the local controller workload?
They Work Hard___ Sometimes Work Hard___ Not Too Busy___

What is the overall additional workload caused by VICON?

Did VICON make any positive contributions to safety? Explain.
What are the benefits of VICON? Explain.

Did VICON make any negative contributions to safety? Explain.
What are the faults of VICON? Explain.

Overall, how much did the local controllers use the system?
At the beginning?_______________
At the middle?_______________
At the end?_______________

Overall, did the local controllers give VICON a fair test?
Explain.

Did you observe any attitude changes during the test period?

Do you have any recommended improvements?

Do you have any recommended alternatives?

What is your recommendation for the future of the VICON system?

Did you have any problems with any FAA people? Explain.

Could we have run the Data Collection better?

In terms of what you did and how you did it?
In terms of planning and administration?
In terms of equipment?

Describe any interesting or unusual events that took place while you were on duty. What part did VICON play in these events?

FIGURE 6-6. TOWER OBSERVER INTERVIEW CHECKLIST

6.3.1 Workload

The local controller's workload varies depending on the traffic level. When the traffic level is high they work hard; when the traffic level is low they have little to do. They can be very busy for a short time but this is followed by a quiet period.

The added workload due to VICON is minimal. The most distracting element is that the controller must take his eyes off whatever he is watching and refocus on the VICON panel to push the right button.

6.3.2 Effect on Safety

There were no positive effects. VICON might have produced benefits if it had been used consistently. There was a negative effect; when the controller mixed up aircraft identification, the green light was given to aircraft that the controller actually wanted to hold. This caused doubt and confusion.

6.3.3 VICON Use

The estimated use of VICON was about 50% at the start of the program increasing slowly to about 75% at the end of the test period.

6.3.4 Controller Attitude

Most of the controllers were biased against VICON. Some predetermined failure of the system; some controllers did approach VICON with an open mind and give it a fair test. Controllers are generally a very conservative group and oppose change.

The controllers were skeptical of the observers at the beginning of the test, but they became more tolerant of both the VICON system and of the observers as the test progressed. By the end of the test they had fully accepted the observers.

The Touch Sensitive panel was not liked (in place 18 January through 4 February), and this discouraged participation in the test. Participation improved after the Mimic panel was reinstalled on 5 February.

6.3.5 Improvements and Alternatives to VICON

All improvements were concerned with the light distinctiveness. The light should be easier to locate and identify and should be positioned better. There was concern about the effects of snow on the lights.

The most highly recommended alternative was to standardize controller and pilot terminology to reduce confusion. Mandatory readback of takeoff clearance was also considered a very good alternative.

6.3.6 Recommendations for the Future of VICON

The two recommendations were: modify the system to correct the light cluster problems and then retest at a major airport, and standardize all procedures and make use of the system mandatory.

6.3.7 Program Management

FAA cooperation was excellent. There were some minor problems with the procedures and equipment provided by IOCS to the observers. Procedures were not as complete as they should have been, the clipboards were too small, and lighting was poor for night work.

6.3.8 Overview Comments

The briefing of the pilots, controllers, and observers should be improved. Many pilots were not familiar with the procedures that should be used during the VICON test. While many of the controllers had a good knowledge of the equipment and procedures, some did not. (Example: On one shift in early January, the tower observer heard the ground controller ask the local controller if the VICON light would automatically go back to red. The local controller answered that it would.) Both pilot and controller groups should have received continuing refresher/upgrade training. The observers should also have received upgrade training from IOCS, and should have been kept better advised of the usefulness and quality of their data.

An additional controller position should be set up to operate VICON. The observers rated the additional workload due to VICON as Very Low to Low. However, they observed that controllers did not use the system consistently (Section 6.3.3), and felt that a separate VICON position would ensure 100% use of the system. They also felt that 100% use was essential if VICON is to produce positive benefits (Section 6.3.2). There is already a local coordinator position in the Bradley tower which is used occasionally, and the local coordinator has been observed to operate VICON using the remote control. Also, even when average operations are low, there are bursts of heavy traffic. An assistant would help smooth out these workload peaks.

The method of doing the test should be revised to provide for more fully trained pilots and controllers, and use of VICON should be made mandatory. Expressions of personal opinions over the radio should be minimized. This may be the most important consideration of all! If the method of testing allows a prejudice to be presented constantly, it is just like propaganda; if you tell it long enough it will be believed.

This test and the resultant findings and suggestions should not be wasted.

6.4 RESULTS AND APPLICATION OF ANALYSIS

6.4.1 Feasibility

The equipment adequately performed its intended functions, but some problems did exist.

- There were equipment failures. Runway 33 equipment caused problems in November but was fixed by the end of the month. Otherwise, the logs showed only six failures, not counting Data Acquisition System problems.

- Light propeller aircraft, and, rarely, other types did not break the microwave beam on takeoff. This allowed the green light to remain lighted, and led to confusion in the next departing aircraft regarding clearance status.

- At certain times of day, sunlight made the light appear to be lighted when it was not, resulting in confusion.

- Controllers reported pushing the wrong button, having to override the error, and then pressing the correct button.

6.4.2 Integration Into the Air Traffic Control System

Integration into the ATC system involved primarily workload and procedures. Integration was successful if routine use of VICON did not affect the smooth flow of traffic, and did not cause any unusual events.

- The average rating of controller workload was slightly greater than Low (Section 6.1.3.1.1).

- Workload increased with increasing traffic levels (Section 6.1.3.1.5).

- Additional workload increased with increasing traffic levels (Section 6.1.3.1.5).

- Workload decreased as the visibility decreased (bad weather) (Section 6.1.3.1.5).

- The average rating of the Additional Controller Workload Caused by VICON lay between Low and Very Low. There was little difference in the monthly ratings (Section 6.1.3.1.2).

- There was a direct relationship between the Controller Workload and VICON Additional Workload, but the rate of increase in additional workload was not as great as the rate of increase in total workload (Section 6.1.3.1.3).

- Additional workload decreased with decreasing visibility (Section 6.1.3.1.5).

- Some controllers were not using VICON, and some were using it intermittently.

- Not all controllers and pilots completely understood the system.

In the opinion of the observers, the impact of VICON on the ATC system, and on the controllers, is low. However, comments made by the controllers regarding VICON are generally negative, and some controllers did not use the system or used it intermittently.

6.4.3 Enhancement of Safety

Ninety five percent of the observers said that VICON had a Neutral effect on safety. This overwhelming neutral response made impossible the correlation of safety with any variable such as visibility. Three occurrences were reported where the VICON green light might have caused the pilot to be confused, creating a potential negative effect. The occurrences of the light plane taxiing across the runway and then returning to the runway are difficult to evaluate; the pilots were already thoroughly confused. VICON might have reduced the confusion if the pilot was familiar with the system and the controllers used it all the time.

It must be reemphasized that VICON was not a control system. The pilot could takeoff upon receiving, understanding, and acknowledging his verbal takeoff clearance even if the VICON light was not lit. VICON confirmed but did not control.

6.4.4 Summary

The equipment generally performed well, but certain design problems remain to be solved, the two major ones being failure of the microwave beam to turn off the light on every takeoff, and troubles due to sunlight.

Integration into the ATC system appeared to be readily achievable, although comments made by the controllers differ markedly from the opinions of the observers.

The overwhelming opinion was that VICON had a neutral effect on safety. There did not appear to be any benefits. No delay in takeoff operations due to VICON could be detected.

6.5 PANELS

During the test program three different control panels were installed. The first was the Mimic panel which contained a map of the runways and mechanical pushbuttons, shown in Figure 6-7. The second was the Matrix panel, Figure 6-8, which had mechanical pushbuttons arranged in rows corresponding to the three runways. The third was the Touch Sensitive panel, Figure 6-9, which contained a map of the runways but had touch sensitive switches instead of mechanical ones.

There were only a few comments regarding the three panels. One controller recommended a change in the arrangement of the push buttons on the matrix panel to have all northbound runways start on the left side. However, in their discussions, the controllers expressed an overall preference for the mimic panel with the mechanical pushbuttons.

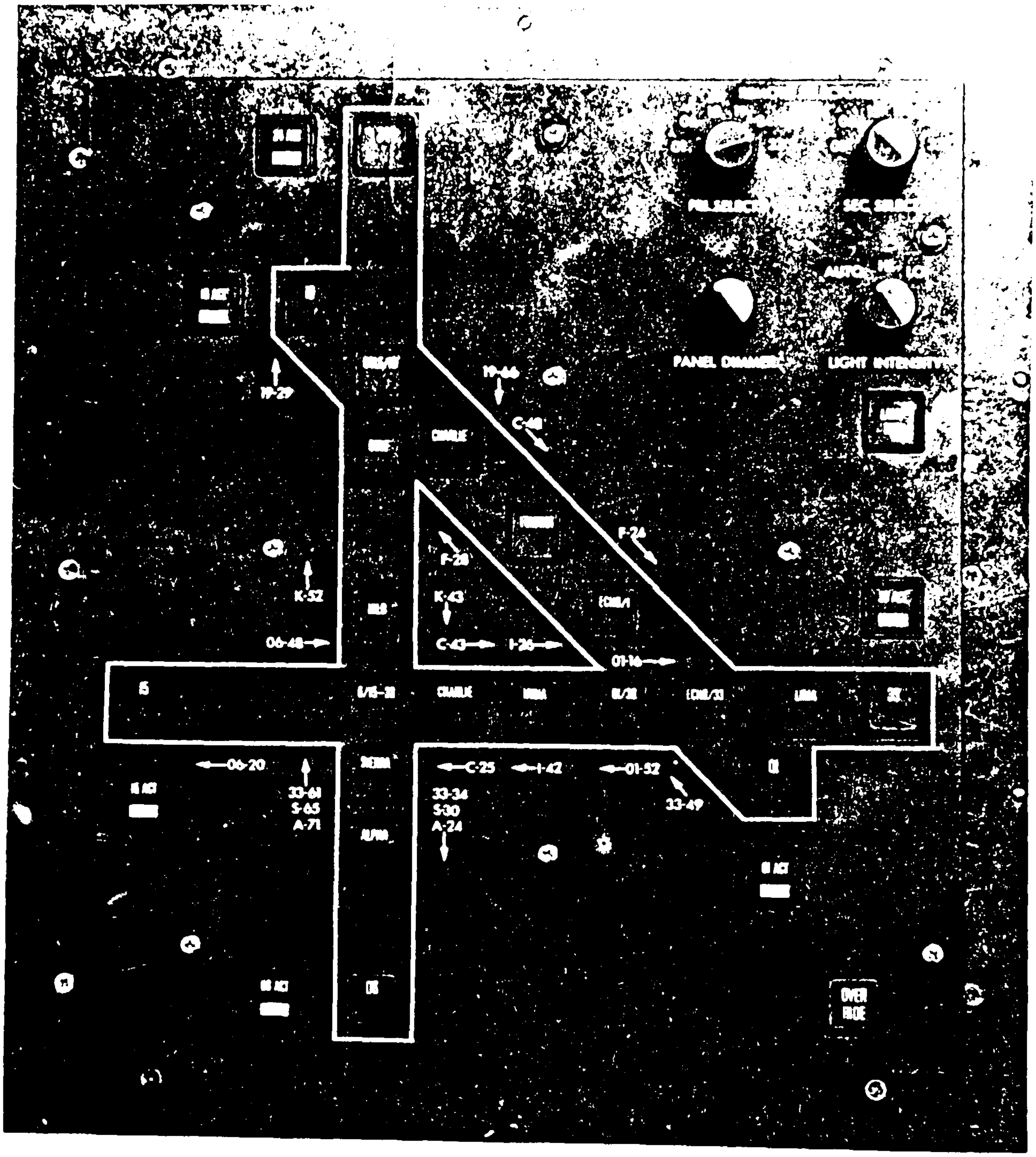


FIGURE 6-7. MIMIC TYPE VICON CONTROL PANEL WITH SWITCH IDENTIFICATION

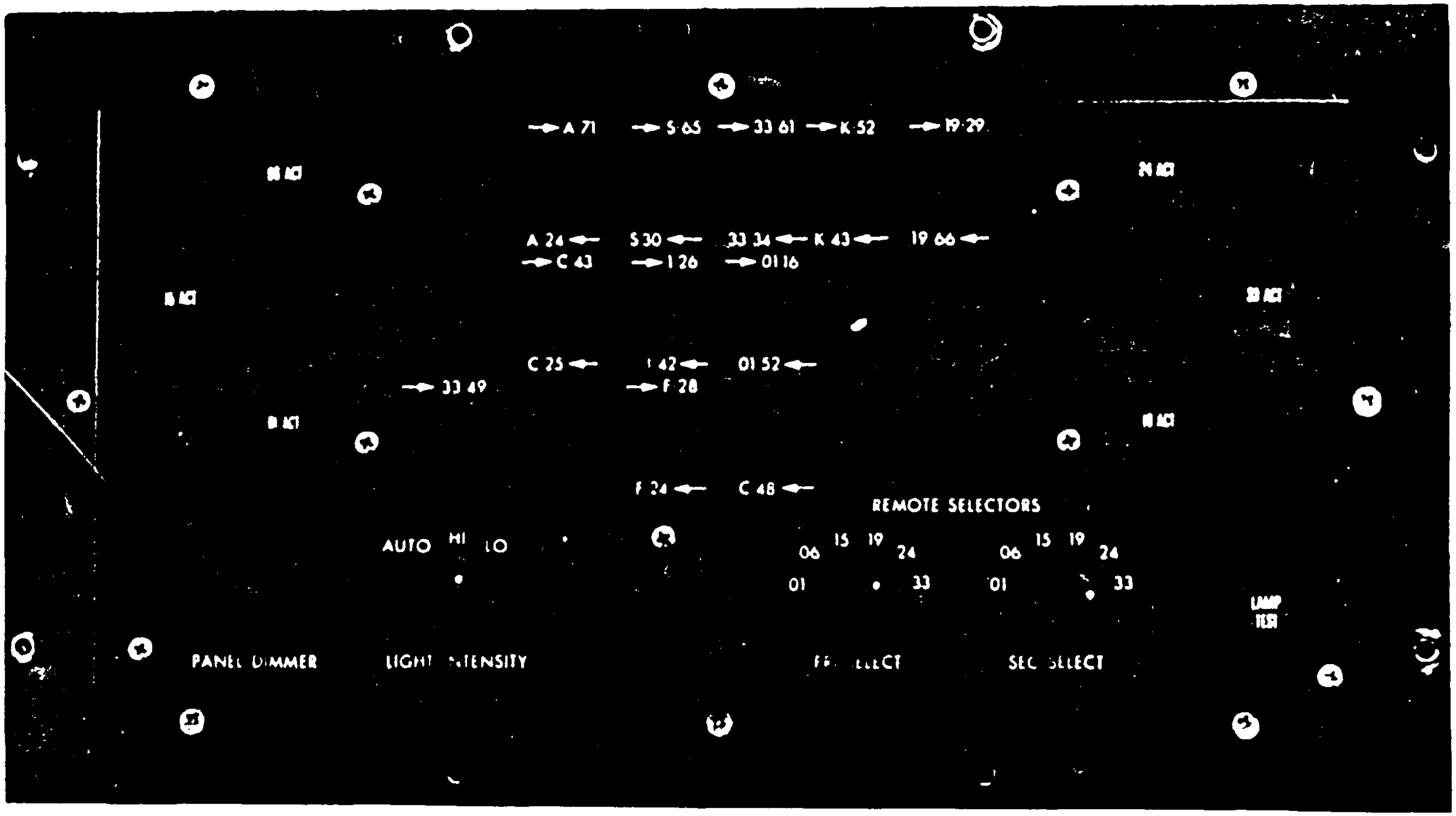
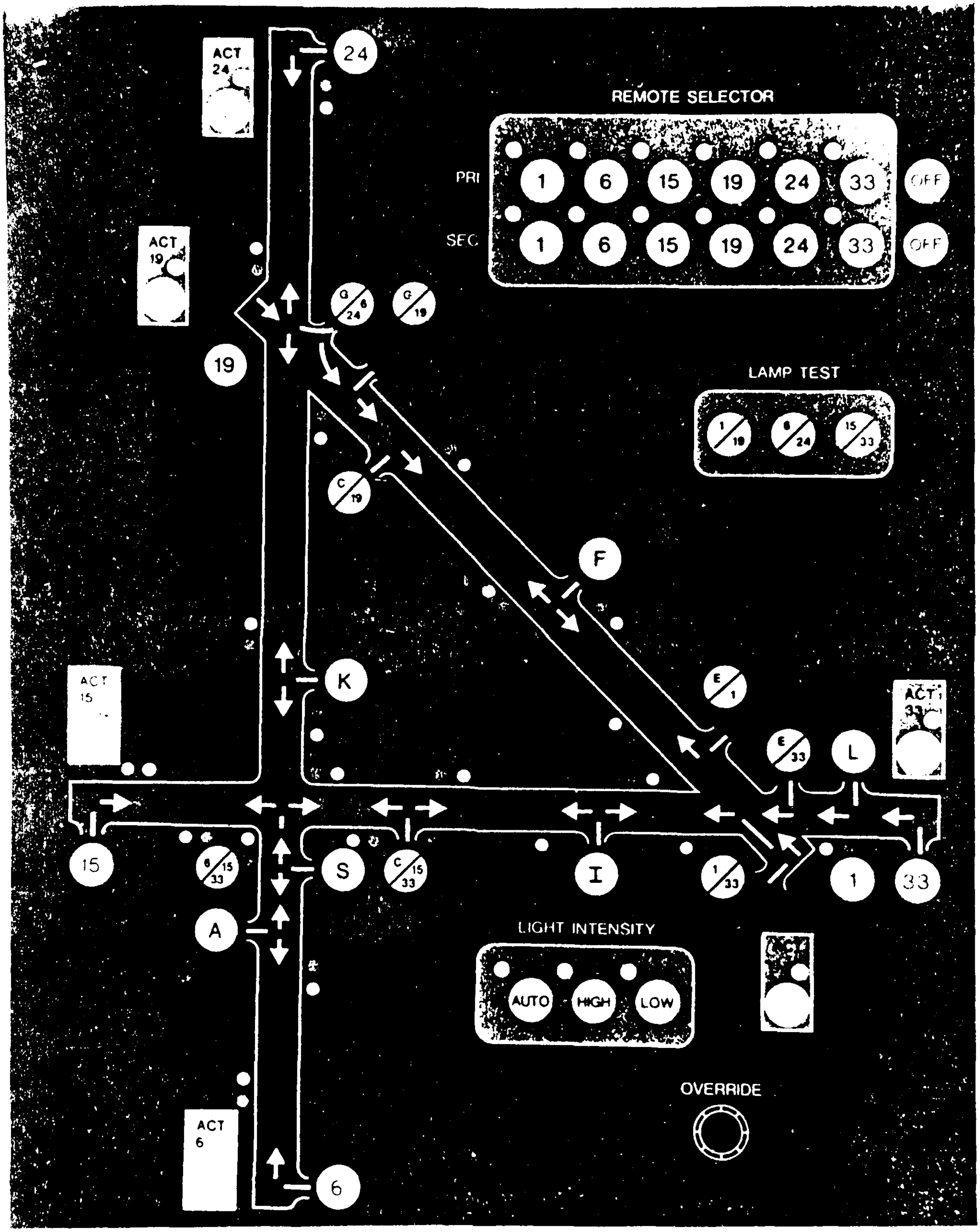


FIGURE 6-8. MATRIX TYPE VICON CONTROL PANEL WITH SWITCH IDENTIFICATION



REMOTE SELECTOR
PRI
1
6
15
19
24
33
OFF
SEC
1
6
15
19
24
33
OFF
LAMP TEST
LIGHT INTENSITY
AUTO
HIGH
LOW
OVERRIDE
ACT 24
ACT 19
ACT 15
ACT 6
ACT 33
24
19
15
6
1
33
F
K
S
A
I
L

FIGURE 6-9. [illegible]

7. PILOT INTERVIEW DATA

7.1 PILOT INTERVIEW REPORT FORM

The pilot interview report form was prepared to serve as both a checklist and a convenient report format. The questions were selected and phrased to obtain information about the key attributes of VICON and to lead the pilots into a discussion about their experiences (if any) with VICON and their opinions and recommendations regarding the system. The form is shown in Figure 7-1.

7.2 DATA COLLECTION

Pilot interviews were held at a motel close to the passenger terminal at Bradley International Airport. The motel was chosen so that pilots flying into Bradley could easily and quickly walk to the interview location. Further, it was felt that this convenient location would provide maximum opportunity for general aviation pilots based at Bradley to attend the interview meetings. In some cases where pilots could not attend the meeting personally, the interviews were conducted by phone.

Three interview sessions were held - 28-29 November 1979, 20-21 February and 17-18 April 1980.

For each interview meeting, one or more invitation letters were sent to all pilot representatives and points of contact identified by the FAA or developed by our own efforts. These letters presented the items to be discussed so that the interviewees would have ample opportunity to talk to their pilots and obtain as much information as possible.

1. What are the greatest values or benefits of VICON?

2. What are the greatest faults or problems with VICON?

   Do the problems require immediate correction? Yes___ No___

3. Have you personally experienced any unusual occurrences with VICON?

   Yes___ No___ If so, what were they?

4. Your assessment of the personal cost, difficulty, or annoyance with VICON is:

   Great Cost   Minor Cost   Neutral   Minor Benefit

   Great Benefit

5. The consensus on the value of VICON to the National Airspace System is:

   Detrimental   Somewhat Negative   Netural   Somewhat Positive

   Essential

6. Should VICON be installed nationwide: Yes___ No___

   If yes, where: All Towered Airports ______
   Air Carrier Airports ______
   Major General Aviation Airports ______
   Intermediate Activity GA Airports ______
   Lower Activity Airports ______
   Please elaborate?

7. List any events reported, and explain.

FIGURE 7-1. VICON PILOT GROUP INTERVIEW REPORT

At the interview, the pilot was given a copy of the interview report so that he could follow the line of questioning and discussion. The IOCS interviewer filled out the form, and took it back to Waltham for later analysis.

7.3 DATA DESCRIPTION AND ANALYSIS

As shown in Figure 7-1, the data consists of three types:

- Three broad questions
- Three questions with scored answers
- Unstructured comments, opinions, and suggestions

In addition, each pilot was encouraged to offer any pertinent remarks he might care to make. In some cases, the pilots' representative gave an airline company position as well as the pilots' opinions.

The answers and comments were analyzed individually, grouped where possible, and summarized.

7.3.1 First Interview Meeting

To balance the size of each expected interview group, six specific meeting groups and times were set up, two air carrier, one military, one business, one general aviation, and one open to all.

Eight pilots were interviewed in person and three by telephone. One telephone interview produced very generalized data, based on only a few pilots' remarks. Details are given in Appendix C.

7.3.1.1 Greatest Values or Benefits - It was felt that VICON would be valuable for:

- Airports serving foreign pilots
- Standardization of procedures if installed and used nationwide
- Possibly reducing repeat voice transmissions

Beyond these benefits, there was little enthusiasm for VICON as pilots do not see the need since voice clearance has caused no problems.

7.3.1.2 Greatest Problems or Shortcomings - The pilots' answers are summarized as follows:

- The lights are poorly placed and are hard to identify - the lights must grab the pilots' attention. They are too far down the runway, too close to the Visual Approach Slope Indicator (VASI), and blend with other lights. There is some concern about snow cover and removal. One pilot suggested that they be embedded in the runway centerline since the pilot's attention is directed to the centerline on takeoff.
- The VICON system is not needed - there is no present problem.
- VICON is too costly for the value received - pilots would prefer to have the money used for other equipment such as VASI, Instrument Landing System (ILS), Distance Measuring Equipment (DME), longer runways, collision avoidance systems, and runway intrusion control systems.

- The system causes distraction and added workload at a very busy time.

- There is concern that VICON may become an unnecessary and undesirable crutch, and may become the primary control method.

- VICON is not consistently used by the controllers.

7.3.1.3 Unusual Occurrences - Only two such occurrences were mentioned by the pilots:

- The system is used intermittently

- In one instance, the light stayed on about two minutes

7.3.1.4 Assessment of Personal Cost, Difficulty on Annoyance - Nine pilots listed Minor Cost and one listed Neutral.

7.3.1.5 Value of VICON to National Airspace System (NAS) - Three checked somewhat negative, four checked neutral, two checked somewhat positive, and one pilot did not answer saying he had too little experience with VICON to judge. The average falls just slightly negative.

7.3.1.6 Nationwide Installation - The answers given were:

- Do not install - three

- All towered airports - one - who also recommended ICAO use for standardization

- Air carrier airports only - two

- Other - three - individually selected airports, based on traffic level, runway layout, and use by foreign pilots

- No answer - one

7.3.2 Second Interview Meeting

Since so few pilots attended the first meeting, att[illegible]s were made to increase attendance. Specific meeting groups and times were not scheduled; instead, interviewers were on hand for one long evening and all of the following day. Pilots were requested to come for the interview at their convenience. The second evening, two interviewers attended a pilots' association meeting to obtain the opinions of a group of general aviation light plane pilots who fly from an airport very close to Bradley.

In addition, posters were placed in a number of general aviation locations and the local television channel included the interview schedule in their announcement of local events.

Only one pilot attended and one telephoned his findings.

7.3.2.1 Greatest Values or Benefits - One pilot liked the VICON concept and the way it worked and one felt there was no benefit.

7.3.2.2 Greatest Problems or Shortcomings - The problems cited were:

- One pilot was worried about communication - would he take off if he had a radio problem but saw the green light?

- VICON causes distraction at a very busy time.
- There should be an opposing signal (probably red) when there has been no clearance issued.
- One pilot confused the VICON light with the VASI.

7.3.2.3 Unusual Occurrences - The only unusual occurrence cited was that frequently the system is not used by the controllers.

7.3.2.4 Assessment of Personal Cost, Difficulty or Annoyance - One mark each for Minor Cost and Minor Benefit.

7.3.2.5 Value of VICON to National Airspace System - One mark for each Somewhat Negative and Somewhat Positive.

7.3.2.6 Nationwide Installation - One mark each for Yes and No.

7.3.2.7 Pilots Association Meeting - The interviewers gave a 15 - 20 minute talk about VICON, citing the reason for the systems, how VICON works in terms of hardware and procedures, where the lights were positioned and what they looked like, and concluding with an overview of the test program at Bradley.

Twenty-nine pilots attended. Two thirds were not aware of VICON, and one third were aware of the VICON test program, but had not seen the lights. Only two pilots reported seeing the lights in operation. Another pilot reported that she had taken off from Bradley several times a week (at least 20 times since 15 October) and had never seen the lights; she was aware of the VICON test program, but did not ask for the lights.

The two pilots had opposite opinions regarding any value of VICON, neither very strong. The problems cited were the frequently given ones - difficulty in locating the lights and intermittent use.

Both pilots felt there was a negative personal cost associated with VICON. For value to the NAS, one marked Somewhat Positive and one Somewhat Negative. One pilot said VICON should not be installed and one listed Air Carrier Airports only.

7.3.3 Third Interview Meeting

In view of the lack of response to the open meeting method used for the second interview session, we returned to the method used for the first session wherein each group of pilots was scheduled for a specific date and time. The air carriers were scheduled to provide the greatest possible convenience for them to fly to Bradley, be interviewed, and fly home that same day. General aviation was set up for a long session the first evening. Since most of these pilots work during the day, it was felt that an evening meeting would encourage greater attendance.

To generate the maximum awareness and interest for the general aviation meetings, a major publicity campaign was carried out. The field supervisor personally visited 22 airports in the Hartford-Springfield area and talked about the VICON program to the airport manager, the fixed base operators, and any flight school owners. He put up 250 8-1/2" x 14" blue posters, Figure 7-2. In addition, announcements of the general aviation interviews were carried on four radio stations and one television station in the week preceding the meetings. Finally, the supervisor made an excellent half-hour presentation of the overall VICON program on a radio talk show.

VICON

PILOT INTERVIEWS

COME IN AND
TELL US YOUR EXPERIENCES
AND OPINION OF
VICON

THURSDAY, 17 APRIL
7:00 PM – 9:30 PM

FRIDAY, 18 APRIL
10:00 AM – 11:30 AM

BRADLEY AIRPORT
AIRPORT RAMADA INN

FIGURE 7-2. THIRD PILOT INTERVIEW MEETING POSTER (REDUCED)

Two pilots from an air carrier and one general aviation pilot attended the meetings. Another air carrier company sent a message with the first two pilots. Later, two letters and two phone calls were received.

7.3.3.1 Greatest Values or Benefits - None as presently designed and used. Might prevent an inadvertent takeoff if used 100% of the time.

7.3.3.2 Greatest Problems or Shortcomings - Those given were:

- One more thing to do when busy.
- Controllers used VICON intermittently, so the pilots were unsure of their proper responses.
- Some pilots hesitated to take off without the green light.
- If the pilot requested the light, he usually got it, but he did not get the light every time, even when requested.
- The GA pilot rarely saw the light, and did not ask for it.

7.3.3.3 Unusual Occurrences - The only occurrences given were that the First Officer had trouble seeing the lights, and that they are intermittently used.

7.3.3.4 Assessment of Personal Cost, Difficulty or Annoyance - Minor Cost to Neutral.

7.3.3.5 Value of VICON to National Airspace System - Detrimental to Neutral.

7.3.3.6 Nationwide Installation - All agreed that VICON should not be installed.

7.3.3.7 *Other Comments* - The air carrier pilots stated that they had never experienced an unauthorized takeoff. However, the General Aviation (GA) pilot stated that many of his fellow pilots were "afraid" of the radio. Accordingly, they avoided towered airports, but when circumstances forced them to use a towered airport they made many mistakes in their radio communications and other procedures and probably did make unauthorized takeoffs.

The air carrier pilots recommended that VICON funds be used for two other systems - runway intrusion control systems and vertical guidance (ILS, VASI) systems for every major runway. The GA pilot urged that the funds be used to provide short, low cost refresher/upgrade educational sessions for GA pilots, with initial emphasis on radio communication procedures and on navigation. Like most GA pilots, he did not have the time or money to take the long and costly training programs offered by flight schools; but, he and his fellow pilots want to maintain and upgrade their proficiency (and thus their safety). If FAA offered a one-night, three-hour course, with the cost to the pilot limited to text books (and possibly a small registration fee), the GA pilots would attend in large numbers. He felt that pilot education of this type would make a far greater contribution to safety than VICON.

7.3.3.8 Pilots Association - Because of the very poor attendance at the interview sessions, 30 members of the pilots association were interviewed by telephone. Of the 30, 6 had actually been into Bradley and had some experience with VICON. One reported the system as: "Good, if used all the time." The other five were negative - more confusion, more distraction, another thing to do. One commented: "I don't go into large airports now if I can help it. I don't understand all their different procedures and I don't want to get written up for a violation." (This ties directly into the previous request for training sessions.) On the two scored questions, the answers were: Assessment of Personal Cost - Minor Cost, 3; Neutral, 2; Minor Benefit, 1; and Value to National Airspace System - Somewhat Negative, 1; Neutral, 4; Somewhat Positive, 1.

Of the remaining 24 pilots, 6 had never heard of VICON, 6 were aware of VICON but were not familiar with its operation and wanted an explanation, 2 felt it was a good idea if used all the time, and 10 were opposed to the system. Reasons given for opposing VICON followed the familiar pattern - not needed, one more thing to do, diversion of attention at a critical time, and too costly for any benefit received. One pilot felt that the money could be better spent on education and training sessions presented by FAA for GA pilots.

7.4 RESULTS AND APPLICATIONS OF ANALYSIS

7.4.1 Feasibility

The pilots indicated that the equipment appeared to work well but felt that there were some serious shortcomings. There was a strong feeling that the lights are poorly positioned and are very hard to locate and identify. The lights must grab the pilots' attention.

7.4.2 Integration Into the Air Traffic Control System

There was a moderate feeling that VICON is not needed as there is no present problem with voice clearance, or that VICON is too costly for the value received. The value of the system to the National Airspace System is slightly negative. There is some increase in pilot workload.

7.4.3 Enhancement of Safety

There was little enthusiasm for the system as pilots generally feel that no unsafe condition presently exists. They feel that funds could far better be spent on other safety-enhancing equipment such as DME, ILS and VASI; there was a strong feeling that runway intrusion is a serious problem and that runway intrusion control systems are very much needed. The general aviation pilots felt the money should be used to provide short, low-cost refresher/upgrade training sessions. Their assessment of cockpit impact was that VICON imposes a minor personal cost, adds workload, and was distracting at the very busy takeoff time. The overall assessment is that VICON either had no safety benefit or had a somewhat negative effect. The negative effect was made worse by the intermittent, unpredictable, and sometimes unresponsive use of VICON by the controllers. Finally, in the general aviation community, there was very little awareness of the VICON system and of the test program at Bradley.

7.4.4 Summary

The results of the three sets of pilot interviews are summarized as follows:

- Technical Feasibility - with the exception of the light position and identification problem, the equipment performed its intended function.

- Integration - the integration had not been wholly successful, and some problems existed.

- Enhancement of Safety - VICON had a slight negative effect on safety, and the money could produce positive safety effects if spent on other equipment.

8. PILOT'S QUESTIONNAIRE DATA

8.1 PILOT'S QUESTIONNAIRE REPORT FORM

The Pilot's Questionnaire was prepared by the FAA to enable a larger population of pilots to report on their individual uses of the VICON system than could possibly report through the direct pilot interviews. The responses to the questionnaires serve as an independent means to supplement and confirm or contrast the information developed through the pilot direct interviews. The questionnaire was printed as a pre-addressed, franked, self-contained unit; the data side is shown in Figure 8-1.

8.2 DATA COLLECTION

The questionnaires were distributed to Airline Flight Offices, both at Bradley and other airports, and to the Military Operations Offices of Bradley. They were also distributed to the Fixed Base Operators and flight training schools at Bradley and other airports, and were mailed or hand delivered to the flight offices of a number of businesses who operated through Bradley in the course of their companies' activities.

Pilots were requested to complete a questionnaire each time they departed from Bradley. The completed form was to be droppe any mailbox for postage-free delivery to NAFEC. The forms were orwarded about twice each week to IOCS, where they were logged and analyzed.

O.M.B. No. 04-S7907

ORIENTATION

This questionnaire is intended to obtain pilot opinion of the VICON system described in the current issue of the Airmen's Information Manual. It is expected that the use of VICON will enhance safety without creation of additional pilot workload. Answer this questionnaire only with regard to your latest departure, fold, seal and drop it in a mail box.

IDENTIFICATION AND CIRCUMSTANCES

Your license type ______________________ Flight hours ______________________

Aircraft type: ☐ Air carrier ☐ Military ☐ Air taxi ☐ Business ☐ Other G.A.

Aircraft make/model ______________________ Date of takeoff __________ Time __________

Departure point at BDL: Runway ________ /Intersection of Runway ________ and Taxiway ________

How many times, including the present, have you filled in one of these VICON forms?

☐ 1 ☐ 2 ☐ 3 ☐ more than 3

VICON DISPLAY CHARACTERISTICS

Did you see VICON lights? ☐ Yes ☐ No

Please rate the VICON light clusters:	Excellent	Good	Marginal	Poor	Bad
Distinctiveness	☐	☐	☐	☐	☐
Perceptability	☐	☐	☐	☐	☐
Location	☐	☐	☐	☐	☐
Intensity	☐	☐	☐	☐	☐

VICON UTILITY RATINGS

Did you ask for VICON lights? ☐ Yes ☐ No

Please rate VICON on the following characteristics, where 1 = made things much easier, 2 = made things easier 3 = made no difference, 4 = slight impediment, 5 = caused difficulty.

	1	2	3	4	5
Effect on cockpit workload:	☐	☐	☐	☐	☐
Effect on clarity and understanding of clearance:	☐	☐	☐	☐	☐
Effect on expeditiousness of your departure from BDL:	☐	☐	☐	☐	☐

VISIBILITY AT TAKEOFF

☐ Poor ☐ Fair ☐ Good

COMMENT

Please write your comments, descriptions or suggestions for VICON here:

FIGURE 8-1. PILOT'S VICON DEPARTURE QUESTIONNAIRE

8.3 DATA DESCRIPTION AND ANALYSIS

As shown in Figure 8-1, the data consists of three types:

- Reference data comprising Identification and Circumstances, and Visibility
- Scored answers to seven questions concerning Display Characteristics and Utility Ratings
- Unstructured comments and suggestions

The reference data provided the background information which permitted the seven sets of scored answers to be examined for possible effects of such variables as visibility, VICON use, pilot flight hours, and aircraft type. It also provided the information which was used to correlate comments to determine if the variables created observable differences in the comments.

The scored data were analyzed statistically, and the comments were assigned to one of five groups and then analyzed for content and frequency of occurrence. The comment groups were: Favorable, Unfavorable, Neutral/Conditional, Equipment, and Procedures.

8.3.1 Questionnaire Breakdown

The number of questionnaires received by month and by type of flying is shown in Table 8-1. The air carriers submitted by far the largest number; military participation was extremely small. Also, the number received decreased each month indicating a decreasing interest in the program. No questionnaires were received in March.

The questionnaire content varied considerably. Some pilots did not answer all the questions or provide all the reference data. Most pilots offered some comment, and a number offered

TABLE 8-1. QUESTIONNAIRES SUBMITTED BY MONTH AND TYPE OF FLYING

MONTH	AC	MIL	AT	BUS	GA	TOTAL	PERCENT
October	41	3	2	11	13	70	16
November	157	0	6	6	7	176	41
December	75	1	0	1	8	85	20
January	29	1	6	2	7	45	10
February	38	13	2	0	3	56	13
March	0	0	0	0	0	0	0
TOTAL	340	18	16	20	38	432	100
PERCENT	79	4	4	4	9	100	100

more than one. Thus, the numbers used in the individual analyses varied over a small range and are not errors or inconsistencies.

8.3.2 Display Characteristics Ratings

The pilots were asked to complete questionnaires dealing with their experience with the VICON system. They were asked to offer their judgements on the VICON Display Characteristics, which dealt with Distinctiveness of the Lights, Perceptibility, Location and Intensity. Ratings were also tabulated on VICON's Effect on Cockpit Workload, Effect on Clarity and Understanding of Clearance, and Effect on Expeditiousness of Departure. The aircraft type was also categorized, along with visibility at takeoff, and pilots were asked to state the number of times VICON had been encountered.

Data was collected and tabulated from October through February. Monthly distributions were checked to determine if any trends developed as the test program progressed. The Display Characteristics were rated as follows:

Excellent	5 points
Good	4 points
Marginal	3 points
Poor	2 points
Bad	1 point

A summary of the scores is shown in Table 8-2.

TABLE 8-2. DISPLAY CHARACTERISTICS RATING SCORES

	DISTINCT		PERCEPT		INTENSITY		LOCATION	
	N	%	N	%	N	%	N	%
Excellent	82	21.7	79	21.0	100	26.4	64	16.8
Good	205	54.2	196	52.0	220	58.0	176	46.3
Marginal	62	16.4	76	20.2	42	11.1	78	20.5
Poor	22	5.8	18	4.8	12	3.2	46	12.1
Bad	7	1.9	8	2.1	5	1.3	16	4.2

8.3.2.1 Evaluation of Display Characteristics Ratings - Table 8-3 summarizes the average rating of the Display Characteristics by the number of times a pilot submitted a questionnaire (usage).

A hypothesis of considerable interest is that of a trend of higher ratings over time, which might suggest gaining familiarity with the system. The Kendall's Tau test was employed and this hypothesis could not be supported by

TABLE 8-3. AVERAGE RATINGS OF DISPLAY CHARACTERISTICS

USAGE	DISTINCT	PERCEPT	INTENSITY	LOCATION
1	3.92	3.89	4.05	3.60
2	3.76	3.63	3.97	3.55
3	4.00	4.10	4.05	3.95
>3	3.65	3.48	3.86	3.57

statistical evidence for each of the four variables. Furthermore, any differences of Display Characteristics Ratings with Usage seem to be due to random variations at an adequate confidence level. The Kruskal-Wallis test was used to support this conjecture.

A similar investigation of Display Characteristics Ratings with visibility was conducted. The Kendall's Tau test and Kruskal-Wallis test were employed and the results suggest that no significant relationships could be found. The visibility seems to have a negligible effect on the Display Characteristic Ratings.

8.3.2.2 Comparison of the Display Characteristics Ratings - An area of concern is that the ratings of location appear to be much lower than those of the other Display Characteristics. One may note the average rating for Location to be 3.59 which is highly significant on the low side compared to the other three using the t-test (see Table 8-4).

Using the statistical techniques of a variant of the t-test which measures whether average values differ, the following relationships were obtained.

1) Location was rated the worst.

2) Intensity was rated the best.

3) Perceptibility and Distinctiveness were rated equally and between Location and Intensity.

TABLE 8-4. DISPLAY CHARACTERISTIC VALUES

	AVERAGE	STANDARD DEVIATION
Location	3.59	1.04
Percept	3.85	0.88
Distinct	3.88	0.88
Intensity	4.05	0.79

It may be noted that most of the Pilots' Comments were directed at the problems associated with the Location of the lights. A look at the deviations also reflects the problems with Location. The larger deviation indicates that the pilots had trouble rating this characteristic. It should be noted that Intensity had the best rating and the lowest deviation which indicates there were fewer problems compared to the others in judging the intensity of the lights.

8.3.3 Utility Ratings

The second major area of investigation of the pilot questionnaires dealt with the VICON Utility Ratings:

1) Effect on Cockpit Workload

2) Effect on Clarity and Understanding of Clearance

3) Effect on Expeditiousness of Departure

The Ratings were as follows:

Made things much easier	= 5 points
Made things easier	= 4 points
Made no difference	= 3 points
Slight impediment	= 2 points
Caused difficulty	= 1 point

A summary of results is shown in Table 8-5.

8.3.3.1 Evaluation of Utility Ratings - The average value and the deviation about the average were calculated, as previously discussed, for the Utility ratings. These are shown in Table 8-6.

TABLE 8-5. UTILITY RATING SCORES

	COCKPIT WORKLOAD		CLARITY AND UNDERSTANDING		EXPEDITIOUSNESS OF DEPARTURE	
	N	%	N	%	N	%
Much Easier	13	3.7	43	12.4	10	2.9
Easier	41	11.8	103	29.6	22	6.5
No Difference	211	63.3	184	52.9	296	87.1
Impediment	68	19.5	13	3.7	8	2.3
Difficulty	6	1.7	5	1.4	4	1.2

TABLE 8-6. AVERAGES AND DEVIATIONS FOR UTILITY RATINGS

	AVERAGE	STANDARD DEVIATION
Cockpit Workload	2.963	0.728
Clarity and Understanding	3.477	0.812
Expeditiousness	3.076	0.498

Most pilots seem to feel that VICON made no difference with regard to Cockpit Workload and Expeditiousness of Departure as evidenced by the average rating being nearly 3. In fact, 63% of the Cockpit Workload variables had a response of No Difference, and Expeditiousness of Departure had a No Difference Response Rate of 87%.

Clarity and Understanding of Clearance stood above the other two Utility Ratings in that the No Difference Response Rate was 53%, and there were many more responses in the Easier and Much Easier categories compared to the other two variables. The average rating was nearly 3.5. This particular variable exhibited more variation in the responses, partly because the pilots were willing to offer more responses toward the "easier" rating compared to those of Cockpit Workload and Expeditiousness of Departure. Generally, a larger variation indicates more difficulty in pinpointing a response to a question, however, the pilots seem to be leaning towards a more favorable response in regard to Clarity and Understanding of Clearance.

8.3.3.2 Effects of Usage on Utility Ratings - The effects of VICON use on the Utility Ratings were investigated, in terms of whether increased use reduces the cockpit workload, improves the clarity and understanding of clearance, and expedites the departure. Table 8-7 summarizes the average values of the Utility Ratings by questionnaires submitted.

TABLE 8-7. EFFECTS OF MULTIPLE VICON USE

QUESTIONNAIRES SUBMITTED	COCKPIT	CLARITY	DEPARTURE
1	2.993	3.515	3.078
2	3.000	3.303	3.121
3	2.900	3.450	3.176
> 3	2.571	3.286	2.905

The Kendall's Tau test was employed to test whether increased usage was associated with better Utility Ratings. It was found that no such relationship could be statistically supported. It may be noted that the ratings for the "more than three" category are on the low side, contrary to our purported relationship. A reason could not be found by the analyst to explain this unusal behavior. Perhaps, as the pilot becomes more experienced with the system, he also becomes more critical with his response.

8.3.3.3 Effects of Weather on the Utility Ratings - No significant relationships could be statistically supported in regard to possible effects of weather on the three Utility Ratings. Thus, to conclude, the Utility Rating are independent of the weather conditions.

8.3.3.4 Display Characteristics and Utility Ratings - Do the Display Characteristics influence the Utility Ratings?

The Kendall's Tau Statistic was applied to test correlations between and within Display Characteristics and Utility Ratings. All correlations were highly significant. Thus an increased rating with one variable also corresponded to an increased rating with any other variables. The converse also applied.

An extension of the simple correlation is Canonical Correlation. The goal of this technique is to maximize the correlation between two sets of variables by assigning relative weights to the variables in each set. These weights give an indication as to the relative importance of each variable in their respective set.

In order to apply this sophisticated technique, the properties of the data were examined. The data, being ordinal, did not have a Normal Error Distribution when simple Linear Regression was applied. However, as the data were aggregated by 2 questionnaires at a time, 6 at a time, 8, 10, 20 and 30, the errors converged to a Normal Distribution. Good consistency of the Error Distribution was achieved by groupings of 8, thus Canonical Correlation was based upon that assumption.

A Canonical Correlation approach is an extension of Simple and Multiple Correlation. Simple Correlation examines one variable correlated with another variable. Multiple Correlation examines a set of variables correlated with one variable. Canonical Correlation examines one set correlated with another set. The purpose of Canonical Correlation is to explain any relationship between two sets of variables in simpler terms using a subset (if possible) of the variables.

The Variables of Interest split naturally into two Sets, Display Characteristics and Utility Ratings. A Canonical Correlation analysis was applied and some significant results were observed at an adequate level of confidence.

- A great disparity between Location and Perceptibility seems to be related to problems associated with Clarity of Clearance. The Confidence Level is 98%.

- Another possible link between Display Characteristics and Utility Ratings is that of a Perceptibility - Controller Workload Relationship. Problems associated with Perceptibility may increase the Controller Workload. The Confidence Level is 86%.

8.3.3.5 Did The Pilot See the Light? - Interest focuses on the effect seeing the light has on Display Characteristics or Utility Ratings. Despite the seeming contradiction, a statistically significant number of pilots marked that they did not see the lights but nevertheless answered the questions. Table 8-£ summarizes the results.

The Wilcoxon Test was applied and all the Display Characteristics were highly affected by whether or not the pilot sees the VICON light. Better ratings occur when the pilot sees the light and roughly 15% of the time the pilot reported not seeing the light. Thus, any improvements with regard to seeing the light should improve the ratings of the Display Characteristics.

Similar tests were performed with the Utility Ratings. Seeing the light has a positive effect on the Clarity of Clearance and Cockpit Workload Ratings, however, statistical evidence cannot support any effect on Expediting the Departure.

TABLE 8-8. AVERAGE DISPLAY CHARACTERISTIC RATINGS AND UTILITY RATINGS WITH SEE LIGHT

	SEE LIGHT	
	YES	NO
Distinctiveness	3.92	2.50
Perceptibility	3.92	2.53
Location	3.65	2.44
Intensity	4.10	2.57
Cockpit Workload	3.02	2.70
Clarity of Clearance	3.51	3.00
Departure Expeditiousness	3.08	3.00

8.3.4 Comments and Occurrences

8.3.4.1 Introduction - The questionnaires were grouped and analyzed by the month entered onto the form regardless of when they were actually received. If there was no date or postmark on the form, it was assigned to the month in which it was received.

The answers to the specific scored questions were transcribed to work sheets which were set up so that the data were separated by type of aviation, by flying hours, by visibility, and by the number of times VICON had been used. Where visibility less than good was indicated, the actual visibility was obtained from the National Weather Service (NWS) surface weather observations data sheets furnished by the NWS office at Bradley, and the indicated visibility was corrected to conform to our definition of poor ($V \leq 1/2$ mile), fair ($1/2 < V \leq 3$ miles), and good ($V > 3$ miles).

Comments were extracted from the forms, and placed into functional groups. Comments ranged in length from very short phrases such as "A great idea!" to very long and detailed discussions and explanations complete with diagrams. Many questionnaires contained more than one statement or idea in the comments section. When a statement was vague, or given only once, it could be considered of minor value and not carried through the analysis and discussion. For these reasons, numbers given in the analyses do not necessarily add to equal group or overall totals. Numerical information is given in Table 8-9. The comments are presented in Appendix F.

8.3.4.2 Comments Received for October - A total of 70 questionnaires was received. Of these, 60 (86%) had all or most of the questions answered, and 10 indicated that the pilot had not seen the VICON lights and thus could not answer the questions. Of the 10 pilots who did not see the lights, only one asked for them and no response was made by the local controller to this request. Forty-three questionnaires contained some type of comment.

Favorable Comments. There were twelve favorable comments ranging from strong endorsement to weak sometimes conditional support. Typical strong endorsement comments were: "An excellent innovation," "Excellent system - let's get more of them," and "Excellent idea, should enhance safety." Weak comments included: "Personally think VICON has merit," "VICON seems of limited use to general aviation traffic but should be good for safety when pilots and controllers get used to the system."

Unfavorable Comments. There were also twelve unfavorable comments. The comments dealt with three primary areas of concern: (1) The VICON system is unnecessary - verbal takeoff clearance is sufficient control, especially if the pilot reads

TABLE 8-9. SUMMARY OF PILOT QUESTIONNAIRE COMMENTS

ITEM	OCT.	NOV.	DEC.	JAN.	FEB.	TOTAL
Total questionnaires received	70	176	85	45	56	432
Answered questions	60	153	76	43	46	378
Did not answer questions	0	1	1	2	10	4
Did not see VICON light	10	22	8*	6*	18*	64
Made one or more comments	43	101	53	34	43	274
Favorable	12	11	12	9	2	46
Unfavorable	12	24	13	10	23	82
Unnecessary/Duplication	7	8	4	1	5	25
Wrong use of funds	5	17	6	3	5	36
Distracting/added work	3	6	3	3	3	18
Neutral/Conditional	0	13	0	0	0	13
Equipment	11	50	27	14	13	115
Position	7	28	17	7	8	67
Distinctiveness	6	23	9	4	4	46
Traffic light type signal	2	4	2	2	0	10
Sun	0	5	1	0	2	8
Procedures	11	14	13	7	8	53
Lights not on	6	7	6	3	3	25
Forgot to look	0	1	1	3	2	7
Unfamiliar with VICON	5	1	2	0	1	9

*Some pilots who answered "Did not see the light" answered the questions apparently based on previous experience with VICON.

back the clearance as acknowledgements (7 comments); (2) VICON is a waste of money that is needed for other equipment (5 comments), and (3) VICON causes confusion and added workload in the cockpit (3 comments).

Equipment Comments. The eleven equipment comments stated that the light clusters were: too far away from the takeoff position (4 comments); too low, especially when there would be snow on the runway (3 comments); too hard to locate - when the VICON light is not on, the cluster is hard to locate and positively identify (4 comments); and not distinctive enough - the green light looks too much like other lights on the airfield and tends to blend into them, especially at night (2 comments). Finally, the suggestion was made that the "traffic light" method - having a red no-go light on at all times until the takeoff clearance is issued and the controller switches on the green go light - would reduce or eliminate many of the above problems.

Procedures Comments. Eleven comments stated either that the VICON system was not being used by the controller (6 comments), or that the pilot was not familiar with the intended functioning of the system (5 comments).

8.3.4.3 Comments Received for November - A total of 176 questionnaires was received. Of these, 153 (87%) had all or most of the questions answered, 22 indicated that the pilot had not seen the VICON lights and thus could not answer the questions, and one saw the lights and made a comment but did not answer the questions. Of the 22 pilots who did not see the lights, only three asked for them. One was told the lights were inoperative and two received no response.

One hundred one questionnaires contained some type of comment.

Favorable Comments. There were eleven favorable comments. Half contained an explanation or qualifier, such as: "Could be a valuable assist in times of heavy traffic and workload," "Lights are a good idea as backup to clearance," "Had weather been marginal - lights would have been very helpful and effective."

Unfavorable Comments. There were 24 unfavorable comments, which ranged from terse statements like: "Delete," "Why spend money on this?" and "System is extraneous," to long explanations and statements of other personal desires. Seven comments stated that VICON was a waste of money, and ten indicated that available funds would be better spent on other equipment such as VASI's, runway intrusion control systems, a proximity warning system, a collision avoidance system, and a rotating beacon (apparently to replace the one destroyed by the October tornado). Other reasons cited for the unfavorable opinion were: added workload (3), crew distraction (3), and expected reduction of VICON usefulness because of snow cover (2). Finally, six pilots stated that confusion of verbal takeoff clearance is not a problem, and three felt that the VICON lights might cause more problems than they solved.

Neutral/Conditional Comments. Thirteen comments were submitted, many of them similar to comments cited above but with conditions attached. Four pilots questioned the cost effectiveness of VICON, three felt that their opinion of VICON's value would probably increase as they got used to the system, and four stated that VICON might be beneficial but that there is really no problem of uncleared takeoffs. One pilot stated that VICON should be tested at a busier airport.

Equipment Comments. There were 50 comments concerning the equipment. Five reported problems caused by the sun. Either the sun blinded them so they could not see the light or the sun was reflected off the lens so that the light appeared to be on when it was not. Thirteen pilots felt the lights were set too low and thus were hard to see and would be even harder to see when snow was present. Seventeen stated that the lights needed to be more prominent and identifiable. Five others confused VICON with VASI lights, and one actually took off on the VASI instead of VICON. Five stated that the lights should be closer to the takeoff position, and ten stated that they either could not see the lights from their location or that the lights should be repositioned or added to so that they could be readily seen. One pilot recommended that proper background material be placed behind the lights to aid in identifying them and to screen out background lights or sun. Three pilots favored use of a green/red go/no-go or cancel combination, and one recommended experimenting with various light and sign combinations to obtain optimum location/identification/control capability. Finally, a number of comments suggested that the pilots were not completely familiar with the VICON equipment and test program.

Procedures Comments. Fourteen comments were submitted. Seven stated that the VICON lights were not turned on. Three pilots reported that checking the VICON light was no longer a problem now that they were familiar with the system. One each reported that the system was inoperative, that the pilot was preoccupied with cockpit duties and did not look for the light, and that the pilot was unclear regarding what response to make to the tower when he saw the light.

8.3.4.4 Comments Received for December - Eighty-five questionnaires were received for December. Seventy-seven (91%) answered all or most of the questions, and eight stated that the pilot had not seen the VICON lights and thus could not answer the questions. None of the eight pilots asked for the lights. Fifty-three questionnaires contained some type of comment.

Favorable Comments. There were twelve favorable comments, most of them brief. One pilot stated his desire to have a traffic light type of light at all intersections to serve the dual function of takeoff confirmation and runway entry control. Another pilot stated VICON would be a great double check if it was used on a constant basis.

Unfavorable Comments. There were thirteen unfavorable comments, again most of them brief. The main areas of concern were: the money could be better used for other programs (6 comments), distraction of the flight crew (3), and system is unnecessary (4).

Equipment Comments. Twenty-seven comments pertained to the VICON equipment. Fifteen stated that the lights are hard to locate, broken down as follows: VICON lights should be placed directly across from the taxiway where you enter the runway (6) or should be on the runway centerline (1); lights are hard to see from the right seat (2); lights are too low (2); and, the lights should be closer to the departure end of the runway (4). Seven pilots reported the lights were not distinctive enough, and one confused VICON with VASI. One pilot had trouble because of reflection of sunlight from the lens. Two favored use of a green/red go/no-go traffic light. One pilot strongly recommended testing various lighting configurations as the present arrangement seems insignificant in relation to its importance. Finally, one pilot repeated his earlier recommendation that all VICON lights should be placed at the same location so crews would look at the same position for every takeoff.

Procedures Comments. There were thirteen procedures comments; six of these stated that the lights were not turned on. One extreme comment stated: "Have made over 20 takeoffs within the past two months and have not yet seen the VICON lights." One additional report stated that the crew did not see the light, possibly because of preoccupation with anti-icing procedures. Two pilots reported that they never did see the red "not cleared" light, thus showing a lack of understanding of the VICON system. There were four statements that the light should be turned on only after the aircraft reaches takeoff position.

8.3.4.5 Comments Received for January - Only 45 questionnaires were received. Forty-Three (96%) had all or most of the questions answered, and six indicated that the pilot did not see the light. None of these six pilots asked for the lights, but one was informed that VICON was inoperative. However, two pilots answered all the questions and two others answered the utility questions. Thirty-four questionnaires contained some type of comment.

Favorable Comments. There were nine favorable comments. One pilot commented in detail that VICON is redundant when visibility is good but would work well in reduced visibility. Another stated that in the day-to-day ATC system, any system that can add to clarification of pilot/controller communication is a "god-send." Three commented that the system will improve safety when installed at all major airports.

Unfavorable Comments. There were ten unfavorable comments. One felt VICON was an overreaction to an incident, three expressed concern about the cost, three felt VICON was a distraction, and two stated that uncleared takeoffs could occur if a pilot saw the green light which had not been properly turned off.

Equipment Comments. Fourteen comments concerned the equipment. Seven pilots indicated that the lights were poorly positioned; one suggested locating the lights in the runway centerline. Four stated that the lights should be more distinctive and one recommended an accenting background panel. Two reported inoperative lights, and two favored the use of red/green or red/yellow/green lights for better control. One pilot reported that the light was on prior to receiving takeoff clearance; he was told the preceding aircraft had not broken the microwave beam to turn off the light.

Procedures Comments. There were seven comments; three pilots forgot to look for the light, and three had to request that the light be turned on. One air carrier pilot was told by his flight operations that the test had ended - he had to ask for a questionnaire.

8.3.4.6 Comments Received for February - Fifty-six questionnaires were received. Forty-six (82%) had all or most questions answered. Eighteen pilots did not see the lights, but seven answered the questions based on their previous experience with VICON. Only two requested the lights. Two pilots thought they saw the green light, but one apparently saw a steady reflection from the sun (he noted this on the form) and the other apparently saw the VASI.

Forty-three questionnaires contained some type of comment.

Favorable Comments. There were only two favorable comments; great at night, and might be positively effective if used at all major airports.

Unfavorable Comments. There were 23 unfavorable comments. Five felt VICON was unnecessary, five were concerned about the cost, and three felt the system caused distraction. Three pilots were concerned about the possibility for error if the light remained on for any reason. Five reported that they had not seen the lights despite numerous takeoffs; in fact, one stated: "In about 50 takeoffs from BDL, I have never seen the VICON lights." While not seeing the lights might be due to a design deficiency or improper controller or pilot procedures, the effect is definitely unfavorable.

Equipment. There were thirteen comments. Eight pilots indicated the lights were poorly positioned; one suggested locating them in the runway centerline. Four stated that the lights should be more distinctive; a rotating beacon-type light, an identifying sign, and a sequenced flasher were suggested. The sun caused problems for two pilots.

Procedures. There were eight comments. Three pilots did not receive the light; one controller told the pilot he did not use VICON. Two pilots forgot to look for the light, and one who was not familiar with VICON recommended that the tower remind the pilot that VICON is in use during the test or introduction period. One pilot again reported that he had to ask for a questionnaire as his flight operations thought the test period had ended.

8.3.4.7 Comments Received for March - None.

8.3.4.8 Summary of Pilot Questionnaire Comments - 432 pilot questionnaires were received. Of these, 376 (88%) answered all or most of the scored questions, and 274 (63%) made one or more comments. The information on the questionnaires and comments is summarized in Table 8-9.

Many of the comments refer to the fact that VICON is a test program and is installed only at Bradley. These comments are usually prefaced by a conditional phrase such as: "If VICON were widely deployed, ..." or "If VICON were used on a constant basis ..." Essentially all of the comments concerning equipment and procedures either recommend improvements or discuss problems.

Favorable Comments. The favorable comments were usually short and simply stated approval of VICON. Where reasons for favoring VICON were cited, they generally presented the following ideas:

- Safety at takeoff is enhanced, especially when visibility is bad.

- Communication saturation, noise, and garbles are common on the local control channel and lead to missed or misunderstood instructions. VICON provides a redundant, independent confirmation of takeoff clearance and thus provides for safer takeoff operations.

- VICON provides a good backup check for verbal takeoff clearance at a time when the pilot is very busy.

Unfavorable Comments. While many of the unfavorable comments cited reasons for opposing VICON, a surprising number were terse and rather emotional. Of those reasons given for opposing VICON, the following were cited most commonly.

- The money could be better used to obtain and install other types of equipment, such as VASI's, DME's, a rotating beacon, and runway intrusion control systems. No particular type of equipment was given priority.

- VICON was not cost-effective in accomplishing the intended task - other systems would be cheaper or better.

- VICON is not needed, and/or is a duplication, because the problem of unauthorized or no-clearance takeoff does not exist in the United States. A number of references were made to the language difficulties which occurred at Tenerife, but do not occur here.

- Safety is negatively affected because VICON creates additional workload for the flight crew and causes distraction from required duties at a time when the crew is very busy with critical pre-takeoff and takeoff activities.

- Another type of distraction occurs at night because of the large number of lights already shining in the runway and taxiway area. This objection is covered in greater detail in the equipment discussion.

- Pilots are concerned that uncleared takeoffs could occur if the green light is not properly turned off. The next pilot in the queue might misinterpret this lighted green light as his takeoff clearance and depart.

Neutral/Conditional Comments. These comments were primarily due to the newness of the system and lack of experience with the equipment. After November they largely ceased, apparently because of the airline pilot familiarization programs. Some comments were very pointed:

- A good backup, I suppose, but it will never substitute for alertness on the part of the departing pilot.

- Good to confirm takeoff clearance - but is it cost-effective?

- Should be tested at a busier airport.

Other comments showed a reluctance to judge the value of VICON based on a single VFR experience.

- Will await an IFR day to fully evaluate the system.

- As we become more used to the system it may be of more value.

- Although the concept of redundancy is generally a good idea, cost would enter into my consideration.

Equipment Comments. The equipment itself was commented on the most.

- The position of the lights was most frequently cited. The lights were considered to be poorly positioned, both for rolling and position-and-hold takeoffs. The lights were felt to be too far down the runway, too close to the ground, difficult to see from certain positions of the aircraft, hard to see from the right seat, and too inconsistent in their placement (different locations at each runway end). Placement in the runway centerline was suggested, since the pilot's attention is concentrated here for takeoff.

- Lack of distinctiveness was next most frequently cited. The VICON lights are hard to locate and identify when not on (awaiting clearance); they look too much like other airfield lights; they are confused with the VASI lights; they blend into the background and into runway edge light strings, and are generally hard to identify. The lights should be attention grabbers that can be immediately located and positively identified. One pilot urged that various light and lighted-sign configurations be tested to establish an optimum pattern and position. Others suggested the use of various panels placed behind the lights to provide contrast and identification.

- A number of pilots preferred a red/green traffic light type of signal. The red light or symbol would be on at all times, and would provide both an immediate identification of the VICON control and a verification of the no-clearance status. Upon being cleared for takeoff, the pilot would see the red light change to green, thus confirming takeoff clearance. After departure of the aircraft, the VICON light would change back to red.

- "Did not see the light" is a common statement. One pilot reported: "In about 50 takeoffs from BDL, I have never seen the VICON lights." It cannot be determined here whether failure to see the lights is due to light clusters that are difficult to locate and identify, the pilots' lack of knowledge about VICON, or failure of the controllers to use the system. However, the problem is serious.

- The sun also caused problems, either blinding the pilots or making the green light appear to be on when it was actually off. Suggested remedies include background panels to block the sun, one light always on, as for the traffic light, and lens hoods and filters.

Procedures Comments. The procedures used for VICON were neither well understood nor consistently followed, according to the pilots' comments.

- The controllers did not use the VICON system in any consistent manner. When the pilot did not receive the green light, he was unsure whether his clearance had been confirmed or whether the controller was not using VICON. (The nonuse of VICON by some controllers and the intermittent use by others had been confirmed by other data sources.) In most cases when the pilot specifically asked for the light he received it, but there were a few instances when the light was not used even when requested.

- Lack of experience with VICON, and the fact that check lists do not include VICON, gave rise to the comment: "I forgot to look." In some cases, the pilot could not identify the light before receiving his takeoff clearance, and then became preoccupied with takeoff duties and forgot to recheck the light.

- In some cases the pilots were not familiar with VICON, how the system operated and how it was to be used.

- At least one air carrier assumed that the test ended in January. It appears that the VICON test program was not well understood by a large number of pilots and organizations.

8.3.4.9 Trends - Only one trend is apparent; there is a decrease in the number of questionnaires received. This is to be expected, since interest tends to decrease in any program as the novelty wears off.

8.3.4.10 Notes on the Questionnaire Results - The comments and the answers to the questions are highly subjective. There are no absolute or common references available, against which the pilots can compare their individual experiences and evaluations. Two interesting examples of this variation in personal frames of reference follow.

- Air carrier large jet crew, February. Captain's comment: "Might be positively effective if used at all airports." First officer's comment: "A waste of money."

- Two air carrier pilots submitted questionnaires for flights on 1 January which departed within three hours of each other, with good daytime weather conditions. The scored answers were identical: both rated all Display Characteristics as Good; Cockpit Workload and Expeditiousness of Departure were rated "Made No Difference" and Clarity of Clearance was rated "Made Things Easier." However, one commented: "A waste of funds" and the other said: "I think it is worthwhile."

8.4 RESULTS AND APPLICATIONS OF ANALYSIS

8.4.1 Feasibility

The pilots' ratings and comments indicate that the equipment satisfactorily performs its intended functions, with a few serious shortcomings.

- The lights were poorly positioned and were difficult to locate and identify. The ratings of these factors did not improve with increasing experience. Also, the ratings did not improve as the weather conditions changed. Unfortunately, there was almost no time during the test period when the visibility dropped to 1/4 mile; there was a major question whether or not the lights can be seen at all by the pilot when the visibility is so restricted. Finally, there was much concern about problems which snow would cause, but these problems could not be investigated.

- There was considerable feeling that a different light system would be much more effective than the present off-on method, and would eliminate many of the above concerns. Possible changes include: the light changing from red to green, the light changing shape, etc.

- A number of pilots stated that, while the system is technically sound, it is not needed as the postulated problem of unauthorized takeoffs does not exist.

- Finally, there were reports that the sun interfered with the proper location and interpretation of the lights.

8.4.2 Integration Into the Air Traffic Control System

Integration of VICON into the overall ATC system has not been completely successful. The concerns and problems range from the basic concept of the system to details of system operation and the effects on controllers and pilots.

- While most of the air carrier pilots were familiar with VICON, the general aviation community was largely not aware of the program. This reduced the GA participation in the test to a very low level and probably led to an incomplete evaluation of the system. VICON cannot successfully become a part of the ATC system unless all pilots are aware of VICON and are knowledgeable about its proper use.

- Military pilots did not choose to participate in the test program. The reasons are not known.

- The questionnaire answers indicated that VICON slightly improved Clarity and Understanding of Clearance. There was no significant correlation of any utility ratings with weather or experience with the VICON system.

- Pilots stated that VICON caused an increase in the pilot's workload, but answers to the question about effect on cockpit workload indicated that VICON makes no difference.

- Many pilots comment that the controllers were using the system on an intermittent and unpredictable basis. In a number of reports, the light was not turned on even when requested by the pilot. Integration into the ATC system is very difficult to evaluate under these conditions as the pilots are uncertain what their correct response should be to "no light" and "refused light" situations.

8.4.3 Enhancement of Safety

The pilots indicated mixed feelings regarding VICON's enhancement of safety. There are indications of both positive and negative effects.

- There were a number of favorable comments on the questionnaires, most of them stating that VICON's contribution to safety increased as the visibility got worse and local control radio channel use increased.

- The scored answers indicated that VICON made things somewhat easier for the clarity and understanding of the takeoff clearance.

- There is a feeling that no unauthorized takeoff problem exists in the U.S. Respondents claimed that a pilot who is not sure of his verbal takeoff clearance will request a confirmation from the local controller. However, two takeoffs made during the test period were seriously incorrect and had the potential for serious consequences.

- The scored answers indicated that VICON has no effect on cockpit workload despite comments that the workload increased.

- Independent of the workload, a number of pilots stated that VICON caused distraction and confusion in the cockpit during the very busy takeoff time.

- Many pilots said that the VICON money could be better spent on other equipment which would have greater positive effects on safety.

- Of the total favorable and unfavorable comments, only 36% favored VICON.

On balance, the assessment by the pilots appeared to indicate a slight negative effect on safety.

8.4.4 Summary

The system is technically satisfactory, although some serious problems exist, and many recommendations for hardware improvements were made. Successful integration of VICON into the ATC system is possible, but has not been demonstrated. Many general aviation pilots were not aware of the test program, and the controllers were not using the system consistently. Finally, the comments and answers indicated that the pilots felt that VICON either served no useful purpose or had a slight negative effect on safety.

9. CONTROLLER INTERVIEW DATA

9.1 CONTROLLER INTERVIEW REPORT FORM

The controller interview report form was prepared to serve as both a check list and a convenient report format. The questions were intended to obtain information about the attitudes regarding VICON and to lead the controllers into a discussion about their experiences using the VICON system including their opinions and recommendations. The report form is shown in Figure 9-1.

9.2 DATA COLLECTION

Controller interviews were held in the FAA Air Traffic Control Tower area at Bradley International Airport. This convenient location allowed the controllers to be interviewed while on a break, and encouraged a high level of participation. The interviews were usually conducted by two interviewers talking with one controller, although, in a few cases, controllers were interviewed in groups of two or three. When controllers were interviewed in groups, they seemed to be less willing to talk freely than when interviewed alone. Hence, the one-person interview was preferred.

Three interview sessions were held, 12 - 13 and 19 November 1979 for the first group of interviews, 30 - 31 January 1980 for the second group, and 7-8 April for the third.

Each interview session was coordinated with the Program Officer at Bradley Tower to ensure that the largest practical number of controllers would be available and that the room used to conduct the interviews was not otherwise in use.

1. a. Have you used the occurrence report forms?
( )Yes ( )No If not, why?

b. Discuss any specific occurrences in terms of cause and effect. If occurrence was negative, what should be done to prevent its reoccurrence? Please be as detailed as possible.

2. What is your estimate of VICON workload on local controller?

_____Very Low _____Low _____Moderate _____High _____Very High

What operating conditions contribute to this workload? (e.g., traffic levels, visibility, etc.)

3. Is there any effect, positive or negative, on other controller positions?

_____Yes _____No _____Positive _____Negative

Who is impacted? ______________________________

Degree of this impact:

_____Very Low _____Low _____Moderate _____High _____Very High

4. What is your assessment of safety effects?

_____Detrimental _____Somewhat Negative _____Neutral
_____Somewhat Beneficial _____Major benefit

5. What is VICON's greatest benefit? ______________________________

its worst flaw? ______________________________

6. What are your suggestions for:

a. Alternatives?

b. Improvements?

c. Extensions?

d. Other changes?

FIGURE 9-1. VICON CONTROLLER INTERVIEW REPORT

At each interview, the interviewer explained the purpose of the meeting and gave the controller a copy of the form so that he could follow the line of questioning and discussion. The IOCS interviewer filled out the form and took it back to Waltham for later analysis.

9.3 DATA DESCRIPTION AND ANALYSIS

As shown in Figure 9-1, the information sought by the interviewer consisted of three kinds:

- Broad, leading questions
- Questions with scored answers
- Unstructured comments, opinions, and suggestions

Each controller was encouraged to offer any thoughts or ideas that he had pertaining to VICON and related air traffic control matters. In the later sets of interviews, some of the findings from the earlier interviews were used to create questions to probe further into frequently raised areas of discussion. For example, mandatory readback of takeoff clearances by pilots was discussed with each controller since this idea had been frequently suggested as an alternative to VICON. In every interview, the controller was encouraged to speak his mind freely and fully. In the opinion of the interviewers, the controllers were open and honest in their statements and were highly cooperative.

The answers and comments were analyzed individually, grouped where possible, and summarized.

9.3.1 First Interview Meeting

Twenty-four controllers were interviewed at the first set of meetings. The system had been in operation two months at that time.

9.3.1.1 Controller's Report Usage - Only 9 of 24 controllers had submitted a Controller's Report (Figure 10-1) regarding VICON use.

9.3.1.2 VICON Additional Workload - The additional workload on the local controller caused by VICON was symmetrically distributed around the Moderate response. All the controllers felt, however, that the workload increased at least as fast as the traffic level, and 33% . the controllers stated that they usually did not use the system at high traffic levels. In addition, 33% stated that the workload increased when using two runways and 17% stated that poor visibility increased the workload.

9.3.1.3 Impact on Other Positions - 17% felt that Ground and Local Coordinator positions were affected by VICON because there is less time available for coordination. The other 83% felt there was no impact on any other position.

9.3.1.4 Assessment of Safety Effects - The following assessments were given of the overall effect of VICON on safety: Detrimental, 11%; Somewhat Negative, 16%; Neutral, 62%; Somewhat Beneficial, 11%; and Major Benefit, 7%. The average rating was slightly negative; thus the system was perceived by the controllers as actually or potentially causing more problems than it solves.

9.3.1.5 Benefits and Flaws - In response to the double question "What is VICON's greatest benefit and worst flaw?" the controllers replied in many cases, with suggestions for alternatives, improvements, and extensions.

The only benefit stated was the effect of independently confirming the voice takeoff clearance. However, 50% of the controllers felt that there was no benefit - that the system was not needed.

The flaws most frequently cited were:

- Distracted attention - 17%
- Could accidently hit wrong button or otherwise increased chance for error or other problems - 17%
- Caused delay in takeoff, or conversely, the majority of pilots took off when cleared regardless of the light - 8%
- The money could be better used for other needs - 4%

In addition, 8% of the controllers reported that they were not yet used to VICON, and 33% reported that pilots needed more training for VICON and other traffic control areas.

9.3.1.6 Suggestions, Comments, and Occurrences - At the end of each interview, each controller was encouraged to report any additional thoughts or experiences with VICON, or with any related facet of air traffic control. Regarding system usage, 54% of the controllers noted that VICON diverts attention, especially when busy, 33% usually do not use the system when busy, and 17% found the system to be one more thing to think about and do. Runway intrusion control was considered much more important by 21% of the controllers.

Regarding the equipment, 13% reported that the sun caused problems for the pilots seeing the light, and 13% had malfunction problems with the timers. These were temporary problems which were corrected early in the test program. One controller recommended that a red light be added.

One controller felt very strongly that strict adherence to standard phraseology would improve safety more than VICON and cost a lot less.

9.3.1.7 Unusual Occurrences - One unusual occurrence was reported. An aircraft was verbally given takeoff clearance but did not take off. When asked why the aircraft was still on the runway, the pilot replied that he was waiting for the green light. The controller then activated the light and the aircraft took off. This situation could cause delays and other problems, especially in heavy traffic.

9.3.2 <u>Second Interview Meeting</u>

Twenty-five controllers were interviewed. The system had been in operation 3 1/2 months.

9.3.2.1 Controllers Report Usage - Of the twenty-five controllers, fourteen had submitted at least one report, six had not submitted any, and five did not answer the question.

9.3.2.2 VICON Additional Workload - The controllers agreed that a simple, scored answer could not correctly be given to the question of additional workload caused by VICON on the local controller. In the opinion of 76%, added workload was low for light traffic and increased at least as fast as the traffic level. At high traffic levels, 44% stopped using VICON while 16% definitely did not stop; 8% did not use VICON at any time and 8% reported no adverse effect. Conditions which also affected workload were two-runway operation and reduced visibility.

9.3.2.3 Impact on Other Positions - There was no impact on other positions according to 68% of the controllers, while 20% reported impacts on each of ground and departure positions. Eight percent were uncertain regarding any effect. Those who felt there was an impact said that VICON distracts the attention of the local controller, thereby causing delay and loss of coordination.

9.3.2.4 Assessment of Safety Effects - The following assessments were given: Detrimental, 8%; Detrimental to Somewhat Negative, 4%; Somewhat Negative, 48%; Somewhat Negative to Neutral, 16%; Neutral, 8%; Somewhat Beneficial, 12%; and Beneficial, 4%. The average rating was slightly negative and was somewhat less favorable than the average rating obtained from the first set of interviews. Thus the system was perceived as somewhat unsafe rather than helpful.

9.3.2.5 Benefits and Flaws - Benefits were cited by 24% of the controllers, although some benefits were qualified. Comments were:

- Improves safety
- Improves safety if mandatory on the pilot
- Good double check but would have to weigh cost
- Hardware is good but do not like concept

Flaws were cited by all but one controller (96%). A summary of those flaws is:

- Very distracting - 32%

- Increased controller workload - 20%

- Equipment problems - 20% The lights are too far down the runway and are hard to find. Light planes do not always break the microwave beam. Busy intersections should have microwave shutoffs. The panel should have lockout switches so that the light control switches on opposing runways cannot be activated at the same time. For example, if runway 06 is in use, then all switches for runway 24 would be locked out.

- Does not prevent runway intrusion - 16%

- Delay if the pilot waits for the light - 12%

- Will not eliminate human side of misinterpretations - 12%

- Keeps local controller tied to his position - 8%

The remote actuator was not mentioned. It was apparently removed early in the test period as observers have verbally commented that they had not seen it for a long time. One controller recommended removing all remote capability. DAS remote activation count was 296 in October, 79 in November, and 0 thereafter.

9.3.2.6 Suggestions, Comments, and Occurrences - The unstructured discussions at the end of the interviews provided many interesting comments and observations. Strong negative opinions were expressed regarding the VICON system: VICON serves no useful purpose because there is no problem, 24%; remove the system, 24%; does not accomplish what it set out to do, 87%; and the system is too expensive for the benefits produced so the money should be used for other needs, 36%.

In the procedures area, the following comments were made: favor required readback by pilots of takeoff clearance, 60%, but do not favor required readback, 24%; greater emphasis on use of standard phraseology, 24%, with one controller urging that this is the only solution (see Appendix G); no procedures have been specified regarding when to turn on the light, 12%; pilots should not be allowed to use U.S. airports if they do not have a good understanding of basic aviation English, 12%; and pilots should be better trained in traffic control procedures, 8%.

9.3.2.7 Discussion Statements - During the course of the unstructured discussions, statements were made which did not fit into the above groupings, but which were deemed to be important. These statements are summarized below:

- Intrusion onto the runway is a serious problem. One controller urged the development of a means to determine if the runway is indeed clear, as he has had problems with snowplows, etc. suddenly appearing out of the murk. Another recommended that, under conditions of poor visibility, only one aircraft should be allowed on the active runway at one time.

- Some highly personal opinions were expressed. One controller said he started the test program with a neutral attitude but now feels negative about the system. Distraction more than offsets any gain from VICON. Another began with a positive attitude, but after the incident reported below, he feels negatively

AD-A097 756 FEDERAL AVIATION ADMINISTRATION TECHNICAL CENTER ATL--ETC F/G 17/7
VISUAL CONFIRMATION OF VOICE TAKEOFF CLEARANCE (VICON) OPERATIO--ETC(U)
FEB 81 J J MAURER, B CASTLE, E DOWE, B HUGHES

UNCLASSIFIED FAA-CT-80-60-1 FAA-RD-80-114-1 NL

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about VICON. One stated that most controllers could handle VICON during heavy traffic, but some could not. One controller stated that too many controllers made up their mind negatively in advance and did not give VICON a full and fair test, and another stated that the distraction claim was overblown since the local controller had to look down to the panel anyway to check the flight strip.

- Other comments indicated that: problems were expected because of snow, controllers had pushed the wrong button, a contrasting no-go light should be added, and landing pilots had asked about the green light.

- Finally, one controller stated that if VICON were installed nationwide, there would soon be an accident because of it.

9.3.2.8 Unusual Occurrences - Several unusual occurrences took place in which VICON was involved or might have played an important part.

- With 1/4 mile visibility, an aircraft was cleared for takeoff on runway 24 but actually took off on runway 19. The tower could not see the takeoff position as it is about one mile away. One can hypothesize that if the pilot had looked for but not seen the VICON light, he might have realized his error. However, the magnetic compass and directional gyro should have indicated the error independent of VICON.

- An aircraft was cleared for takeoff but did not go. When asked about the delay, the pilot replied that he was waiting for the green light. This concern was cited 5 times. In one actual event, a large air carrier jet on final approach had to go around. This event was the cause of the change of opinion about VICON cited in the preceding section. (Cited six times, one actual event involving the go-around.)

- Two controllers reported that they had each experienced only one unauthorized takeoff in their service as controllers. Accordingly, unauthorized takeoff is not a problem. However, an unauthorized takeoff occurred 6 February 1980 under the following conditions: A large jet was on final approach for runway 06. A twin-engine light plane was instructed to taxi into position and hold on runway 33. The large jet landed. After passing the runway intersection, the jet was instructed to make the first available right turn off the runway and to switch to ground control. At that point, the light plane took off. The pilot of the light plane had apparently assumed that the next radio message would be his takeoff clearance, and therefore took off upon receiving the next message. Whether or not the routine use of VICON would have caused the pilot to recheck his clearance cannot be estimated.

- A light aircraft failed to break the microwave beam on takeoff so the green VICON light remained on. A heavy jet was instructed to taxi into position and hold. The pilot replied "Roger, I see the light, rolling". This potential unauthorized takeoff was cited three times, but only happened once.

- There is confusion when a takeoff clearance and light are given to an aircraft at midfield, with another aircraft at the end of the runway ready for takeoff. (Cited three times, but actual events are unknown.)

- There have been a large number of reports that a light plane will not break the microwave beam on takeoff when there is any wind. One situation, also seen by the tower observer, involved three light planes taking off in rapid succession on a windy day. None of them broke the beam to turn off the light. This situation requires extra vigilance by the controller or the light will remain on indefinitely.

9.3.3 Third Interview Meeting. Nineteen controllers and one team supervisor were interviewed. The 5-1/2 month test program had ended one week earlier.

9.3.3.1 Controllers Report Usage - Of the nineteen controllers, ten had submitted at least one report, four had not submitted any, three did not answer the question, and one supervisor and one trainee both said "No."

9.3.3.2 VICON Additional Workload - Confirming their previous opinions, most of the controllers stated that a single answer could not be given. Added workload is low for light traffic; it increases at least as fast as the traffic level in the opinion of 11 (58%) controllers, and faster than the traffic level in the opinion of five (26%). Two (11%) controllers reported a very low constant workload and one reported a high constant workload. Four (22%) stated visibility did not affect the added workload, the others offered no comment. One controller made a very unusual and interesting statement - if using Brite exclusively, VICON adds no extra workload; if looking outside the tower, VICON adds a large extra workload.

The controllers were asked how much they used the system, and whether their use changed over the test period. One controller did not answer. The results for the other 18 are shown in Table 9-1.

TABLE 9-1. CONTROLLER VICON USE

REGULAR VICON USAGE	CONSTANT	LESS AT END	MORE AT END
Little	0	1	0
About half time	2	2	0
In light/mod tfc only	1	2	0
Almost all the time	5	1	1
All, except VERY heavy tfc	2	0	0
All the time	1	0	0

9.3.3.3 Impact on Other Positions - There was no impact on other positions in the opinion of 14 (74%) of the controllers. The other five felt there was some impact on the ground and departure controllers because the distraction and added workload on the local controller. This impact ranged from minimal (2 controllers) to an important added workload at high traffic levels (3 controllers).

9.3.3.4 Assessment of Safety Effects - These assessments were given: Detrimental, 5%; Somewhat Negative, 53%; Somewhat Negative to Neutral, 16%; Neutral, 16%; Neutral to Somewhat Beneficial, 5%; and No Answer - Need More Evaluation, 5%. The average rating lay between Neutral and Somewhat Negative but is close to the Somewhat Negative value. This average was more negative than the average rating obtained from the second set of interviews. The trend, as the test progressed, was toward increasingly negative assessment of the safety effects of VICON.

9.3.3.5 Benefits and Flaws - No benefit was cited by 74% of the controllers, and 5% stated more evaluation should be done. Benefits cited were:

- Would accomplish its intent if made mandatory.
- Might be useful if the radio failed.
- Good, if it increases safety. (Controller's emphasis)
- Good system but unsure exactly what it is to do.

No flaws were cited by 16% of the controllers. A summary of the cited flaws is:

- Causes extra workload, distraction, and hindrance - 42%.
- Light aircraft do not break the microwave beam. The light does not always shut off. Never sure what the system was doing - light stayed on, etc. - 16%.
- Pilots are taking off on the light instead of verbal clearance.
- Controller has his head down - he is not looking at the Brite scope or the airfield.
- Slows the system down, thus has negative safety effect on ATCS.

- There is still confusion with the system

- Mechanical failure could cause an incident.

- VICON requires an assistant local controller, with resultant coordination problems.

- Does not do the intended job.

9.3.3.6 Suggestions, Comments, and Occurrences - The controllers were encouraged to express their opinions regarding VICON, alternatives, and other traffic control requirements (where could the money be better spent?). Also, pertinent experiences were solicited. Finally, because of prior statements by both controllers and pilots, questions were asked about unauthorized takeoffs, runway intrusion, and mandatory readback by pilots of takeoff clearances.

Since the unfavorable opinions about VICON had been presented earlier in the interviews, the interviewers tried to direct this discussion toward positive statements of what the controllers felt was needed or what should be undertaken.

Requested comments are given here:

- Unauthorized takeoffs are a problem, 32%; they are not a problem, 58%; no answer, 10%. Unauthorized takeoffs are usually made by GA pilots with little experience. The highest estimate was one per month. They usually cause no problem, but could have serious consequences. One controller told about a GA pilot who took off on the parking area in front of the passenger terminal. If no problem arises from an unauthorized takeoff, it is seldom reported; statistics on unauthorized takeoffs are accordingly understated. One controller reported that he had one incident where the VICON light just came on (apparently turned on elsewhere for maintenance or test) and the pilot took off without clearance.

- Mandatory readback of the takeoff clearance by the pilot is frequently mentioned by controllers and pilots as an alternative to VICON. Mandatory readback was favored by 74%, not favored by 11%, not favored but not objected to by 5%, not needed by 5%, and no answer given by 5%. The reasons cited by those not in favor were that no problem exists, so readback is not needed, and that readback will overload the local control channel.

- The controllers were asked if they considered runway intrusion to be a serious problem. The overall picture is not clear, but there is evidence that concern exists. Answers were: no problem, 32%; minor problem, 5%; no problem but concerned, 5%; some merit to an intrusion control system but it would be distracting, 5%; not certain, 5%; no experience with intrusion problems, 5%; and a serious problem, 43%. Within the serious problem answers, three statements expanded the discussion. The biggest problem is not being able to ensure that the runway is clear in bad weather - intrusion is only part of the problem. Intrusion is a daily problem at Bradley. There should be no crossing or entering of any runway without specific clearance (cited twice).

Open comments follow:

- Emphasize standard phraseology. This involves no direct cost but requires training, supervision, and enforcement. This was favored by 47%. Two controllers included procedures in their standardization recommendation, and two included language. One controller mentioned better overall controller training.

- Improve pilot training. Better training and refresher training of pilots, especially GA pilots, was recommended by 16%. This is necessary if standardization of phraseology is to be effective. It also ties directly into the recommendation of those GA pilots interviewed in the third series of pilot interviews.

- Enforce FAR's. Strict enforcement of present FAR's was recommended by 11%. This is a part of the overall recommendations for more standardization, tighter enforcement, and better training.

- Too much pressure to expedite traffic. Pressure to expedite traffic was reported by 11%. This sometimes causes both pilots and controllers to cut corners. This idea also points to a general raising of standards.

- The VICON system itself. Potential for takeoff on the light only was cited by 11%; one controller reported one such incident, caused in part by the light remaining on when it should not have. Delayed takeoff was also cited by 16%; one controller cited four incidents which occurred when he was local controller. Ideas cited by one controller were: the light will make no difference for preventing unauthorized takeoffs since it does not control; system is not effective and is too expensive; system does not accomplish its intended function since it does not control but only confirms; and had times when the light stayed on.

- The test program. Individual controllers offered a number of comments regarding the test program. They are: strongly likes including the controllers in the evaluation process; the low level of formal training gave a clue to a low level of interest in VICON - management did not come on strongly in favor of the system; FAA must advise the controllers of test criteria, conditions, objectives, etc.; and, feels the controllers gave VICON a fair trial.

- Procedure. One controller recommended that, when visibility is bad, no aircraft should be put into position and hold when when another aircraft is on the runway.

- Special test recommendation. One controller stated that the controllers were uncertain of the VICON status after the snow plow damaged the lights. This fits the earlier recommendation for a status board for the VICON equipment.

9.3.3.7 Supervisor Interview - While the supervisor did not actually work at the local controller position, he did discuss VICON at great length with his team. Thus, his ideas were formed from the experiences of all his team members plus his own observations, and are more broadly based that the individual controller opinions. His statements were:

- The response from the controllers to VICON is negative.

- FAA should have made an effort to sell the system and the test program to the controllers.

- VICON is not practical under a heavy workload like O'Hare.

- Would prefer to see the money spent for better communication equipment, refined procedures, and runway intrusion control.

- Does not like the light for confirmation or control.

- Does like mandatory readback of takeoff clearance.

9.4 RESULTS AND APPLICATIONS OF ANALYSIS

9.4.1 Feasibility

Overall, the controllers reported few technical problems with the equipment and associated procedures. One basic system design problem was reported; light planes frequently did not break the microwave beam on takeoff, so the green light was not turned off automatically. Some difficulties have been reported with the timers. Thus, the system was technically feasible and, in general, performed well. Some concern had been expressed about problems with the lights due to snow, but this could not be tested. In the one heavy snowfall that occurred, some lights were damaged during plowing operations. By the time the system was returned to operation three days later, most of the snow accumulation was gone.

9.4.2 Integration Into the Air Traffic Control System

Integration of the equipment into the ATC system was successful, in that there were no problems cited by the controllers. However, overall integration of VICON into the ATC system was much less successful in the opinion of the controllers. Problems most frequently cited were the added workload on the local controller, the impact on the ground and departure controllers, delays caused by both controllers and pilots, and the very common feeling that VICON did not accomplish its goals.

9.4.3 Enhancement of Safety

The consensus is that VICON did not enhance safety, but rather had a negative effect. The assessment of safety opinions was more negative in the second interview than the first, and even more negative in the third interview. The most frequently cited negative effects were distraction, added workload and delay.

9.4.4 Summary

The summarized results of the three sets of controllers interviews are:

- Technical Feasibility - with one exception, the equipment performed its intended functions satisfactorily.

- Integration - integration of the equipment into the ATC system was successful. Integration of the overall VICON system into the ATC was less successful, and some serious problems existed.

- Enhancement of Safety - the overall assessment was that VICON had a slightly negative effect on safety.

9.5 PANELS

Three different control panels were installed at the local controller's position during the test program. All three panels provided the same controls and functions, but they were constructed with different hardware and layouts. (See Section 6.6)

The first was a mimic panel laid out to look like a scale map of the airfield, with each light control push button located at its actual position on the map.

The second was a matrix panel with the light control push buttons laid out in three rows to correspond to the three runways.

The third was a mimic panel similar to the first panel but using touch sensitive control switches.

The controllers were specifically asked to state their preferences and their reasons for them. The results were:

- First choice - push button mimic panel, 64% liked best. This panel was easiest to use, with the map layout and the positive feel of the push button with its click when contact was made.

- Second choice - touch-sensitive mimic panel, 24% liked best. The map layout was well-liked (same comment as for the push button mimic panel). Those who liked this panel felt it had a cleaner appearance. Those who disliked the panel cited the lack of a click when switch contact was made, the warped top surface, and the difficulty of clearly seeing the switch locations and lights in sunlight. The opinions regarding this panel were very strong; it was either very much liked or very much disliked.

- Third choice - matrix panel, 8% liked best.

- No preference - 4%.

Many preferences were expressed over minor design features of the various panels such as lighting and lighting controls, available runway lengths, arrows, etc. These features can be incorporated into any panel design. The controllers should be interviewed again before any "final" panel design specification is established. Twenty percent of the controllers did not like any panel and indicated which design was least objectionable.

10. CONTROLLER'S REPORT DATA

10.1 CONTROLLER REPORT FORM

The Controller's report was intended to provide a means for the controller to make known any experiences, occurrences, and opinions which developed during a work shift. The controller was requested to complete and submit the form immediately upon completion of the shift while the details and events were still fresh in his/her mind.

The form, Figure 10-1, provided a count of the number of times each of six different situations occurred in the course of a shift. The form also asked for the details of an occurrence and suggestions for improvement.

10.2 DATA COLLECTION

An adequate supply of report forms was made available in the controller's lounge (ready room). A locked box was used to collect the forms in order to preserve anonymity. Once or twice each week the completed forms were collected by the IOCS on-site supervisor and sent to IOCS in Waltham for reduction and analysis.

10.3 DATA DESCRIPTION AND ANALYSIS

10.3.1 <u>Scored Data Results</u>

Sixty-eight report forms were submitted. Very few forms clearly indicated the number of times certain situations occurred. Thus, Table 10-1 refers only to the number of times each situation was cited by a controller. The format of Table 10-1 is identical to Summary section of the report form and shows the number of times each situation was cited, by month.

Date:____________________ Tower Shift: From__________ To__________

SUMMARY OF WHAT HAPPENED:

Situation	How Many Times?
VICON Prevented Possible Incident	________
VICON Failure Occurred.	________
I Had Difficulty Using VICON.	________
Pilot Had Difficulty Using VICON.	________
VICON Impeded/Delayed Operation	________
VICON Improved Operation.	________

EXPLAIN OR DISCUSS WHAT HAPPENED FOR EACH OCCURRENCE:

Give Time, Location, Weather, Traffic Conditions, and Details. Use reverse side if needed.

SUGGESTIONS FOR IMPROVEMENTS:

Explain problem or area needing improvement, and give your suggestions for improving system. Use reverse side if needed.

FIGURE 10-1. CONTROLLER'S VICON REPORT FORM

TABLE 10-1. SCORED ANSWER SUMMARY

SITUATION	NO. OF TIMES CITED							
	UNK	OCT	NOV	DEC	JAN	FEB	MAR	TOTAL
Prevented Possible Incident	0	0	0	0	0	0	0	0
Failure Occurred	0	6	7	0	2	0	3	18
I Had Difficulty	0	10	3	2	0	0	2	17
Pilot Had Difficulty	0	5	0	0	1	2	3	11
Impeded/Delayed Operation	0	12	4	2	3	3	4	28
Improved Operation	0	1	0	0	0	0	0	1
Number of Reports	6	28	9	5	7	5	8	68

10.3.2 <u>Occurrences</u>

The occurrences, suggestions, and opinions entered onto the lower part of the form are presented here, by month. The material reported was unstructured since the controllers were requested to report any and all items that might be of use in evaluating the VICON system.

10.3.2.1 Undated - Three very terse comments said the system should be removed, one didn't use VICON anymore, and one reported that a pilot could not see the lights on runway 24 on a "real foggy" day much like the conditions at Tenerife.

10.3.2.2 October - This was the first month of the test program, and the controllers made their opinions known promptly. Nearly half of the report forms were submitted in October.

Most of the occurrences concerned the equipment. Four reports stated that the lights were oriented poorly and could not be seen from the taxiways, and one stated the lights were too far down the runway. Five controllers encountered microwave beam problems, and one felt 30-second timer settings were too long as only light planes take off from the intersections.

There were six reports of unstated equipment failure, and one that the system was not dependable. One controller stated that the remote control did not work well. There was one complaint that there was no notice available of system problems and no one was sure of the status of the equipment. This tied directly to the suggestion for an equipment status board. (See also Section 13.5.3)

Concerning procedures, 13 controllers reported that VICON was very distracting when they were busy; one stated that he stopped using the system when busy and one stopped using it completely. Two stated that when verbal clearance and VICON activation were given at different times, the added workload was very great.

Among possible alternatives, three controllers favored runway crossing or intrusion control systems and one favored a complete restructuring and simplifaction of the local controller's position and duties. Seven stated that VICON should be removed and two that VICON was a waste of money which could be better spent on other (unstated) things. One controller recommended that VICON should be used only when visibility dropped to one mile or less.

In the area of safety, two controllers were concerned about incorrect takeoffs that might occur if the wrong VICON button were pushed. There was one incident in which a pilot was confused by the lights. He started his takeoff roll, saw the lights, and stopped. He requested and received verbal confirmation and then took off.

10.3.2.3 November - Equipment still accounted for the most comments. There were four reports of failure of the microwave beam to turn off the lights, one on Runway 06 and three on 33. One report regarding Runway 33 indicated at least six failures on one shift. One controller reported problems with the Override and stated he would not use VICON until the system was fixed. Two controllers recommended removing VICON, and one urged that the system be removed and the money reallocated to move productive tasks.

Two controllers stated VICON was very distracting, and did not use it when busy.

One controller was concerned about incorrect takeoffs that might occur from position-and-hold instructions if the green light were still on from an earlier takeoff.

One incident was reported. With weather reported as WOX 1/4F, an aircraft called ready for takeoff on Runway 24. Takeoff clearance was given and the correct VICON light activated. However, the aircraft took off on Runway 19. The tower could not see the takeoff location.

10.3.2.4 December - Equipment comments were all concerned with the newly installed matrix panel. Three controllers felt the panel was harder to use than the mimic panel. One recommended the buttons for Runway 15/33 be reversed so all south runways would be on the same side of the panel. One recommended removal of the system and reallocation of the funds to more productive (unstated) uses.

Three reports indicated VICON was distracting and one that it added greatly to the workload at busy traffic levels. One controller stated that insistance upon use of good English and standardized phraseology would do far more to enhance safety than VICON could, and would do so at very little cost.

10.3.2.5 January - One microwave beam problem was reported. Also, late in the afternoon, on Runway 06, sunlight reflected off the light lens and made the light appear to be on when it was not.

Three reports stated the system was distracting, especially when busy. Four said the system should be removed, and one that it was a waste of money.

One controller said that VICON attempted to solve a problem that did not exist.

10.3.2.6 February - One report stated that the Touch Sensitive panel was disliked - it did not have the feel of the Mimic panel but required as much pressure, and was hard to see in the sunlight (see Section 9.5). One report stated the green light intensity could not be controlled. (See February and March Maintenance Log data, Section 12 and Appendix E. Repair was made on 7 March).

One controller stated that VICON was not the solution to the control problem - the money could be better spent on navaids and airport development.

Safety was the subject of seven reports. One controller reported four separate incidents where an aircraft instructed to taxi into position and hold stated that the green light was on and were they cleared for takeoff? One case was possibly due to reflected sunlight and three were caused by failure of the microwave beam to detect departing aircraft. Another controller reported an incident where a jet remained in position-and-hold after being cleared because the pilot did not know the purpose of the flashing green light. A third controller reported three incidents in February where an aircraft was instructed to taxi into position-and-hold but saw the flashing green light and asked if takeoff were approved. In each case the lights were flashing but the exact cause was not known.

10.3.2.7 March - There was one report of microwave beam problems and one that the lights were too bright and could not be controlled. (Repaired shortly afterward).

A controller reported no acknowledgements of VICON in more than 30 takeoffs; he felt the pilots had lost interest in the test. (Pilot questionnaires indicate some pilots and air carriers thought the test had ended). There were five recommendations that the system be removed. One controller stated VICON caused diversion of attention, and one stated he did not use the system as he was too busy.

Pertaining to safety, one controller was concerned that VICON might cause "tunnel vision" - the pilot would look for the light but would not check that the runway and approach areas were clear. When cleared for takeoff, one pilot delayed by asking why he had no green light. This produced a critical situation as there was another aircraft on a short final approach. When cleared for takeoff, one pilot reported that <u>all</u> lights on 06 were on - apparently due to late afternoon sun reflections.

A controller stated that VICON accomplished nothing. Since VICON only confirmed but did not control, a pilot could properly take off regardless of the status of the light.

10.3.3 Suggestions for Improvement

Few concrete suggestions for improvement were made by controllers using the report forms. Three controllers mentioned a possible redesign of the system to address the runway crossing or runway intrusion problem. One commented that the test should be done in peak traffic periods, and another referred to possible improvements to the local controller position (tube system for communication with departure controller, adjustable podium, another person to push VICON signal buttons). Nine controllers suggested removal of the system. There were numerous reports of possible sunlight reflections causing the lights to appear to be on when they were not.

10.4 RESULTS AND APPLICATIONS OF ANALYSIS

From this relatively small sample of controller opinion, the following points can be stated regarding feasibility, integration, and safety.

10.4.1 Feasibility

Except for minor malfunctions and problems which were corrected during the test period, the system appeared to be technically feasible. One significant question concerned the microwave beam light cutoff and the apparent difficulty with the length of smaller aircraft takeoff rolls, and with right cutoff timer setting for the intersections takeoffs. Several controllers felt that 30 seconds was too long since only small aircraft use the intersection for takeoff. Reflected sunlight also appeared to be a problem.

10.4.2 Integration Into the Air Traffic Control System

The overwhelming majority of responses indicated that VICON caused significant distraction or diversion from intended duties, especially in busier traffic periods. However, greater familiarity with VICON by controllers and pilots, through mandatory use during the test periods, or through nationwide deployment, might cause changes in this result.

10.4.3 Enhancement of Safety

Since only one controller report form indicated any beneficial results from the use of VICON, the negative factors clearly outweighed the positive. From the small sample of data obtained, it was not possible to quantify the amount of distracton, diversion, or delay in performance experienced by the entire controller team at Bradley. On the other hand, it was apparent that many of the controllers did not have the confidence needed for the system to have a positive impact on safety. Over a dozen actual or potential incidents were reported where VICON created problems or might have set up a hazardous situation.

10.5 PANELS

There were not sufficient responses from the controller reports in this area to warrant any conclusions. Possible improvements to the matrix panel were discussed by two controllers.

11. MAGNETIC TAPE DATA

11.1 DATA ACQUISITION

11.1.1 Equipment

The data acquisition system for this data source consisted of a specialized HP 3964A Instrumental Recorder, a Systron Donner time Gen-Reader, and specialized circuitry designed and constructed by the FAA Technical Center. The recorder was voice actuated. Data reduction equipment supplied by FAA to IOCS consisted of the same two commercial items driving a specially built display panel. A sports-type stopwatch was also used.

11.1.2 Collection Period

The recording occurred on a continuous 24-hour a day basis throughout the entire evaluation period. Each tape could record up to four days of tower communications. It was sometimes possible that a tape would run out during a late hour. In this case, a new tape might not be mounted until a few hours later. Hence there were some periods for which no tape data was available. Since airport activity during these periods was usually very low, lost data were not a serious handicap. However, a few events of interest were lost.

11.1.3 Available Information

The following information was recorded on the tapes:

- Local Control - Pilot communications
- Ground Control - Pilot communications
- VICON Signal Activities Tone by location
- Continuous Digital Time Readout

Ground Control was not monitored in this analysis as its applicability to the analysis was limited. It did provide additional information not heard through Local Control such as runway/taxiway location for takeoffs.

The time was recorded to the nearest second in Greenwich Mean Time (GMT). The day of the year was numbered consecutively. The date may not necessarily coincide with that determined from a calendar, as it is based on GMT. The tapes were changed by FAA personnel and mailed to IOCS for analysis.

11.2 ANALYSIS OBJECTIVES AND RESULTS

11.2.1 Hours Reduced

One-hundred-thirty-two hours of local control communications at Bradley International Airport have been reduced and analyzed. A log of the periods reduced is presented in Appendix D, Table D-1. A summary by weather condition, traffic level and runway use is given in Table 11-1.

11.2.2 VICON Use

Use of the VICON system was not mandatory during the evaluation period. Table D-2 shows VICON usage in detail in terms of number of activations. There has been an average of 60.5% usage of VICON during the observation period. Table 11-2 summarizes the VICON use patterns by month. Table 11-3 shows the pattern of decreasing pilot response to VICON over the test period.

TABLE 11-1. *HOURS OF TAPE DATA REDUCED*

CONDITION		NO. OF HOURS
Traffic:[1]	High	45
	Low	87
Weather:	Good	99
	Fair	22
	Poor	11
Runway Use:	6-33	50
	33	38
	24	6
	24-33	9
	6	10
	15	4
	Other	15

[1]Greater than 30 operations/hour or 15 takeoffs/hour - High

TABLE 11-2. VICON USE BY MONTH

MONTH	NO. OF TAKEOFFS	NO. OF VICON ACTIVATIONS	PERCENT VICON USE
October	57	48	84.2
November	252	137	54.4
December	318	212	66.7
January	316	197	62.3
February	219	153	69.9
March	464	236	50.9
TOTAL	1626	983	60.5

TABLE 11-3. FREQUENCY OF PILOT RESPONSE TO VICON

MONTH OF OBSERVATION	NO. OF PILOT VICON RESPONSES	NO. OF VICON CLEARANCES	PERCENT OF VICON RESPONSES
October	7	48	14.6
November	17	137	12.4
December	13	212	6.1
January	9	197	4.6
February	9	153	5.9
March	7	236	2.9
TOTAL	62	983	6.3

In an attempt to confirm use of VICON by the local controller, the light activation counts from the DAS were totalled and compared to the number of takeoffs recorded by the tower on NE Form 7230-12. To compare the counter data with the tower record, the following method was used: the tower operations number was divided by 2, to obtain the approximate number of takeoffs. The individual switch counters were added and recorded, together with the number of override (cancel) activations. The gross and net switch counts were then compared with the tower takeoff record. The results are shown in Table 11-4.

TABLE 11-4. COMPARISON OF TOWER TAKEOFF COUNTS WITH DAS SWITCH ACTIVATION COUNTS

MONTH	TOWER TAKEOFF COUNT	GROSS SWITCH COUNT	OVER-RIDE COUNT	NET SWITCH COUNT	RATIO GROSS/ TOWER	RATIO NET/ TOWER
November	5,457	5,015	1,103	3,912	0.919	0.717
December	6,027	4,882	468	4,414	0.810	0.732
January	5,969	6,272	864	5,408	1.051	0.906
February	5,668	3,986	342	3,644	0.703	0.643
March	6,311	3,731	318	3,413	0.591	0.541

The counter data was considered to be a poor indicator of VICON use. On a number of days the switch activation count appeared to exceed the number of takeoffs; the January Gross/Tower ratio exceeded one. The tower observers have commented that the controllers would sometimes activate the VICON lights for test, training, or demonstration purposes, and would use either the timer or the override to turn off the lights. There was no way to adjust for these uses. In addition, counter malfunctions occurred in November and January. Overall, the counter data was not a reliable indicator of use by the controllers.

The Net/Tower percentages for November and December [71.7% and 73.2%] are reasonably close to the Data Tape percentages [54.4% and 66.7%]. However, the corresponding January percentages of 90.6% and 62.3% do not agree well. The counter percentages for February and March [64.3% and 54.1%] are quite close to the tape results [69.9% and 50.9%].

11.2.3 Channel Use

Two approaches have been used to measure the impact of VICON on channel use.

First, a specific hour was selected which contained a significant amount of local control communications pertaining to VICON. The period selected was the November 9, 1979 (1500-1600Z) data containing about 27 seconds of VICON chatter. This hour was used to determine, at the micro level, the additional channel use per message due to VICON, on a message by message basis.

The second approach was to measure VICON's impact at the overall, or macro, level. This was accomplished by timing all VICON-related messages for every period reduced and determining its contribution to the sum total of all messages (including VICON).

The results of the first approach are presented in Table 11-5 and Table 11-6. It is evident from these tables that the contribution of VICON to channel use was minimal.

This conclusion was supported by the results of the second approach (Table D-2, cols. 6-7). In only seven instances (Obs. Nos. 3, 4, 35, 62, 79, 112, and 114) did VICON's contribution to message duration surpass one percent, and in most cases it was zero. The average VICON contribution to the total channel use for the 132 hours analyzed was 0.1%. The total channel use was 13.8%. If VICON had been used and acknowledged 100% of the time, the effect on channel loading would still be minor. Moreover, in routine operation, acknowledgement would not be required or would be included in the mandatory takeoff clearance acknowledgement and additional channel loading would be minimal.

TABLE 11-5. BREAKDOWN OF MESSAGE DURATION (SECONDS) FOR TRANSMISSIONS CONTAINING VICON MESSAGES

COMMUNICATION STREAM NUMBER	DURATION OF STREAM (SECONDS)	DURATION OF VICON MESSAGE (SECONDS)	PERCENT VICON
1	5	4	80.0
2	11	2	18.1
3	19	4	21.1
4	6	1	16.7
5	5	1	20.0
6	21	12	57.1
7	7	3	42.9
TOTAL	74	27	36.5

Source: November 9, 1979 Tape, Observation No. 3.

TABLE 11-6. EFFECT OF VICON ON LOCAL CHANNEL LOADING

Duration of Study Period	475,200 seconds
Duration of All Messages	65,402 seconds
Duration of VICON Messages	174 seconds
Percent Channel Use With VICON	13.8 percent
Percent Channel Use Without Vicon	13.7 percent

11.2.4 Unusual Occurrences

11.2.4.1 Introduction - Two approaches have been undertaken in order to look into noteworthy events that occurred during the evaluation period.

First, those events that occurred repetitively were categorized according to the type of event. These occurrences included (1) erroneous light selection (2) number of multiple VICON clearances and (3) number of multiple verbal clearances. Table 11-7 presents a summary of the frequency of occurrence, by category, of such events.

The second approach to studying unusual occurrences involved performing a detailed examination, by listening to local control, of events cited by the tower observers. Twelve such occurrences were investigated and the results are documented in Appendix D, Table D-3.

TABLE 11-7. SUMMARY OF UNUSUAL OCCURRENCES

EVENT	FREQUENCY	PERCENT
Multiple Verbal Clearances	22	1.35*
Multiple VICON Clearances	19	1.93**
Erroneous Light Selection	5	0.51**

*Based on 1,626 takeoffs
**Based on 983 VICON activations

11.2.4.2 Reissuance of Verbal Clearance - Occasionally, controllers issue a verbal takeoff clearance more than once for a given operation. Sometimes the original clearance was not intelligible and hence the pilot requested clarification, or, sometimes, the controller did not obtain acknowledgement from the pilot. Verbal clearance was reissued in all instances in conjunction with VICON use. There were 22 instances of multiple verbal clearance during the observation period, corresponding to 1.35% of all takeoffs. It must be emphasized that VICON cannot be used for takeoff clearance in place of a completely understood verbal clearance. Thus the second verbal clearance was mandatory even though the green light had been turned on.

11.2.4.3 Multiple VICON Clearances - VICON signals were occasionally observed several times for a particular takeoff. In this instance, the controller was probably making sure that the pilot saw the VICON lights. In some instances, it was not possible to associate a particular VICON signal with any takeoff operation; the controller might have been testing or demonstrating the system. There were 19 instances of multiple VICON clearances, or 1.93% of all VICON activations.

11.2.4.4 Erroneous Light Selections - Five erroneous light selections were noted. While these did not cause any detrimental effects, continued occurrence of this situation would warrant close attention, and might have negative safety consequences.

11.3 ANALYSIS CONCLUSIONS

11.3.1 Feasibility

In the 132 hours analyzed, there were no occurrences or other information that would indicate that VICON was not technically feasible. In one instance, a departing pilot indicated that he saw the VICON lights, however, neither a tone was heard nor any runway indication was recorded. This may point to a problem with the monitoring system rather than with VICON itself.

11.3.2 Integration Into the Air Traffic Control System

The available information obtained from the tapes indicated that VICON could be easily integrated into the ATC system. The possible delays as well as the contribution to channel loading appeared to be minimal.

11.3.3 Enhancement of Safety

The tapes provided little information concerning possible enhancement of safety. The redundant clearance confirmation provided by VICON assured the pilot that his takeoff clearance was correct. However, in the case of a misunderstood or garbled first clearance, the VICON light was not an acceptable alternative to requesting a repeat or confirmation of the verbal clearance instructions. Second clearances were issued when requested by the pilot or when the controller did not receive an acknowledgement. The tapes gave no indication of any takeoff problem that was not resolved by the controller.

12. EQUIPMENT FAILURE/MAINTENANCE DATA

The Facility Maintenance Logs (FAA form 6030-1) were reviewed to determine equipment failures, system downtime, and maintenance times. The logs were analyzed beginning 1 November. Prior to 1 November, the equipment was considered to be in a shakedown status, and had several temporary arrangements required by tornado damage. Details are given in Appendix E.

12.1 EQUIPMENT

Equipment failures were extracted from the logs for both the primary equipment and the Data Acquisition System (DAS).

12.1.1 Primary Equipment

During November, the Runway 33 equipment suffered repeated problems with the microwave beam unit used to turn off the green light and with the light circuit itself. A number of repairs and adjustments were made, but the troubles were not completely eliminated. The entry for 20 November reported that NAFEC was continuing to work on the problem. The following day some parts of the microwave system were replaced and the system was adjusted. There were no further indications of problems. The runway 06 light cluster failed once.

After November, the number of failures decreased. There were single failure reports on the receiver which controlled the lights on runway 33, on the lamps in the tower control panel, on the runway 06 Kilo indicator light, and on the light intensity control.

On Friday, 14 March, lights on Runway 33 approach end and intersection Alpha/Sierra were damaged by a snow plow. On

Monday, 17 March, the lights were repaired and returned to service except for the Alpha/Sierra cluster, which worked intermittently until final repair was accomplished on 28 March. This damage was the only equipment problem which occurred in March.

12.1.2 Data Acquisition System

During November the switch activation counters required considerable maintenance. In December there were problems with the tape recording equipment, primarily concerned with failure of the tape-out alarm. The only DAS problem in January was one unexplained failure of the counters.

In February one receiver had to be readjusted to stop continuous feed on the voice-actuated tape recorder, and the time unit power supply failed. There was also a problem with the tape alarm. No DAS corrective maintenance was required in March.

There is some evidence that unauthorized individuals were tinkering with the DAS equipment.

12.2 FAILURE AND MAINTENANCE REPORTING METHODS

When the controller encounters an equipment failure, he reports this fact verbally to this supervisor. The supervisor verbally reports the problem to the maintenance chief, who directs a technician to repair the failure.

Upon arrival on-site, the technician logs in on the form. He performs troubleshooting and repair, routine checks and preventive maintenance, and any other necessary work. He then enters the work done onto the log form, and logs out.

There is no formal feedback to the controllers that the failure has either been corrected, or, if not corrected, when it will be repaired. (See previous references to the suggestions for a VICON status board.) Nor is an unrepaired item carried forward in the log to show the need for eventual repair.

The only documentation is this Log, Form 6030-1, which contains time in, work done, and time out.

12.3 SYSTEM DOWNTIME AND RELIABILITY

As previously discussed, the failure reporting method does not provide any written notification or records of failure reporting. Thus it is not possible to learn from written records when a failure occurred or when it was reported to the various levels in the reporting sequence. It is therefore not possible to determine system downtime or reliability.

As an example of the slippages possible in a verbal reporting system, the log contains the following entry: "1400, 26 February, ATC (TS) advised me of a log entry of about a week and one-half ago concerning the intensity not working." There is no indication of any maintenance action, nor any carrying forward of this problem for later repair. There is an entry on 7 March: "ATC (AS) reports rwy 6 VICON lights too bright, cannot be adjusted. Connected Hi-Low wires in field for intensity, all operations normal." This is apparently the repair action for the 26 February entry's but no specific reference is made to this fact in the log.

12.4 MAINTENANCE TIMES

Because of the way the log is kept, maintenance times (times to repair a failure) cannot be developed. Based on log in/log out times, the daily maintenance requires 5 to

10 minutes, and the weekly check about 30 minutes. For other maintenance actions, a crude estimate can be given in a few cases from the total time spent on-site. However, in most cases, multiple actions during the time period, or failure to log in or out, precluded making any reliable estimates of repair times.

12.5 LOG COMPLETENESS

As mentioned above, the log entries were often incomplete. In some cases, there was no indication that a repair was completed or that the repair cured the problem. Modifications to the equipment were not always recorded so the configuration of the equipment could not be reliably determined from the logs. For example, the installation of the matrix panel on 29 November was recorded, but the installation of the touch sensitive panel on 18 January and the reinstallation of the mimic panel on 5 February were not recorded. Thus the logs did not furnish reliable data for the determination of system configuration or the calculation of maintenance data such as system downtime, Mean Time Between Failures (MTBF), Mean Time To Repair (MTTR), or reliability. Based on tower observer reports and controller comments, the reliability of the system was very high from November through March.

13. DATA INTEGRATION

13.1 INTRODUCTION

The data obtained from the individual sources have been discussed, analyzed, and evaluated in the preceding sections. Following the material on each individual data source, these individual results and findings were interpreted in terms of the three basic questions regarding technical feasibility, integration into the ATC System, and enhancement of safety. These interpretations will now be consolidated.

13.2 APPROACH

The feasibility, integration, and safety findings from each individual analysis will be brought together under these same headings, as shown in Table 13-1, and will be discussed to determine whether the individual findings confirm and reinforce each other or whether they conflict and disagree. The results will be compared, and the findings discussed. Serious disagreements will be presented where they occur. Before addressing the three basic areas, all unusual occurrences will be presented to create a background of operational experience.

13.3 UNUSUAL OCCURRENCES

These occurrences were cited in interviews and reports obtained from pilots and controllers, and from the experiences of the tower observers.

TABLE 13-1. ORIGINAL SOURCE/KEY QUESTION INTEGRATION MATRIX

ORIGINAL SOURCE	TECHNICAL FEASIBILITY	SYSTEM INTEGRATION	ENHANCED SAFETY
Tower Observer Report			
Controller Workload		P	
Additional Workload		P	
Contribution to Safety			P
Comments/Occurrences	P	P	P
Tower Observer Log			
Takeoff Time Intervals		P	
Comments/Occurrences	S	P	P
Pilot Interviews			
Values of Benefits		P	P
Problems or Shortcomings		P	P
Personal Occurrences	S	P	S
Personal Cost/Annoyance		P	S
Value to NAS		P	P
Nationwide Deployment	S	P	P
Comments/Occurrences	P	P	P
Pilot Questionnaire			
Distinctiveness	P	S	
Perceptability	P	S	
Location	P	P	
Intensity	P	S	
Cockpit Workload		P	S
Clarity of Clearance			P
Expedite Departure		P	
Comments/Occurrences	P	P	P
Controller Interviews			
Local Controller Workload		P	S
Impact on Other Controllers		P	
Assessment of Safety Effects			P
Greatest Benefit		P	P
Worst Flaw		P	P
Alternatives	P	P	P
Improvements	P	P	P
Comments/Occurrences	S	P	P

P = Primary Input, S = Secondary Input

TABLE 13-1. (Cont.)

ORIGINAL SOURCE	TECHNICAL FEASIBILITY	SYSTEM INTEGRATION	ENHANCED SAFETY
Controller's Report			
Prevented Possible Incident		P	P
Failure Occurred	P		
Difficulty Using (Controller)		P	
Difficulty Using (Pilot)		P	
Delayed/Impeded Operation		P	P
Improved Operation		P	P
Comments/Occurrences	S	P	P
Maintenance Log			
Failure/Repair Entries	P	S	S

P = Primary Input, S = Secondary Input

13.3.1 Favorable Occurrences

One favorable occurrence (VICON improved operation) was checked by a controller, but details were not given. No other favorable occurrences were reported.

13.3.2 Neutral/Unassigned Occurrences

These occurrences were neither favorable nor unfavorable, but were offered to help provide a feeling for operations as they took place during the test period.

- There were a number of instances when the pilot requested a repeat of the takeoff clearance.

- The pilot of a small air carrier jet did not receive the green light and asked for it. The controller pushed the button. The pilot reported lights on farther down the runway. The controller pushed override and then the correct button. Pilot stated: "That's it, we're rolling." After takeoff, the pilot commented that it looked like a Christmas tree there for a second. The controller made some very unfavorable off-radio remarks.

- With 1/4 mile visibility, an aircraft was cleared for takeoff on runway 24 but actually took off on runway 19. The tower could not see the takeoff position about a mile away.

- A large jet was on final approach for runway 06. A twin engine light plane was instructed to taxi into position and hold on runway 33. The jet landed and after passing the intersection was instructed to make the first available right turn off the runway and to switch to ground control. At that point the light plane took off.

13.3.3 Unfavorable Occurrences

An occurrence was considered unfavorable if it involved VICON and created a potentially unsafe situation.

- There were a number of occurrences in which an aircraft was cleared for takeoff but did not go, because the pilot was waiting for the green light. This indicated that the controllers did not use VICON for these takeoffs. It also indicated that the pilots did not fully understand the use of VICON, as they should have requested the light from the local controller. However, many pilots stated that they were uncertain what they should do if they did not get the green light (see Sections 6.1.3.2.1 and 8.3.4). Also, occasionally the pilot did not receive the green light even when he requested it. Finally, under the test program ground rules wherein VICON confirmed but did not control takeoff clearance, the pilot could have correctly taken off without receiving the green light. In one case, a landing air carrier jet had to go around because of the delay.

- An air carrier pilot reported having the green light before receiving his takeoff clearance. The controller could not determine any reason for this except possibly failure of the preceding aircraft to break the microwave beam.

- A light plane failed to break the microwave beam on takeoff and the green light remained on. A heavy jet was instructed to taxi into position and hold. The pilot replied: "Roger, I see the light, rolling." The controller corrected the situation immediately.

13.4 GENERAL COMMENTS

All comments from the tower observers are listed in Appendix B, those from pilot interviews in Appendix C, and those from the pilot's questionnaires in Appendix F.

13.4.1 Favorable Comments

The pilot questionnaires contained 46 favorable comments, such as "Excellent idea, should enhance safety," "Excellent system - let's get more of them," and "Personally think VICON has merit." A number of comments stated that VICON would be a great benefit when visibility was bad, which is the situation that existed at Tenerife.

One pilot stated: "Communication saturation, noise, and garbles are common on the local control channel and lead to missed or misunderstood instructions. VICON provides a redundant, independent confirmation of takeoff clearance and thus provides for safer takeoff operations." Another stated: "In the day-to-day ATC system, any system that can add clarification of pilot/controller communication is a god-send."

13.4.2 Neutral/Conditional Comments

In just one month, November, there were 13 such comments in the pilots' questionnaires. They included questions about the cost effectiveness of VICON, statements that the value would probably increase as they got used to the system, and the opinions that VICON might be beneficial but there really was no problem of uncleared takeoffs.

13.4.3 Unfavorable Comments

The questionnaires contained 82 unfavorable comments. Those most frequently cited were:

- The system is unnecessary, especially if the pilot reads back the verbal clearance.
- VICON causes confusion and increased workload.
- The money could be better used for other equipment which would have greater benefit. There were many systems mentioned, but runway intrusion control was by far the most frequently mentioned, perhaps because VICON addresses the question of runway occupancy.

Controllers also felt runway intrusion control was a very serious problem. One recommended a system to ensure that the runway was indeed unobstructed. He had personally experienced situations where snow plows were on the active runway with no knowledge in the tower of this activity.

One controller stated that if VICON were installed nationwide, there would soon be an accident because of it.

Tower observers reported a number of times that controllers stated that they would have to accept VICON whether they liked it or not because so much money had been spent on it.

13.4.4 Suggested Alternatives

A number of alternatives to VICON were suggested. These were proposed as being more urgently needed, more cost/effective, or more readily implemented.

- Provide a runway intrusion control system to ensure that the local controller knows the status of the active runway at all times. This might well include a means to verify that the runway is completely clear.

- Require readback of all takeoff clearances by the pilot and confirmation by the controller.

- Require the use of standard phraseology by all pilots and controllers.

- Pilots should not be allowed to use U.S. airports unless they have good command of basic aviation English.

- Pilots should be better trained in air traffic control procedures. This was urged by both the controllers and those GA pilots whom we interviewed.

- Controllers should never have more than one aircraft on the active runway when they cannot see the entire runway from the tower.

13.5 FEASIBILITY

This section seeks to answer the first fundamental question: "Is visual confirmation of voice takeoff clearance technically feasible?" As restated: "Is the equipment capable of performing the visual confirmation function correctly, effectively, efficiently, and reliably?"

13.5.1 Reliability

Overall reliability of the equipment appeared to be good. The basic design approach of connecting all components in series ensured that equipment failures will be promptly detected. There were a number of failures early in the test program but these appear to have been satisfactorily resolved.

One comment was recorded early in the test program which indicated some dissatisfaction with the equipment. Local controller: "When the panel is finally right I will use it."

By the end of the evaluation period, the equipment appeared to be highly reliable. There was one reported equipment malfunction in February and none in March.

13.5.2 Equipment Design Problems

There were a number of equipment design and installation shortcomings which have caused difficulties and which have the potential for causing serious problems.

- Pilots reported that the lights were poorly positioned and were hard to locate and identify. The lights must grab the attention of all pilots on the flight deck.

This was a very common theme in both pilot interviews and pilot questionnaire comments.

- Light planes frequently did not break the microwave beam when the wind is moderate to strong. Thus the green light was not turned off automatically, and the controller must use manual override. If several aircraft were in a queue for departure, the light remaining on could be misinterpreted as a takeoff clearance.

- Some pilots also suggested the use of two lights, like a traffic light. The red light would be lighted at all times and would indicate an uncleared status; upon issuing the verbal clearance, the controller would switch the light to green to indicate a cleared status.

- Pilots were also concerned about the effects of snow, in terms of snow removal, masking the light, reflection, etc.

- Under certain conditions, sunlight reflecting from the light lens made the light appear to be on when it was not.

- At certain times of day, the sun blinded the pilot and he could not see the light.

13.5.3 Controller Use

- Controllers reported pushing the wrong button, overriding, and then pushing the correct button.

- Early in the program, controllers suggested that a clipboard be installed next to the VICON control panel where notes could be placed indicating the status of the system. The status changed frequently because of the experimental nature of the system and damage done by the tornado. This idea was not approved; controllers normally brief their replacement as to any unusual conditions. However, these briefings were not always carried out and uncertainties arose. This problem was especially serious when the lights were damaged in mid-March. There was a period of considerable uncertainly regarding the status of the system.

- The need for an assistant local controller was cited, based on the claim that the local controller has a lot of little things to do and to coordinate, and the feeling that VICON adds to the local controller's workload.

13.5.4 <u>Pilot Use</u>

The pilots' use of the equipment was limited to locating and observing the green light. Their comments have been reported in Section 13.5.2.

13.5.5 <u>Other Considerations</u>

A number of alternatives were suggested. These are presented in Sections 13.4.4 and 13.5.2.

It appears that VICON was not connected to the standby emergency power system, and would become inoperative in event of a power failure. VICON might well be of unusual importance under such emergency conditions. In this instance, VICON was only a test facility and not a commissioned facility, and as such it could not be interfaced nor interfere with other commissioned equipment. However, if VICON were to be installed in the future as a commissioned facility, it should have emergency power backup.

There was nothing in the magnetic tape recording data that would indicate any type of equipment problem not already presented.

13.5.6 Findings and Results

1. In general, the equipment worked well and performed its intended functions. After the initial shakedown period, reliability appeared to be good as few comments have been made regarding failures. The status board was highly desirable during the experimental period but may not be as important should the system become part of the regular tower operational equipment.

2. Potentially serious problems existed in the design. These were:

   First, the lights were poorly positioned and were difficult to locate and identify. Snow may cause problems, but this could not be examined.

Second, the lights may well not be visible in their present configuration under conditions of very low runway visibility, when the system should have its greatest usefulness and safety benefit.

Third, the sun caused reflection and blinding problems at certain times of day.

Fourth, some aircraft did not break the microwave beam on takeoff, so the green light was not automatically shut off.

13.5.7 Summary

In summary, subject to the correction of the cited problems, the VICON equipment demonstrated that it performed satisfactorily and met the requirements of the program. VICON was technically feasible.

13.6 INTEGRATION INTO THE ATC SYSTEM

This section tries to answer the second fundamental question: Can VICON be integrated into the present ATC System?" As restated: "Can VICON be incorporated into the present ATC System so as to create no disruption, distraction, or confusion?" Integration is primarily concerned with workload and procedures, and with the absence of unusual events attributable to VICON. Integration is successful if the regular use of VICON imposes little or no penalty on the smooth and uneventful flow of traffic.

13.6.1 Impact on Controllers

The controller impact information was obtained from tower observer reports and controller interviews and reports.

- The tower observers rated the controller overall workload as slightly greater than Low, and felt the workload did increase with increasing traffic level, and with increasing visibility.

- The observers rated the additional workload due to VICON between Very Low and Low. They indicated that as workload increased, the additional workload also increased but at a lower rate. Additional workload did increase as the visibility increased.

- The controllers reported in their interviews that VICON did indeed add to the workload of the local controller. This added workload was low for light traffic, and increased at least as fast as the traffic level. At high traffic levels, nearly half the controllers stated that they stopped using VICON, but one-sixth stated they definitely did not stop using the system then.

- About one-tenth of the interviewed controllers stated that they did not use the system at any time.

- The above statements confirmed the pilots' claim that VICON was used intermittently.

- In addition to the increased workload, controllers claimed that VICON was very distracting.

- About one-fifth of the controllers felt that VICON caused some added workload for ground and departure controllers, primarily because of coordination problems.

- However, some strong statements were made that VICON did not receive a full and fair test by some controllers, and that the distraction claim was overdone because the controller had to routinely look down to check the flight strip.

- The observers reported that many pilots asked the controller questions about VICON, and in some instances received vague or incorrect answers. Neither pilots nor controllers were properly familiar with the system.

- The average time interval of 4.4 seconds between issuance of the verbal voice clearance and the VICON signal indicates that the system caused little or no delay in takeoff operations. Since the signal might well occur at the same time as the pilot's acknowledgement of the clearance, there was some small possibility of distraction.

There was a conflict between the tower observers and the controllers in the ratings of overall workload and added workload due to VICON, as shown in Table 13-2.

TABLE 13-2. OBSERVER AND CONTROLLER WORKLOAD RATINGS

	OBSERVER RATING	CONTROLLER RATING
Overall Workload	Low +	Moderate
Added Workload	Very Low +	Moderate
Rate of Workload Increase with Increasing Traffic	Lower Rate	Equal Rate
Rate of Added Workload Increase with Increasing Traffic	Lower Rate	Higher Rate
Rate of Workload Increase with Increasing Visibility	Increase	Increase
Rate of Added Workload Increase with Increasing Visibility	Increase	Increase

The controllers were very probably more familiar with their true workload, as many functions and actions were difficult or impossible to note from the observers' location in the tower. One would likely have selected the controller ratings as more accurate and representative of actual conditions. However, two facts added strength to the observers' ratings; first, two observers were retired air traffic controllers with considerable experience in the Bradley tower, and second, the strong negative bias often displayed by a number of controllers suggested that their workload ratings may be exaggerated, either subconsciously or deliberately.

There were also conflicting opinions among the controllers. Some have stated that the added VICON workload was so great that they either did not use the system at all or did not use it when they got busy. Others have stated that the added workload is minimal and they had no problem using VICON during periods of heavy traffic.

There did appear to be some increase in the local controller workload due to VICON. There may have been some increased workload for ground and departure controllers. There was no evidence to support the claim of delay due to VICON. Finally, there was strong evidence that the controllers were not thoroughly familiar with the system.

13.6.2 Impact on Pilots

The ` .lot impact information was obtained primarily from the pilot questionnaires, with limited information coming from pilot interviews and observer reports.

- Pilots stated a moderate feeling that VICON was not needed as there was no present problem. The value to the National Airspace System was slightly negative.

- Pilots also stated in their interviews and questionnaires that VICON caused some increase in confusion and cockpit workload. However, their questionnaire scored rating of Effect on Cockpit Workload indicated that VICON made no difference in workload.

- Questionnaire answers indicated that VICON did not expedite departure, and that there was no improvement with increasing familiarity with the system. Further, answers indicate that the results were independent of the visibility.

- Pilot interviewees felt there was a minor personal cost and annoyance in using the system.

- Many pilots were not aware of VICON, and quite a few were not familiar with it. A number of occurrences of pilot confusion were reported.

- Controllers did not use the system in any consistent manner. When the pilot did not receive his green light, he was uncertain whether his clearance had not been confirmed, whether VICON was inoperative, or whether the controller was not using it. In a few cases, the light was not given even when requested. The pilots were unsure what their response should be when no light was given.

- There was no evidence from the magnetic data tapes or departure logs to indicate that VICON caused delays in takeoff operations.

- There was strong evidence that communication channel saturation did not exist, and that VICON had a negligible effect on channel usage.

The pilots stated that VICON was not needed as there was no present problem, and that its overall value was slightly negative because of confusion, delay, and increase in cockpit workload. However, questionnaire scored answer results indicated that VICON made no difference in pilot workload or expeditiousness of departure. There was no time interval measurement data evidence that VICON caused delay or impacted communication channel usage.

There was evidence that pilots were not familiar with VICON. Air carrier pilots were the best trained, while general aviation light plane pilots were frequently totally unaware of VICON. The problems of pilot unfamiliarity were compounded by the intermittent use of the system by the controllers, and by the lack of understanding of the system by some controllers.

13.6.3 Other Impacts

The impact of VICON on the local controllers and the pilots has been discussed in detail. Possible impacts on ground and departure controllers have also been mentioned.

The only other impact mentioned (by both controllers and pilots) was delay. If delays were caused by VICON, they might reduce airport capacity during periods of very high traffic, and they might cause some delay throughout the entire Air Traffic Control System because of delayed departures. However, the pilot questionnaire scored answers indicate that VICON caused the pilots no delay, and the takeoff clearance/start of roll time measurements also indicated that no takeoff delay existed. The tower observer ratings of added workload lie between Low and Very Low which does not confirm the controllers' claims of added workload and distraction which could cause delays. Finally, the magnetic tape data suggested that VICON did not create any delay for the local controller, and strongly indicated that there was no communication channel saturation which might contribute to delay.

13.6.4 Findings and Results of This Test at Bradley

1. Successful integration of VICON into the ATC System has not been demonstrated. While the reports and ratings were not clear, and on some matters were in conflict, there was a reasonable indication that VICON did cause added workload, distraction, disruption, and confusion.

2. Despite the conflicting views of observers and controllers, VICON did appear to add to the local controller's workload, and possibly to the workload of ground and departure control. While some controllers

stated that they used VICON all the time without difficulty, even at high traffic levels, the great majority stated that VICON did add an appreciable workload at high traffic levels. There was also some evidence of distraction and disruption of the local controller.

3. There were also inconsistencies in the results concerning the pilots. The overall evaluation, however, is that there was probably a slightly negative impact on the pilots because of increased workload and distraction.

4. One can argue that properly located and designed lights, better understanding and familiarity on the part of the pilots, and regular use of the system by the controllers would eliminate the claims of added workload and distraction.

5. The pilots and controllers felt the system was not needed.

6. Neither pilots nor controllers were completely familiar with the system.

7. Some controllers used VICON all the time, some did not use it at all, and some stopped using it when they got busy with heavy traffic. This caused confusion on the part of the pilot, who was unsure of his proper response when he was verbally cleared but did not get the green light.

8. There was no evidence that VICON had any negative effect on communication channel usage at Bradley.

9. There was no evidence to support claims by pilots or controllers of delay due to VICON.

13.6.5 Summary

In summary, VICON was not completely integrated into the ATC system. VICON did appear to increase controller and pilot workload, and to cause some distraction.

There was also a moderate feeling that no problem of unauthorized takeoff exists, and that, accordingly, the system was not needed.

13.7 ENHANCEMENT OF SAFETY

This section addresses the third fundamental question: "Does VICON enhance safety?" or, "Does the VICON system have enough positive factors to outweigh any negative factors, so that the addition of this redundant system will indeed increase the likelihood that no harm or loss will occur?" It must be again noted that VICON is not in fact a redundant system. The verbal clearance controls, VICON confirms. If the voice clearance radio system fails, takeoffs stop; if the VICON system fails, takeoffs continue. If the pilot understands and acknowledges his verbal takeoff clearance, he may correctly take off regardless of the indication from the VICON lights.

13.7.1 Positive Effects

- A pilot representative felt VICON would be valuable for standardization of procedures, if installed and used nationwide.

- Pilot questionnaire ratings of the effect of VICON on Clarity and Understanding of Clearance lay between Made No Difference and Made Things Easier. Reducing the possibility of a misunderstood clearance had a slight positive effect on safety. The improvement was independent of visibility conditions.

- Pilots claimed that any pilot who is uncertain about his clearance will not take off but will request a confirmation from the controller. However, there were two seriously incorrect takeoffs during the test period which could have had serious consequences.

- Of the controllers interviewed, one-fourth felt VICON made some improvement in safety.

13.7.2 Neutral/Unassignable Effects

- The predominant observer opinion (95%) was that VICON has a neutral effect on safety.

- There was little enthusiasm for VICON among the controllers and pilot representatives who were interviewed, as they felt that no unsafe condition presently exists.

13.7.3 Negative Effects

- There was little enthusiasm for VICON among those pilots who were interviewed. They felt that the funds could be far better spent on other equipment which would make a far greater contribution to safety.

- The pilots stated that VICON imposed a minor personal cost, added workload, and caused distraction at the very busy takeoff time. Their overall assessment of the safety contribution was neutral or slightly negative.

- The interviewed controllers were almost unanimous (90%) in citing flaws or problems which they considered serious enough to create an overall negative opinion of the system. The opinions were more strongly negative in the second interview than in the first, and even more strongly negative in the third interview.

- The negative effects most frequently cited by the controllers, both in their interviews and their reports, are distraction, increased workload, concern about equipment problems, and delay. In addition, they feel VICON would not prevent runway intrusion or the human side of misinterpretation. Many of the controllers did not have the confidence in the system that was necessary if the system were to have a positive effect on safety.

13.7.4 Findings and Results

1. Positive effects were predicated on the idea that a pilot must not take off if uncertain of his takeoff clearance, as this is an inherently unsafe situation. Pilots claim that any pilot who is uncertain about his clearance will not take off, but will request verbal confirmation. However, two seriously incorrect takeoff did occur during the test period. Questionnaire ratings indicate that VICON did improve the pilot's clarity and understanding of his takeoff clearance.

2. The predominant rating by the tower observers was that VICON had a neutral effect, and that the system was not needed.

3. Negative effects were cited in three major areas:

First, the pilots' overall assessment of VICON was neutral to slightly negative. VICON imposed a minor personal use cost, added workload, and caused distraction at the very busy takeoff time.

Second, both pilots and controllers felt that no safety problem existed, and that the money could be better spent on other facilities which could make major improvements in safety.

Third, the controllers' overall assessment of VICON was somewhat negative. They cited increased workload, distraction, and concern about equipment problems. Available data indicated that these concerns are real, even though they may be overstated.

13.7.5 Summary

On balance, the ratings and results indicated that the negative effects slightly outweighed the positive effects. If, in fact, a pilot will not take off without a clearly understood and verbally confirmed clearance, then there is no problem to be solved and VICON is unnecessary. However, uncleared takeoffs do occur.

The use of VICON did create added workload and distraction at the critical time of takeoff. If VICON use increased the probability of a hazardous situation due to distraction and added work more than it decreased the probability of a hazardous situation due to unauthorized takeoff, then VICON's net effect was negative and it reduced safety. The data and analysis indicated that the likely impact of distraction and added workload was greater, and that VICON in its present configuration did not, on balance, enhance safety.

13.8 OVERALL SUMMARY

VICON was technically feasible, although design problems did exist. If these were corrected, the equipment met the requirements of the program.

VICON was not smoothly and completely integrated into the ATC System. VICON did appear to increase controller and pilot workload and to cause some distraction. While these problems may be minimized with greater familiarity with the system and improved equipment, they did exist to a notable degree during the test period.

VICON has not demonstrated that it enhanced safety. The use of VICON seemed to have slightly more negative factors than positive ones, and the net effect appeared to be that added workload and distraction somewhat outweighed the benefits. There was a moderate feeling among both pilots and controllers that VICON was intended to solve a problem that really does not exist. Finally, VICON was not truly a redundant system. If the pilot understood and acknowledged his takeoff clearance, he could properly and safely take off regardless of the indication from the VICON lights; if he did not understand the verbal clearance, he could not properly take off even with a green VICON light.

APPENDIX A

STATISTICAL DEFINITIONS

Averages, $\overline{x}$ or μ

An average is a measure of central tendency. Central tendency gives us a concise description of the typical performance of the group as a whole.

Variability

Measures of variability provide information with respect to the extent of scatter, or conversely, the degree of clustering in a set of data. Measures of variability are useful in evaluating the representativeness of a measure of central tendency. The most useful measures are the variance (s^2, σ^2) and the standard deviation (s or σ). The more clustered the data, or the smaller the variability, the more effectively the measure of central tendency represents the distribution as a whole.

Two Sample t-test

A two sample t-test is a comparison of two averages. Frequently we ask the questions, "Are there differences between the averages of two treatments?" or "Does treatment X produce a higher average than that of treatment Y?" This test evaluates whether significant differences exist between two treatments. The t-test is applied in the following manner:

Suppose we have observations from two samples $X_1, X_2, \ldots, X_m$ and $Y_2, Y_2, \ldots Y_n$

$$\text{Let } \overline{X} = \frac{\sum_{1}^{m} X_i}{m} \qquad \text{and} \qquad S_X^2 = \frac{\sum_{1}^{m} (X_1 - \overline{X})^2}{m - 1}$$

$$\bar{Y} = \frac{\sum_{1}^{n} Y_i}{n} \quad \text{and} \quad S_Y^2 = \frac{\sum_{1}^{n} (X_1 - \bar{X})^2}{n - 1}$$

Under the assumption of equal variances, let

$$S^2_{\bar{X}-\bar{Y}} = \frac{S_X^2}{m} + \frac{S_Y^2}{n}$$

Then the statistic $\dfrac{\bar{X} - \bar{Y}}{\sqrt{S^2_{\bar{X}-\bar{Y}}}}$ follows the t-Distribution with

m + n - 2 degrees of freedom

For further explanation, see

1) Freund, John E., Modern Elementary Statistics, Third Edition, 1967, pp. 254-257.

2) Parsons, Robert, Statistical Analysis, Second Edition, 1978, pp. 429-434.

3) Pfaffenberger and Patterson, Statistical Methods for Business and Economics, First Edition, 1977, Chapter 11.

Kendall's Tau - A Measure of Correlation

Frequently, we want an index that expresses the degree of relation between two variables. Such an index is called a correlation coefficient. If there is ranked data, we resort to a Rank Correlation Coefficient. Kendall's Tau is considered to be one of the best correlation measures for ranked data. It is applied in the following manner:

Suppose we have the following pairs of data:

$$(X_1,Y_1),\ (X_2,Y_2),\ \ldots,\ (X_n,Y_n).$$

For any two pairs (X_i,Y_i), (X_j, Y_j), we say that the relation is:

Concordant if $Y_i > Y_j$, whenever $X_i > X_j$ or

if $Y_i < Y_j$, whenever $X_i < X_j$

Discordant if $Y_i > Y_j$, whenever $X_i < X_j$ or

if $Y_i < Y_j$, whenever $X_i > X_j$

Let N_c = number of concordant pairs

N_d = number of discordant pairs

$\binom{n}{2} = \frac{n(n-1)}{2}$ = the number of combinations of n objects taken 2 at a time

and define $T = \dfrac{N_c - N_d}{\binom{n}{2}}$

For large sample size ($n \geq 8$), the statistic T has an asymptotic normal distribution with mean 0 and variance $\dfrac{4n + 10}{9n\ (n - 1)}$

The statistic $Z = \dfrac{3T\ \sqrt{n(n - 1)}}{\sqrt{4n + 10}}$ may be treated as a standard Normal Random Variable.

References:

1) Rohatgi, V.K., An Introduction to Probability Theory and Mathematical Statistics, 1976, pp. 567-569.

The Kruskal-Wallis Test and Analysis of Variance

While the two sample t-test evaluates possible differences between two treatments, the Kruskal-Wallis Test and Analysis of Variance is concerned with the equality of two or more treatments. Basically, they are extensions of the t-test. The Kruskal-Wallis test applies to ranked data, and Analysis of Variance deals with data that conforms to the Laws of the Normal Distribution. Detailed explanations of the tests are described below:

Analysis of Variance

Given treatments 1, 2, ..., n, denote their sample averages by $\overline{X}_1$, $\overline{X}_2$, ..., $\overline{X}_n$ respectively. Under the assumption that all treatments produce equal averages, there is no variation between averages and all variation would be due to within sample variation.

Let S_W^2 = Within Sample Variation

Let S_B^2 = Between Sample Variation

Let $F = S_B^2/S_W^2$. If F is small, then S_B^2 will be negligible compared to S_W^2, which suggests the difference between the sample means is not enough to conclude they differ. If F is large, then the difference between the averages suggests differences occur between the sample averages. The Statistic F follows the F-distribution.

References: See Parsons, Pfaffenberger and Patterson, and Freund

Kruskal-Wallis Test

Given the treatments 1, 2, ..., n with observations

$X_{11}, X_{21}, \ldots, X_{n_1,1}$ belonging to treatment 1

$X_{12}, X_{22}, \ldots, X_{n_2,2}$ belonging to treatment 2

$\vdots$

$X_{1n}, X_{2n}, \ldots, X_{n_n,n}$ belonging to treatment n ,

We rank all the data points from 1 to $N = n_1 + n_2 + \ldots n_n$ and for each treatment i, obtain the sum of their ranks, R_i.

The Kruskal-Wallis Statistic is defined to be

$$K - W = \frac{12}{N(N+1)} \sum_{1}^{n} \frac{R_i^2}{n_i} - 3(N+1)$$

The K - W statistic follows the Chi-Square Distribution with n - 1 degrees of freedom.

References:

1) See Freund

2) Lehman, E.L., Non-parameterics: Statistical Methods Based on Ranks, 1975, pp. 204-210.

The Wilcoxon Rank-Sum Test

The Wilcoxin Test is the nonparametric statistical analog to the two-sample t-test. Given treatments 1 and 2 with observations

$X_{11}, X_{21}, \ldots X_{n_1,1}$ belonging to treatment 1

$X_{12}, X_{22}, \ldots X_{n_2,2}$ belonging to treatment 2

We rank all the data points from 1 to $N = n_1 + n_2$ and for either treatment, obtain the sum of its Ranks, and call it W.

For treatment i, i = 1, 2

$$EW = \frac{1}{2} n_1 (N + 1)$$

$$VW = \frac{1}{12} n_1 n_2 (N + 1)$$

The Statistic

$$Z = \frac{W - EW}{\sqrt{VW}}$$ follows the Z - distribution.

Note:

The application of a rank test may involve the handling ot many ties in the ranking procedure. The presence of ties will modify the formula for VW = the variance of W.

Reference:

1) See Lehman

APPENDIX B

LIST OF TOWER OBSERVER COMMENTS

This appendix lists all comments made by the tower observers in both their Reports and Departure Logs. The entries in the two forms have been consolidated to avoid duplication. The only comments not listed are those such as "Light traffic this period" which serve no purpose in this listing.

Data observations were conducted on the following dates, as shown in Table B-1:

TABLE B-1. OBSERVATION DATES

October:	23, 24, 25, 26, 28, 29, 30, 31	(8)
November:	3, 4, 5, 7, 8, 9, 12, 13, 14, 15, 18, 19 20, 21, 26, 27, 28, 29, 30	(19)
December:	3, 4, 5, 6, 9, 10, 12, 13, 14, 16, 18, 19 20, 21, 28, 29, 30, 31	(18)
January:	2, 3, 4, 5, 7, 8, 9, 10, 11, 13, 14, 17, 18, 20, 21, 22, 23, 24, 25, 28, 29, 30, 31	(23)
February:	1, 3, 6, 7, 8, 10, 11, 13, 15, 16, 18, 19, 20, 22, 25, 26, 28, 29	(18)
March:	3, 4, 6, 7, 8, 9, 10, 12, 13, 14, 16, 18, 19, 21, 22, 24, 26, 27, 28	(19)

The comments are listed by date in Table B-2. The visibility rating is also given; where two ratings are given, the first rating applies to the beginning of the observation period and the second to the end of the period. For example, Visibility - Good to Poor means that the visibility at the start of the period was greater than three miles but had dropped to 1/2 mile or less by the end of the period.

TABLE B-2. TOWER OBSERVER COMMENTS

October 23, Tuesday. Visibility - Good

1. Incoming planes caused queue to grow (4) and then many takeoffs in short time.

2. Medium prop delayed due to other aircraft on runway.

3. Numerous delays due to incoming aircraft (3 entries).

4. Large jet pilot asked several questions regarding VICON.

5. The use of two runways for landings and takeoffs added additional workload overall.

October 24, Wednesday. Visibility - Good

1. VICON seems to be working.

2. Medium prop questioned VICON light.

3. Large jets (3) confirmed light.

4. Large jets (2) confirmed light.

5. Medium jet confirmed light.

6. Traffic routine due to single runway operation.

October 25, Thursday. Visibility - Good

1. Pilot visiting tower advised he recently received TO clearance 5 times before he could spot VICON green lights. Suggests they be made more visible or otherwise identified.

2. Confirmed lights - 2 heavy jets.

October 26, Friday. Visibility - Good

1. Several tours of 7-8 men visited tower.

2. Pilot: "I've got the VICON light."

3. Controller advised at 1501Z that VICON control panel not to be used TFN. Back on at 1621Z.

4. Heard several pilots confirm green lights.

TABLE B-2. (Cont.)

5. Pilot queried controller as to operation of VICON. Controller not sure about light color when VICON off. After explanation (by Hopper) controller called pilot and explained light is either green or off. Pilot suggested red when off.

October 28, Sunday. Visibility - Fair to Poor

1. Raining and light fog. Visibility varying between 1/2 mile and 1 mile.

2. VICON lights all visible from tower.

3. Small prop confirmed lights.

4. Small prop confirmed lights.

5. Controllers report VICON working.

6. Local controller called me to panel and showed me that he had to activate the Override button to get runway 06 light to go back on after the microwave unit had turned off the VICON light. Two pilots reported light was OK after this.

7. Weather poor by any standards (visibility poor to fair) and getting poorer in visibility. Two pil[illegible]s remarked on getting the light before 4:00 PM EST. Runways a bit slippery. TWA held extra long due to a panel from earlier 727 on runway in use. Pickup removed it. TWA left.

8. Weather still a factor (fair).

9. Weather cleared up somewhat and planes were leaving evenly, except destination was loaded at Boston. Still hazy but not foggy as before. Can see lights at end of runway 24.

October 29, Monday. Visibility - Good

1. Aircraft delay requested by pilot.

2. Small jet confirmed light.

3. VICON on runway 15 erratic. Does not always cancel with override.

TABLE B-2. (Cont.)

4. Large jets (2) confirmed light.

5. Technician arrived (1333Z) to fix VICON board that has not been working properly since yesterday.

6. Small prop reported VICON light on runway 06. Large jet confirmed light. Both pilots advised they were not sure as to whether they were weak or it was the sun's reflection. At this time (1440Z) VICON was supposed to be shut down.

7. VICON runway 01 down.

8. When volume is too high on any VICON observer's receiver, local controller will receive a feedback in his headset. Observers should check volume periodically.

9. I started to explain to new local controller that the override was erratic. He cut me off by stating that if the panel was not correct he would not use it. "When the panel is right I will use it."

10. Pilots are not offering additional information on VICON other than good, fine, or readable.

11. Runway 24 - VICON light out. Runway 33 - timer only. Runway 06 - panel not correct indication. Runway 15 - normal.

12. VICON light on runway 24 repaired (1630Z). Operation normal.

13. During this hour (1700Z-1747Z) another VICON light was fixed - back to normal.

October 30, Tuesday. Visibility - Good

1. Local controller only used VICON intermittently.

2. Pilot was cleared to take off. Pilot then called back and said:" I am waiting for the green light." Pause. "OK, I have it, rolling."

3. Local controller not using VICON

4. Pilot asked: "Is green light working?" Local controller said: "It sure is," and activated it. Pilot confirmed.

TABLE B-2. (Cont.)

5. This controller uses VICON sometimes.

6. Air carrier confirmed lights.

7. Controller to small prop: "VICON negative."

8. Controller to small prop: "Takeoff without light. Too busy to press the buttons."

9. VICON activated by Ground Controller for small prop.

October 31, Wednesday. Visibility - Good

1. Pilot: "Where are the lights located?" Controller: "Down the runway." Pilot: "Oh, yeah."

2. Pilot given clearance. Pilot: "I see you winking at me."

3. Pilot: "Do we get the green lights tonight?" Controller: "If you insist."

4. Controller in ready room remarked: "I don't use that damn thing, it's just more work."

5. Small prop reported does not have lights.

6. Small prop: Lights working on 6?: Controller: "Yes, when we get to it."

November 3, Saturday. Visibility - Fair to Good

1. Traffic very light due to weather (fair). No light aircraft activity during this period.

2. Pilots still seem reluctant in their remarks concerning VICON operation.

3. Very quiet period. Only unusual occurrence when two large US Air jets almost landed at intersecting runways, but controller diverted one from runway 33 to runway 06, after first one. Captain appeared annoyed.

4. Heavy jet advised he had non-standard green light in sight (VICON).

5. Large jet and medium prop confirmed light.

TABLE B-2. (Cont.)

November 4, Sunday. Visibility - Good

No comments pertaining to VICON

November 5, Monday. Visibility - Good

1. Large jet advised light was not on. Controller then turned it on.
2. Small jet and then large jet confirmed light.
3. Large jet requests VICON, gets light, confirms light.
4. ARTS was not programming. Therefore the misplacement of various aircraft on the sheet.
5. Very slow except at end of period (80 minutes).
6. One pilot was seeking the VICON light, asked again for location and configuration, saw it, and asked if it was supposed to be pulsating. Noted location of VICON lights along runway.

November 2, Wednesday. Visibility - Good

1. Confirmed lights - heavy jet, large jet.
2. Large prop pilot wondered if VICON was on a 30 second timer.
3. Large jet confirmed lights.
4. Small prop did not get VICON, asked controller if he was cleared for takeoff. Controller said affirmative.
5. Small jet confirmed lights.

November 8, Thursday. Visibility - Good

1. Changed runways due to maintenance.
2. Small prop had questions on VICON. Controller: "Lights mounted on runway. When I press the button, they flash. When they flash you can depart." Normal takeoff.
3. Small prop confirmed lights.
4. Small prop taxied on runway and turned around.

TABLE B-2. (Cont.)

5. Small prop didn't see green light, then said: "There it goes."

6. Small prop did U-turn on runway 01.

November 9, Friday. Visibility - Good

1. Controller made mention to departing pilots re VICON. VICON lights were acknowledged. When controller left shift, replacement did not mention VICON first. One small prop acknowledged the light.

2. "When green light observed, cleared for takeoff," controller. "Light observed," pilot large prop.

3. "Cleared when you see the light." "Light confirmed." Small prop.

4. "Perhaps you see a green light flashing at you," controller. "Oh yes, is that the experimental thing?" pilot small prop. "Spiffy, isn't it?" controller.

5. Heavy jet: "We see the green light -- is that what we're supposed to say?"

6. Small prop confirmed light.

7. Emergency landing.

8. Small prop: "Is there a correct way to acknowledge light?" Controller: "If you don't see the green light, you don't take off." Pilot comment unheard. Controller: "Gives us something to do."

9. Most pilots commented on use of VICON, then confirmed to controller.

10. One pilot asked if there was an approved procedure to respond to VICON. When told No, the pilot asked about its use. Controller said it is confirmation of a verbal OK and gave an example of two departures on intersecting runways. Pilot said: "OK, hope it works." Controller (aside) said: "Well, its not a brick wall."

TABLE B-2. (Cont.)

November 12, Monday. Visibility - Good

1. Small prop missed microwave unit. Flew above it.

2. Large jet confirmed light.

November 13, Tuesday. Visibility - Good

1. VICON inoperative when reporting for duty at 1300Z. Operational at 1400Z.

2. Heavy jet inquired about lights.

3. Large jet requested lights. Advised they were inoperative.

4. Large jet advised lights not in service. 1345Z.

5. Small jet confirmed light.

6. Small prop delayed due to aircraft on runway.

November 14, Wednesday. Visibility -

1. Controller to small jet: "Disregard VICON lights. They're unreliable."

2. Controller to small jet: "Disregard VICON lights. Taxi into position and hold."

3. Small prop confirmed lights.

4. Pilot large prop: "That VICON is a nice thing to have."

5. Military jet given clearance on UHF only.

November 15, Thursday. Visibility - Good

1. Large jet: "Negative on the VICON."

November 18, Sunday. Visibility - Good

1. Small prop advised did not have the light.

2. Confirmed light - 2 small props.

TABLE B-2. (Cont.)

November 19, Monday. Visibility - Good

1. Heavy jet confirmed lights.
2. Small prop taxied around airport to see VICON lights.
3. Confirmed lights - large prop, 2 large jets.

November 20, Tuesday. Visibility - Fair to Good

1. Confirmed lights - 2 heavy jets, large jet.
2. Clearance given on taxiway first (then again on runway).

November 21, Wednesday. Visibility - Good

1. Traffic above average due to holiday.
2. Three pilots mentioned VICON. One said it was out (it was, later fixed at 1750Z) and and 2 said saw it OK.
3. Small prop aborted takeoff.
4. VICON working 1750Z.
5. Medium prop requested lights.
6. Small jet delayed due to departing heavy jet.
7. Heavy jet confirmed lights.
8. Small prop delayed due to heavy jet wake.

November 26, Monday. Visibility - Fair to Good

1. Heavy jet confirmed lights.
2. Fog getting heavy. Two miles, rain and fog.
3. Large jet prepared to depart, delay, returned from end of taxiway.
4. Large jet confirmed lights.
5. Two mile visibility, heavy rain.
6. Rain lessened, visibility 4 miles.

TABLE B-2. (Cont.)

November 27, Tuesday. Visibility - Good

1. Small prop confirmed lights.

2. Controller asked small jet if he sees light flashing at intersection. "Can you see it?" Pilot confirmed seeing it.

3. Military jet cleared twice.

November 28, Wednesday. Visibility - Good

1. Small prop questioned whether lights were working.

November 29, Thursday. Visibility - Good

1. Small jet confirmed lights.

2. Large jet had VICON - or sun, maybe - too early. (1251Z, runway 33)

November 30, Friday. Visibility - Good

1. Medium prop held up because of extensive runup.

2. Heavy jet saw funny green light blinking.

3. Large jet delayed due to improper routing not acceptable to pilot.

4. Air carrier commented on a funny green light blinking at the side of the runway.

December 3, Monday. Visibility - Good

1. Two delays due to landing traffic.

2. Controller suggested a change in the button arrangements on the matrix panel - put all north and all south runways on the same side (reverse the 15-33 buttons).

December 4, Tuesday. Visibility - Good

1. Heavy jet confirmed lights.

2. Heavy jet, runway 24. Controller advises VICON light won't go off. 1454Z

TABLE B-2. (Cont.)

December 5, Wednesday. Visibility - Good

1. Large jet confirmed lights.
2. Large jet: "If you are still looking for comments on that green light, it works pretty good."
3. There were many helicopters taking off and landing.
4. TV channel 8 is now here filming. Very difficult to obtain any real times. 1917Z
5. Small prop taxies past Sierra (runway 24) - did 180° and then took off on 24.
6. As soon as (small) jet clears, small prop was cleared.

December 6, Thursday. Visibility - Good

1. Large prop confirmed lights.
2. Heavy jet - no takeoff, returned to taxiway to check clearances.

December 9, Sunday. Visibility - Good

1. Confirmed lights - 3 small props.
2. Small prop cleared. Cleared at intersection Charlie. Went right through 33 very fast. Controller upset. Made 180 - recleared. It was is if he was planning to take off from the taxiway.
3. Heavy jet confirmed lights.
4. Large jet cleared and th[illegible] to hold short, runway 24.
5. Heavy jet departure. "Roger - VICON is ON," controller.

December 10, Monday. Visibility - Good

1. Small jet - delay due to excessive runup.
2. Two props delayed due to wake turbulance.
3. Large jets (2) confirmed lights.
4. Traffic very light during period.

TABLE B-2. (Cont.)

December 12, Wednesday. Visibility - Good

1. Traffic in this period high in both arrivals and departures (1200Z - 1300Z).
2. Traffic low (1530Z - 1620Z).
3. Small prop delayed due to flight in training.
4. Small prop stops and waits - then off (39 seconds, clearance to start rolling).

December 13, Thursday. Visibility - Good to Fair

1. Weather good becoming fair - down to 1 mile visibility when rain changed to snow.
2. Large jet, returned to gate.

December 14, Friday. Visibility - Good

1. Large prop - no transmitter on plane.
2. Small prop - cleared second time.
3. Heavy jet - 2 clearances.
4. Military jet - 2 clearances.
5. Small prop - cleared twice.
6. Small prop - cleared twice.
7. Large jet confirmed lights.
8. If large jet was cleared only once, I missed a small plane at an intersection.
9. Small jet - 2 clearances.

December 16, Sunday. Visibility - Poor (1/4 to 1/16 mile)

1. Weather is very poor. Unable to determine entrance on runway 33 and roll on 33. Slightly better visibility on runway 06.
2. Visibility 1/4 mile. Unable to see even the threshold of runway 06.

TABLE B-2. (Cont.)

3. Visibility 1/8 mile. Unable to see aircraft not directly in front of tower.

4. Small prop - heard clearance but could not find airplane.

5. Small prop: "Got the VICON lights for takeoff."

6. Heavy jet confirmed lights.

7. Large jet - roll time is very late.

8. Heavy jet - Enter and roll times based on radio conversation.

9. Small jet - estimated roll time by sound.

10. Approach lights - engine generator failed 2321Z.

11. Large jet - estimated roll time by sound.

12. Small prop - estimated roll by sound.

13. Heavy jet - heard roar of engines as plane taxied.

14. Weather so poor all departures delayed until at least 0100Z (0015Z).

December 18, Tuesday. Visibility - Good

1. Small prop doesn't have the lights. Controller tried again - no lights. Checked lights on 33 - not working (1304Z).

2. Small prop aborted takeoff - had back door light.

3. Large jet asked for light.

4. Override button hit once or twice as demonstration.

5. VICON lights threshold runway 33 microwave unit failed. Technicians switched to timer.

TABLE B-2. (Cont.)

December 19, Wednesday. Visibility - Fair to Good

1. Large jet confirmed lights.

2. Small prop pilot: "Didn't see the light." Controller" "Didn't you see it?" Couldn't hear more.

3. Large jet takeoff. Controller reported light problem - couldn't hear comment. Pushed override.

5. Visibility changed to 4 miles.

December 20, Thursday. Visibility - Good

1. Small prop confirmed light.

2. Large prop delay due to excessive runup.

3. VICON confirmed by large jet, 2 heavy jets, small prop.

4. Large jet: "Where is your little green light tonight? Oh, there it is. Thanks."

December 21, Friday. Visibility - Good

1. Pilot reports no VICON - 3 large props.

2. Pilot large jet requested VICON. Got light.

3. Confirmed lights - 2 heavy jets, large jet.

4. Air carrier asked if lights worked - evidently controller failed to activate light. Pilot confirmed seeing light without further conversation.

December 27, Thursday. Visibility - Good

1. Confirmed lights - 2 large jets, small prop.

2. Large prop pilot: "No green light - there you go."

3. Heavy jet pilot: "Want to give us the visual confirm?"

4. Large prop confirmed lights.

TABLE B-2. (Cont.)

December 28, Friday. Visibility - Good

1. Delay due to landing aircraft.

2. Delay due to runup.

3. Large prop pilot: "Looking for the lights." Controller: "Forgot to push them."

4. Small prop confirmed lights. Asked how system was working. No reply.

5. Heavy jet pilot: "Where's that VICON light?" Told by controller, then: "VICON confirmed."

6. Heavy jet - third pilot to request which side VICON light was on.

7. Small prop delayed because of jet wash.

8. Large prop sat in runup position "forever."

9. Confirmed lights - 2 small props, large jet.

10. Only VICON comment from controller: "No light for helicopter departing runway 01. Charlie intersection."

December 29, Saturday. Visibility - Good

1. Small prop confirmed lights.

December 30, Sunday. Visibility - Good

1. Large prop: "VICON not working."

2. Large jet: "No light"

3. Small prop and large prop confirmed lights.

4. Large jet: "VICON? OK."

5. Traffic high this period (2249Z - 0045Z) despite the lack of usual light aircraft activity.

January 2, Wednesday. Visibility - Good

1. Air carrier reported green light not working. Told by controller: "It's just experimental." Pilot replied: "I just got used to it." Somewhat favorable?

TABLE B-2. (Cont.)

2. Large jet confirmed lights.

3. Small prop pilot requested delay in takeoff. Sat on runway longer than usual.

4. Small prop confirmed lights.

5. Small prop said after clearance: "We don't have a light." Controller: "OK. I'll get you one."

January 3, Thursday. Visibility - Good

1. One report from pilot - got the green light.

2. Small prop unable to get gear down - made good wheels up landing.

3. Ground controller asked Local controller: "When I push override on panel does the VICON light automatically go back to red?" Local controller answered: "Yes." (Hopper) explained that there was the green light, off or on. Implication is that lack of understanding of the system could cause a safety hazard. Suggestion - possibly have a test to see if controllers understand VICON.

January 4, Friday. Visibility - Good

1. Small prop: "We have the light."

2. Heavy jet cleared twice - wanted to reaffirm clearance. VICON was not mentioned.

3. Controller had trainee on (3 entries for different periods).

4. Controller pushed Override button by mistake.

5. Small prop touch and go. Had to hold on runway due to traffic landing on 06. Then he was cleared and took off.

6. "Rolling and VICON confirmed" - large jet.

7. Large jet: "Green light flashing over here."

8. Large jet cleared twice.

9. Confirmed lights - large prop, 2 large jets.

TABLE B-2. (Cont.)

January 5, Saturday. Visibility - Good

1. Small prop, already cleared for takeoff, taxied onto runway 06, and just sat. Called local controller and asked what flashing green light meant. Thought perhaps it was a warning signal.

2. Confirmed lights - 4 small props.

January 7, Monday. Visibility - Good

1. Large jet confirmed lights and requested to know what happened to the good old days with the light in the tower.

2. Controller advised that at sunset time with aircraft departing runway 06, the sun's reflection gave an indication the VICON lights are on.

3. Confirmed lights - large jet and small prop.

January 8, Thursday. Visibility - Good

1. The controllers were discussing VICON and stated they were going to have to take it whether they liked it or not after all the money spent on it.

2. Pilot: "What's this light doing out here?" (VICON)

3. Air carrier confirmed light.

4. Pilot commented on green light.

5. Pilot waited until given green light <u>and</u> clearance.

6. Large jet: "Are we cleared to go? (on runway)."
   Controller: "Affirm."

7. Confirmed lights - large jet and small prop.

8. Small prop cleared twice.

January 9, Wednesday. Visibility - Good

1. Runways 33 and 24 in use. Wind WSW - picked up a bit.

2. Air carrier confirmed VICON after his verbal takeoff clearance.

TABLE B-2. (Cont.)

3. Controller reported that when Lear jet took off on runway 33, passage of the aircraft did not deactivate VICON light. No further difficulty with subsequent departures.

4. Air carrier on ru·way 33 reported: "83 has the green light."

5. Air carrier reported: "Roger, your green light."

6. Small prop confirmed lights.

January 10, Thursday. Visibility - Good

1. Two small props confirmed green light.

2. Panel malfunctioned 2016Z. Fixed in 15 minutes. (No maintenance log entry.)

3. Air carrier reported VICON working.

4. Small prop cleared twice.

January 11, Friday. Visibility - Fair

1. Local controller: "Is this idiot machine working here?" Ground: "Should be."

2. No clearance heard for XWF, small prop, runway 24.

3. Air carrier confirmed VICON.

4. Air carrier taxied down runway - do not know where he entered.

January 13, Sunday. Visibility - Good

1. Small prop acknowledged VICON and asked how system was working. Controller advised it was too soon to evaluate.

2. Confirmed lights - small prop, large jet, and heavy jet.

3. Large jet - hold in position. Cleared for second time.

4. Small prop confirmed lights.

TABLE B-2. (Cont.)

January 14, Monday. Visibility - Good

1. Small air carrier taking off runway 01, when cleared for takeoff, advised he did not have the lights. Controller scrambled to give him the VICON lights for runway 01. Pilot advised he had the lights in sight, and took off.

2. Heavy jet aborted takeoff because of nearby traffic.

3. Air carrier cleared for takeoff runway 06 commented: "See your green light." Controller asked: "Do you like that?" Pilot said: "Personally, I don't."

4. Large prop: "No green light. (Got it) Thank you."

January 17, Wednesday. Visibility - Good

1. Confirmed lights - 2 small props

2. Small prop: "Oh you have the green light now."

3. Confirmed lights - 2 large jets, heavy jet, small prop.

4. Controller: "Notice that one (small prop) didn't trip the light on six? It's still blinking on the board." Controller pushed override button and restored to normal.

5. Air carrier on runway 06 delayed departure due to debris on runway.

January 18, Friday. Visibility - Good (occasional snow flurries)

1. National Guard flight of 12 planes landed one at a time.

2. Small prop, runway 33I, confirmed green light, but aborted due to engine trouble.

3. Heavy jet confirmed light.

4. Controller examining VICON panel, pushing buttons, remarking on pressure required. (Newly installed touch sensitive panel)

5. Air carrier reported after verbal clearance "We don't see any light, but rolling." Runway 33

TABLE B-2. (Cont.)

6. Large jet, runway 06, "We've got the green light and are going.

7. Every VICON light was flashed by local controller (2334Z). Air carrier taxiing off runway didn't stop once nor question why green lights were flashing. Controller mentioned this fact.

8. Air carrier confirmed light.

January 20, Sunday. Visibility - Good

1. Pilot confirmed light.

2. Pilot confirmed light.

3. Pilot asked: "What's the green light?" Controller answered: "That's the VICON."

4. Small prop confirmed light.

5. Large prop pilot: "May I have the green light?" VICON console is hit by controller. Pilot then reported that the lights were on farther down the runway. Controller turns on VICON again. Pilot then stated: "That's it, we're rolling." Pilot commented after takeoff that it looked like a Christmas tree there for a second. Controller made very unfavorable remarks off radio. Have noticed local controller is not using a headset during this period.

6. Air carrier pilot: "I guess VICON confirmed - see a green light." Controller made negative comments off radio.

7. Small prop confirmed light.

8. Air carrier confirmed light.

9. Air carrier cleared twice - did not acknowledge first clearance.

10. Small prop cleared twice.

January 21, Monday. Visibility - Good (snow flurries)

1. Controller demonstrated use of control panel.

2. Air carrier confirmed light.

TABLE B-2. (Cont.)

3. Air carrier weather report, 1400 foot overcast, tops at 3,500 feet.

4. Air carrier advised no green light. No comment from controller.

5. Small air carrier cleared for takeoff while on taxiway. Taxied onto runway, then stopped and requested green light. Controller replied: "That's not operational." (Not true, as far as observer knew.)

6. Small air carrier advised he had the light. Controller advised it meant nothing - test purposes only.

7. Air carrier asked: "What does the green light mean? Does it mean I can take off?"

January 22, Tuesday. Visibility - Good (Fair at 1800 EST)

1. Controller discussion re VICON (touch sensitive) panel - I don't think present one is as good as the first. Second panel (matrix) is too confusing.

2. Confirmed light, 2 small props, large jet.

3. Large jet pilot: "Please be advised we have a flashing green light." Controller: "You have it?" This dialog happened prior to aircraft clearance time. (Very unfavorable impact.) Plane was in Position and Hold.

4. Snow flurries. No departures 1617Z - 1657Z.

5. Emergency arrival. Jaguar fighter low on fuel. Landed fine.

6. Small prop cleared twice.

January 23, Wednesday. Visibility - Fair

1. Air carrier forced to go around. Aircraft still on runway.

2. Air carrier confirmed VICON.

3. Air carrier asked: "That flashing green light, is that the audio and visual system?" Controller explained VICON name and purpose.

TABLE B-2. (Cont.)

January 24, Thursday. Visibility - Good

1. Confirmed light - 2 air carriers.

2. Pilot confirmed light.

3. Pilot confirmed light.

4. Supervisor who normally does not work tower positions commented: "First time I ever worked VICON."

January 25, Friday. Visibility - Good

1. Confirmed light - 2 air carriers.

2. Pilot: "Light for us?" Controller: "Cleared for takeoff." (second time)

3. Small prop: "Negative lights." Controller pushes panel button. "We've got them now."

4. Large prop: "No green light. I'm rolling."

5. Large jet aborted takeoff. Recleared and took off 7 minutes later.

6. Small prop landed, did 180, taxied back on runway to exit.

January 28, Monday. Visibility Good

1. Pilot: "Negative light - pause - OK, we have it."

2. Small air carrier advised negative light.

January 29, Tuesday. Visibility - Good

1. Large jet cleared for takeoff and proceeded very slowly toward runway. VICON activated. "Roger, the green light." Plane then proceeded rapidly toward runway.

2. Large jet: "Are we cleared for takeoff?" Controller pushed VICON button and verbally confirmed clearance.

3. Large jet: "Cleared to go, right?" Controller: "Clear to go." (Watched to see if VICON was activated and did not see controller activate light.)

TABLE B-2. (Cont.)

4. Large jet cleared for takeoff twice.

5. Small prop acknowledged light, runway 33.

6. Observed controller pushing VICON button religously but no response from pilots.

7. Large prop acknowledged light.

January 30, Wednesday. Visibility - Good

1. Controller to relief: "VICON lights are blinking."

2. Air carrier confirmed lights.

3. Air carrier requested adjusting approach light level - too bright.

January 31, Thursday. Visibility - Good

1. Heavy jet confirmed VICON.

2. Helicopter landings/takeoffs very confusing re radio.

3. Large jet confirmed light.

4. Small prop, runway 33. Green light given by controller. Light did not trip off. Small jet landed approximately 1 minute later and turned off light.

5. Large jet confirmed light, runway 06.

6. Large jet confirmed light, runway 33.

7. Observations discontinued because of arrival of large number of visitors to tower.

February 1, Friday. Visibility - Good

1. Confirmed lights - small prop, large prop.

2. Large prop - got the green on the roll

3. Small prop asked when they were going to terminate the green light (test). Controller answered - March.

February 3, Sunday. Visibility - Good

1. Confirmed lights - 2 small props, 4 large jets, 1 heavy jet.

TABLE B-2. (Cont.)

2. Large jet asked "Green light? Last time it wasn't very bright."

February 6, Wednesday. Vibibility - Good

1. Three aircraft (small props) did not trip the switch on VICON (Runway 06).

2. Supervisor advised that he had noticed a number of small aircraft not tripping the microwave on 33 also.

3. Confirmed lights - small jet, 2 small props.

4. Small prop advised he did not get VICON.

5. Small twin prop took off without clearance. Pilot instructed to taxi into position and hold on Runway 06, with a large jet on final for 33. The jet landed. Local control instructed the jet to make the first right turn off and switch to ground. At this transmission, the small prop took off.

6. Confirmed lights - 4 small props, 3 large jets.

February 7, Thursday. Visibility - Good

1. Confirmed lights - large prop.

2. On 06, small prop asked controller where the VICON lights were. Controller told pilot the location and the pilot spotted them.

3. Confirmed lights - heavy jet, 2 small props.

4. Small prop: "We got a light and we're on the roll."

February 8, Friday. Visibility - Good

1. Confirmed lights - 2 large props, large jet, small jet.

2. Visitor from ATA got VICON introduction from one of the controllers.

3. Heavy jet reported a (non-VICON) light problem, delayed landing.

4. Small prop began takeoff roll before being cleared.

February 10, Sunday. Visibility - Good

1. Confirmed lights - 2 small props.

TABLE B-2. (Cont.)

2. Controller cleared 2 small props for takeoff at same time, one on 06 and one on 33. Controller immediately caught error and instructed both pilots to abort takeoff. One aircraft took off, and one aborted and stopped short of the intersection. Controller activated the incorrect VICON light for first clearance, correct light for second clearance.

3. Heavy jet takeoff clearance cancelled. Light still on. Pilot notified controller, who turned it off.

4. Confirmed lights - 2 large jets.

February 11, Monday. Visibility - Good

1. Green light confirmed - relayed by controller. Neither observer heard any communication on their radio.

2. Confirmed lights - small prop.

February 13, Wednesday. Visibility - Good

1. Controller remarked that the last air carrier large jet did not break the microwave beam.

2. Confirmed lights - large jet.

3. Air carrier large jet: "We've got the green light, whatever that means." Controller: "That's a visual confirmation of clearance." Pilot: "Terrific."

4. Confirmed lights - small prop.

February 15, Friday. Visibility - Good

1. Confirmed lights: large jet, small prop.

2. Heavy jet confirmed VICON. Controller: "It's not on." After takeoff, controller asked whether light cluster was in the sun, and whether light was steady or flashing. Pilot: "In sun, light steady." (Assumption is that sunlight made the pilot think the light was on).

3. DC-10 failed to trip microwave beam on Runway 33. Pilot of next landing aircraft told controller light was still on.

February 16, Saturday. Visibility - Poor to Fair

1. Visibility 1/4 - 1/2 mile for first 5-1/2 hours, rising to 1 mile at end of shift. Light snow.

TABLE B-2. (Cont.)

2. Do not believe controller using VICON.

3. Cannot see Runway 6 and taxiway.

4. Plows on runway.

5. Series of runway closings and reopenings as visibility fluctuates. Ceiling reported 900-1000 feet.

6. Small prop confirmed lights.

7. Large jet requested: "Turn runway lights up."

8. Large arriving jet: "Circle back? Have a little problem." Landed 5 minutes later.

February 18, Monday. Visibility - Good.

1. Confirmed lights - large prop, large jet, 3 heavy jets, small prop.

February 19, Tuesday. Visibility - Good

1. Confirmed lights - large jet.

2. Heavy jet: "Whered are the lights?" Controller gives clearance. Pilot: "Oh, I see them now." Controller: "You don't get the lights til I clear you." Pilot: "There are no red lights, just the flashing green?" Controller: "Affirmative." Pilot said that <u>lights</u> confirmed takeoff.

3. Large jet: "Have the green light - still doing that?" Controller: "Yep, for a while anyway."

4. Traffic being held - Chester/Boston lost all radio frequencies. All frequencies back 17 minutes later.

5. Large jet taxied down Runway 15, did 180 into position.

6. Pilot of small prop did not know what intersection he was at.

7. Controller thought he was clearing small prop 28C on Runway 24 at intersection Sierra, but was, in fact, clearing herboprop 201CH on Runway 24 at the end. In this case, controller <u>could</u> have pressed wrong VICON, in my opinion. 28C was not aware of the confusion.

TABLE B-2. (Cont.)

February 20, Wednesday. Visibility - Good
1. Large jet confirmed VICON - very late. Was 1000 feet in the air when he transmitted.
2. Confirmed lights - small prop, heavy jet.
February 22, Friday. Visibility - Fair
1. Visibility about 1-1/2 ± 1/2 mile during period. Snow.
2. Weather below VFR minimum.
3. Large prop air carrier cleared twice.
4. Two large jets landed, did 180, taxied back up Runway 06, about 24 minutes apart.
5. Small prop delayed due to vehicles on runway.
6. Aircraft using more of runway because of (poor) braking action.
7. Small prop landed, did 180, taxied back up Runway 06.
8. Confirmed lights - small jet.
9. Large prop aborted takeoff, Runway 33, no reason given.
February 25, Monday. Visibility - Good
1. Small prop did not trip the microwave beam, Runway 06.
2. Large prop cleared twice.
3. Confirmed lights - large jet.
4. Heavy jet cleared twice.
5. Large jet cleared for takeoff while taxiing. Controller cancelled clearance and instructed taxi into position and hold. Pilot asked: "Can't you cancel the green light?" Controller turned it off.
6. Small prop requested VICON. Got it.
7. Confirmed lights - small prop.
8. Large prop confirmed lights; controller cancelled takeoff, ATC delay. Got second clearance 5 minutes later, again confirmed lights.

TABLE B-2. (Cont.)

9. Small prop did not trip microwave beam, Runway 06.

February 26, Tuesday. Visibility - Good

1. Confirmed light - 2 large jets, 2 small props.

February 28, Thursday. Visibility - Good

1. Due to wake turbulence, small prop entered Runway 33, taxied down runway, and took off on 01.

2. Large jet - Runway 33, light flashing prior to verbal clearance (reported by observer). Confirmed lights.

3. Large prop - Controller asked: "Pick up the VICON light OK?" Couldn't hear pilot's comment. Controller asked: "Got VICON?" Pilot: "Affirmative."

4. Confirmed lights - small prop, large jet, heavy jet.

5. Small prop cleared twice. Aircraft taxied onto Runway 33 and sat there. Was issued second clearance before he began his roll.

6. Small prop, Runway 33. Controller told taxi into position and hold - will be a 2-minute wait for wake turbulence. Pilot: "You may waive that if you wish." Controller: "I cannot do that."

7. Second clearance issued to a small prop as pilot could not read the first one.

8. As small prop entered Runway 33, not yet cleared for takeoff, pilot reported flashing VICON light. Controller said" "Please disregard." Next part of controller's comments garbled, but ended on radio with: "End of month we will get rid of this piece of junk." Observer's note: "When controller was making changeover he reported pilots comments and then mentioned he had shut it off. Told new controller to do what he wanted in reference to VICON." Our supervisor's note: "This occurrence caused a big flap between super and controller. The controller invoked some article in their work contract and said he would have to be ordered to use it on each separate takeoff. The super said I am ordering you to use it on all takeoffs - never mind each takeoff."

9. Small prop entered Runway 33, but due to wake turbulence taxied down 33 and took off on 01.

10. Confirmed lights - large prop, large jet.

11. At 23207, observers in tower could see the lights flashing for air carrier jet. Could also see shut-off working. At 23487, continue to see lights.

12. Small air carrier prop asked controller a question about VICON. Controller replied that there are lots of opinions about it; not too favorable on the professional side.

February 29, Friday. Visibility - Good

1. Confirmed lights - small prop.

2. Large jet: "We have no green light. OK - have it."

3. Small prop: "No lights. OK now."

March 3, Monday. Visibility - Good

1. Confirmed lights - large prop, heavy jet, small prop.

2. Small prop received several clearances - pilot on wrong frequency.

3. Small jet cleared twice.

4. Arriving large jet asked: "Isn't that green light supposed to turn itself off? Controller: "Yes - last departure (small prop) failed to trigger it."

5. Large prop confirmed lights.

6. Small prop: "Don't see any green lights."

March 4, Tuesday. Visibility - Good

1. Small prop first cleared Runway 24. Confused as to which runway. Headed for 33, then did 270 turn and headed for 24.

2. Confirmed lights - small jet, 2 small prop; heavy [illegible]

3. Large jet: "Did you do away with the green [illegible] Oh, just saw it."

4. Emergency, smoke in cockpit of small jet. [illegible]

AD-A097 756 FEDERAL AVIATION ADMINISTRATION TECHNICAL CENTER ATL--ETC F/G 17/7
VISUAL CONFIRMATION OF VOICE TAKEOFF CLEARANCE (VICON) OPERATIO--ETC(U)
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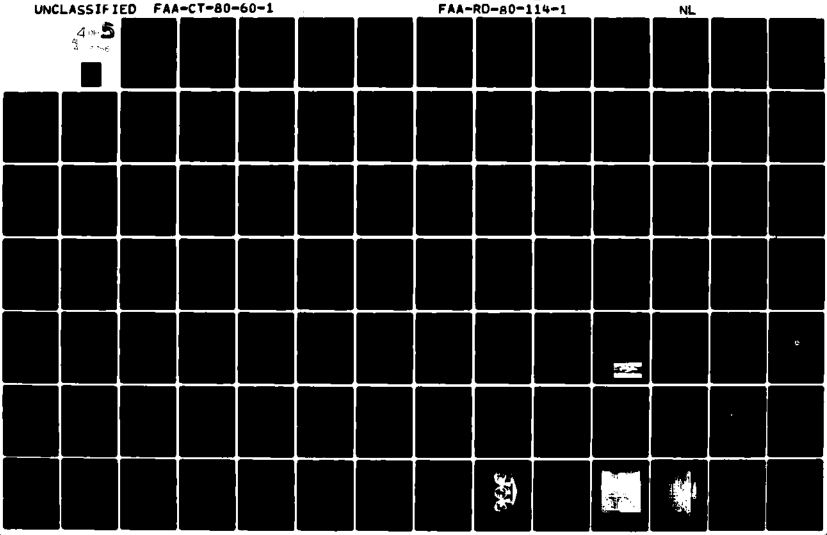

TABLE B-2. (Cont.)

5. Large jet: Is that visual thing working today? Oh - very good. You could dim that light - it would be much better." Controller: "I'll pass it on." (7 p.m.)

March 6, Thursday. Visibility - Good

1. Large jet cleared twice.

2. Confirmed light - large prop.

March 7, Friday. Visibility - Good

1. Confirmed lights - large jet, small prop.

March 8, Saturday. Visibility - Mostly Poor

1. (Visibility 1/2 mile at start of period, rose to 1 mile after 2 hours, then deteriorated to 1/4 mile. Light rain and fog).

2. Confirmed lights - small prop.

3. Large jet cleared twice.

4. Takeoff end of active Runway 06 not visible. (Times recorded by sound of engines).

5. One controller remarked: "I won't use this _______ thing unless they physically make me."

6. (Only 36 takeoffs during this 5-3/4 hour period).

March 9, Sunday. Visibility - Good

1. Confirmed lights - large jet, 2 small props.

2. Departing large jet: "How is the light system working?" "It's on - just wondering - perhaps it should be on the taxiway."

3. Controller repeatedly pushed VICON button. No pilot confirmation.

4. (End of shift). Traffic low - due to low activity was able to observe controller using VICON panel with no acknowledgement from pilots.

March 10, Monday. Visibility - Good

1. Confirmed lights - large prop, large jet.

TABLE B-2. (Cont.)

2. Film crew in tower, 2211Z.

3. Film crew on field to photograph VICON lights. Frequent statements by controller to incoming flights that they should ignore the green lights.

March 12, Wednesday. Visibility - Good

1. Confirmed lights - 2 small props.

2. Large jet: "We're cleared to go, right?"

March 13, Thursday. Visibility - Good

1. Confirmed lights - large jet, small prop, heavy jet.

2. Large prop air carrier: "Thanks for the green light."

March 14, Friday. Visibility - Fair

1. (Visibility 1/2 - 1-1/2 miles; ceiling 400-1000 feet; rain, snow, and fog).

2. Large jet cleared twice.

3. Large jet took off on Departure Control channel.

4. Small prop taxied down Runway 24, preparing to take off on Runway 06. VICON lights, already activated for 06, were turned off by his passage in opposite direction. We did this on purpose to see if it would deactivate. Visibility - 1-1/4 miles.

5. At 1846Z, air carrier small prop on Runway 33 said: "We don't have the green light. Is it buried in the snow?" Controller replied: "I guess so." Attempted to verify this visually, but could not tell which installation was VICON.

6. At 1851Z, large jet on Runway 33, controller asked whether pilot could see the VICON light. Pilot reported no light, cluster knocked over, perhaps by snow plow. (This opinion was later verified as correct).

March 16, Sunday. Visibility - Good

1. VICON not being used. (Damage by snow plow repaired and system returned to service 1725 EST on 17 March).

2. Small prop aborted takeoff. Door open.

TABLE B-2. (Cont.)

3. Small prop cleared twice.

4. Small prop held in position due to heavy jet wake turbulence.

5. VICON system not in operation. Controller requested explanation; was told snow piles beside runways obscure the light, and one cluster was knocked down by a snowplow during earlier (Friday) storm.

March 18, Tuesday. Visibility - Fair to Good

1. Four lined up waiting for weather improvement. (400 scattered, 1100 scattered, measured 4500 overcast, 3 miles in light rain).

2. Small prop: "We don't have the VICON. OK, we have it now."

March 19, Wednesday. Visibility - Good

1. Large jet, Runway 15, asked: "Is that green light working?" Controller replied: "I intended to turn them on when you were cleared for takeoff." Pilot then reported: "I have the green light." Takeoff aborted - no reason given. Second takeoff 7 minutes later was normal.

2. Confirmed lights - small prop, heavy jet.

3. Air carrier large prop returned to gate with problem. (Took off 20 minutes later - normal).

March 22, Saturday. Visibility - Good

1. Military small jets cleared on UHF - 3 entries.

2. Large jet: "Is VICON still working?" Controller: "Yes." Pilot: "Where is it?" Controller: "On the runway." Pilot: "OK, I see it - VICON confirmed."

3. Traffic very light.

March 24, Monday. Visibility - Good

1. Heavy jet, Runway 06, asked if cleared for takeoff prior to entering the runway. Second clearance issued by controller.

2. Confirmed light - small prop, large prop.

TABLE B-2. (Cont.)

3. Heavy jet cleared for immediate takeoff, but pilot decided to hold short.

4. Controller asked large jet: "Did you get the green light at takeoff clearance?" Pilot: "Did not notice it."

5. Small prop, Runway 06. "Negative on VICON."

6. Large air carrier jet cleared three times before leaving.

7. FAA personnel taking pictures of VICON panel and local controller pressing various buttons on (mimic) panel.

March 26, Wednesday. Visibility - Good

1. Confirmed lights - large prop.

2. Delay on Runway 33 for several minutes because air carrier small prop's IFR clearance was delayed by departure control. Pilot finally decided to cancel IFR flight plan and go VFR. Takeoff normal. (Weather: 3500 scattered, measured 6000 broken; 20 miles).

3. Air carrier small prop taxied onto Runway 06, stopped, and reported: "Cleared for takeoff, but we don't have the lights." Controller repeated clearance and pushed VICON button.

4. At 14157, controller reported possible malfunction of lights on Runway 06, at least at intersections Alfa and Sierra.

5. Large jet indicated 30 second takeoff delay.

6. Air carrier large prop confirmed lights.

7. Pilot of air carrier large jet, who had been told while he was near SE intersection to taxi into position and hold on Runway 33, entered the runway and asked the controller whether he had been cleared for takeoff. Controller said No and reminded him that he should be in position and hold. This seems to be a clear instance where VICON might be valuable.

March 27, Thursday. Visibility - Good

1. Confirmed lights - 3 small props.

TABLE B-2. (Cont.)

2. Large jet: "What happened to the lights? (Pause) I see them."

March 28, Friday. Visibility - Good

1. Large jet taxied down Runway 15, did 180o turn.

APPENDIX C

PILOT INTERVIEW DATA

Three pilot interview sessions were held. The first was held 28-29 November, after approximately five weeks of system use; the second was held 20-21 February, after about 14 weeks use; and the third was held 17-18 April, shortly after the end of the 5-1/2 month test period. Table C-1 reports the results of the first session. Only two pilots were interviewed at the second session, so details were included in the text and are not given here. Similarly, only three pilots were interviewed at the third session, and those details were included in the text only.

TABLE C-1. FIRST SESSION RESULTS

<u>Item 1 - Greatest Values of Benefits</u>

VICON may cut down on repeat transmissions, especially by GA pilots who have poorer radios and use non-standard terminology.

Useful as a confirmation of verbal clearance, but have had no problems with verbal clearance alone.

Lights would be an asset to foreign pilots.

Useful for standardization - if installed and used nationwide.

Should improve safety.

Little enthusiasm or positive comment.

Not really needed - pilots don't see much benefit.

Useful - value Ineffective to Good; company says Marginal.

<u>Item 2 - Greatest Problems or Shortcomings</u>

System is not needed.

Lights have little effect or value - pilot will request repeat if clearance is missed or garbled.

Unnecessary crutch which may cause trouble for controllers, and may come to replace verbal clearance at times.

Concerned that VICON could become primary control.

Too costly for value.

Distraction/workload - one more thing to do at a very busy time.

Increase in pilot and controller workload.

Some distraction and added workload at a busy time.

Lights hard to locate - blend into other lights.

Lights too close to VASI.

Lights too far down runway - especially for Category III takeoff, and are hard to use.

TABLE C-1. (Cont.)

Lights should be real attention grabbers.

Lights are a distraction on a rolling takeoff.

Most commonly make a rolling takeoff - in these takeoffs the pilot never sees the light.

Pilots are looking at centerline on takeoff - not at the side. This is distracting.

Concerned about snow cover and removal.

Not consistently used.

Item 3 - Personally Experienced Unusual Occurrences

System is used intermittently.

One estimate that the light stayed on for 2 minutes.

Item 4 - Personal Cost, Difficulty, or Annoyance

Minor Cost - 9; Neutral - 1.

Item 5 - Value to the National Airspace System

Somewhat Negative - 3; Neutral - 4; Somewhat Positive - 2; No Answer - 1.

Item 6 - Should VICON Be Installed Nationwide

No - 3; All airports (if also used by ICAO for standardization) - 1; Air Carrier Airports only - 2; Other - 3 (individually selected airports based on traffic level, runway layout, and use by foreign carriers; No Answer - 1.

Common Statement: If money is available, use it for the following instead of VICON:

Runway intrusion control/detection system.

Better overall ground control.

More/better approach systems - ILS and microwave ILS, VASI, R-NAV, nonprecision approaches.

More and longer runways.

APPENDIX D

MAGNETIC TAPE DATA

This appendix provides the detailed data as obtained from the 132 hours selected for reduction. The selection was made as follows:

- 4 hours - high VICON use, to develop data reduction and analysis procedures, and to obtain high-use data.

- 18 hours - bad weather, but using the highest traffic hour during each period of reduced visibility.

- 54 hours - high traffic levels (40 or more operations per hour) to observe VICON system performance at very high operations levels.

- 56 hours - random sample, to study VICON under varying airport conditions.

Table D-1 provides a log of the time periods reduced. Table D-2 provides the statistical details which are summarized in Section 11.

Table D-3 documents the various unusual occurrences examined in detail. All aircraft identifications have been changed to preserve anonymity. However, the new identifications retain the structure of the true call signs.

TABLE D-1. LOG OF TIME PERIODS REDUCED

OBSERVATION NUMBER	DATE	HOUR	WEATHER	NUMBER OF TAKE-OFFS	RUNWAY CONFIGURATION
1	1-22	9-10 P	Poor	9	6-33
2	1-13	4-5 P	Good	26	6-33
3	11-9	3-4 P	Good	11	15-24
4	10-29	7-8 A	Fair	18	6-33
5	2-22	5-6 P	Poor	12	6-33
6	2-10	3-4 P	Good	12	6-33
7	2-22	8-9 A	Poor	11	6-33
8	1-11	5-6 P	Fair	11	24
9	1-23	9-10 A	Fair	16	6
10	11-20	11-12 N	Fair	15	6
11	12-19	12-1 P	Fair	19	33
12	2-28	7-8 A	Poor	8	6-33
13	2-23	8-9 A	Poor	13	6-33
14	11-26	4-5 P	Fair	18	33
15	12-26	7-8 A	Fair	15	33
16	12-24	4-5 P	Poor	8	15-24
17	12-24	5-6 P	Poor	5	15-24
18	12-16	3-4 P	Poor	13	33
19	12-16	11-12 N	Fair	6	33
20	12-6	9-10 P	Fair	10	15-33
21	1-11	7-8 P	Fair	8	24
22	1-23	8-9 A	Fair	15	6-33
23	1-22	7-8 A	Fair	7	6-33
24	11-4	4-5 P	Good	8	6-33
25	11-16	7-8 A	Good	16	24-33
26	11-17	1-2 P	Good	16	33
27	11-17	4-5 P	Good	19	33
28	11-18	4-5 P	Good	16	33
29	11-19	4-5 P	Good	17	24
30	11-21	4-5 P	Good	4	24-33
31	11-21	3-4 P	Good	4	33

TABLE D-1. (Cont.)

OBSERVATION NUMBER	DATE	HOUR	WEATHER	NUMBER OF TAKE-OFFS	RUNWAY CONFIGURATION
32	11-25	12-1 P	Good	13	24
33	11-30	4-5 P	Good	9	33
34	12-4	11-12 N	Good	13	15
35	12-6	12-1 P	Good	17	33
36	12-7	12-1 P	Good	11	33
37	12-9	11-12 N	Good	11	6-33
38	12-15	11-12 N	Good	7	6-33
39	12-17	8-9 A	Good	16	33-24
40	12-20	8-9 A	Good	17	6-33
41	12-21	2-3 P	Good	7	6-33
42	12-26	1-2 P	Good	21	33
43	12-29	3-4 P	Good	17	33
44	12-31	4-5 P	Good	14	6-33
45	1-3	9-10 A	Good	15	6-33
46	1-4	9-10 A	Good	10	6-33
47	1-8	8-9 A	Good	17	33
48	1-9	4-5 P	Good	15	6-33
49	1-15	2-3 P	Good	9	6-24
50	1-25	2-3 P	Good	9	33
51	1-28	9-10 P	Good	20	33
52	1-31	4-5 P	Good	14	6-33
53	2-1	3-4 P	Good	9	33
54	2-7	4-5 P	Good	18	6-33
55	2-9	12-1 P	Good	11	6-33
56	2-10	10-11 A	Good	22	01-33
57	2-18	4-5 P	Good	19	33-24
58	2-20	4-5 P	Good	16	6-33
59	2-21	2-3 P	Good	8	6-33
60	2-23	3-4 P	Good	13	6-33
61	1-23	2-3 P	Fair	7	6-33

TABLE D-1. (Cont.)

OBSERVATION NUMBER	DATE	HOUR	WEATHER	NUMBER OF TAKE-OFFS	RUNWAY CONFIGURATION
62	10-28	3-4 P	Poor	14	6-33
63	3-25	7-8 A	Fair	14	6-33
64	3-21	8-9 A	Fair	10	6-33
65	3-18	8-9 A	Fair	8	24-33
66	3-17	8-9 P	Fair	2	24
67	3-15	10-11 A	Fair	6	33
68	3-14	9-10 A	Fair	8	6
69	3-13	4-5 P	Fair	12	15
70	3-8	5-6 P	Poor	4	6
71	3-8	4-5 P	Fair	9	6
72	3-8	12-1 P	Poor	6	6
73	3-5	9-10 A	Fair	8	24-33
74	3-5	8-9 A	Fair	15	24-33
75	11-5	5-6 P	Good	11	24
76	11-12	12-1 P	Good	4	6
77	11-13	10-11 A	Good	9	6-33
78	11-29	8-9 A	Good	14	15
79	12-3	8-9 A	Good	13	15
80	3-26	8-9 A	Good	15	6-33
81	1-24	5-6 P	Good	13	33
82	1-18	4-6 P	Good	12	6-33
83	1-17	4-6 P	Good	17	6-33
84	1-7	8-9 A	Good	10	6-24-33
85	1-1	8-9 A	Good	15	6-33
86	2-1	3-4 P	Good	15	33
87	2-28	3-4 P	Good	11	33
88	10-16	3-4 P	Good	16	6-33
89	3-30	5-6 P	Good	9	6-33
90	3-25	4-5 P	Good	15	6-33
91	3-20	8-9 A	Good	16	33

TABLE D-1. (Cont.)

OBSERVATION NUMBER	DATE	HOUR	WEATHER	NUMBER OF TAKE-OFFS	RUNWAY CONFIGURATION
92	3-15	2-3 P	Good	7	33
93	3-5	12-1 P	Good	11	15-24-33
.94	2-29	11-12 N	Good	8	33
.95	2-24	10-11 A	Good	6	6-33
96	2-19	9-10 A	Good	10	15-24
.97	2-9	5-6 P	Good	6	6-33
.98	2-4	4-5 P	Good	10	6-33
.99	1-28	3-4 P	Good	8	6
100	1-13	12-1 P	Good	9	6
101	1-8	11-12 N	Good	9	24-33
102	1-3	10-11A	Good	12	6-33
103	11-26	1-2 P	Good	14	33
104	11-21	12-1 P	Good	6	33
105	11-16	11-12 N	Good	10	24-33
106	11-11	10-11 A	Good	3	33
107	11-6	9-10 A	Good	15	6-33
108	12-2	2-3 P	Good	16	33
109	12-12	4-5 P	Good	11	6
110	12-17	12-1 P	Good	13	33
111	12-27	9-10 A	Good	14	6-33
112	12-13	7-8 A	Good	13	6-33
113	10-17	9-10 A	Good	8	6-33
114	10-24	3-4 P	Good	12	33
115	10-19	9-10 A	Good	8	6
116	10-18	7-8 P	Good	9	6-33
117	3-2	4-5 P	Good	16	6
118	3-3	5-6 P	Good	19	6-33
119	3-4	3-4 P	Good	9	33

TABLE D-1. (Cont.)

OBSERVATION NUMBER	DATE	HOUR	WEATHER	NUMBER OF TAKE-OFFS	RUNWAY CONFIGURATION
120	3-6	3-4 P	Good	17	33
121	3-9	3-4 P	Good	16	33
122	3-12	2-3 P	Good	11	33
123	3-13	10-11 A	Good	28	33
124	3-16	4-5 P	Good	17	6-33
125	3-16	4-5 P	Good	28	33
126	3-19	8-9 A	Good	16	6-33
127	3-20	3-4 P	Good	11	15
128	3-24	2-3 P	Good	17	6-33
129	3-26	12-1 P	Good	23	33
130	3-28	12-1 P	Good	18	15-24
131	3-29	12-1 P	Good	12	15-24
132	3-31	8-9 A	Good	31	6-33

TABLE D-2. STATISTICAL SUMMARY

OBSERVATION NUMBER (1)	NUMBER OF VICON ACTIVATIONS (2)	NUMBER OF ERRONEOUS LIGHT SELECTIONS (3)	NUMBER OF MULTIPLE VICON CLEARANCES (4)	NUMBER OF MULTIPLE VERBAL CLEARANCES (5)	OVERALL MESSAGE DURATION (SEC) (6)	VICON MESSAGE DURATION (SEC) (7)	NUMBER OF PILOT VICON RESPONSES (8)
1	9	0	1	1	330	0	1
2	21	0	1	2	1,260	12	2
3	8	2	8	0	374	27	8
4	16	0	1	2	404	8	2
5	0	0	0	0	598	0	0
6	11	0	2	2	308	1/2	1
7	10	0	0	1	390	2	2
8	7	0	0	0	858	0	0
9	14	0	0	0	349	2	2
10	9	0	1	0	624	3-1/2	1
11	3	0	0	0	786	0	0
12	6	1	0	0	368	0	0
13	12	0	0	0	696	4	3
14	12	0	0	0	759	1	1
15	15	0	0	0	330	1-1/2	1
16	7	0	0	0	293	0	0
17	3	0	0	0	226	0	0
18	11	0	0	0	364	0	0
19	0	0	0	1	290	0	0
20	0	0	0	0	244	0	0

TABLE D-2. (Cont.)

OBSERVATION NUMBER (1)	NUMBER OF VICON ACTIVATIONS (2)	NUMBER OF ERRONEOUS LIGHT SELECTIONS (3)	NUMBER OF MULTIPLE VICON CLEARANCES (4)	NUMBER OF MULTIPLE VERBAL CLEARANCES (5)	OVERALL MESSAGE DURATION (SEC) (6)	VICON MESSAGE DURATION (SEC) (7)	NUMBER OF PILOT VICON RESPONSES (8)
21	3	0	0	0	229	1	1
22	15	0	0	0	360	1	1
23	0	0	0	0	306	0	0
24	1	0	0	0	301	0	0
25	14	0	0	0	411	0	3
26	5	0	0	1	359	0	0
27	15	0	0	0	744	0	0
28	16	0	0	0	739	0	1
29	4	0	0	0	381	0	0
30	4	0	0	0	105	0	0
31	3	0	0	0	140	0	0
32	9	0	0	0	394	1	1
33	9	0	1	0	420	0	0
34	8	0	0	0	578	1	1
35	15	0	0	1	797	17	1
36	2	0	0	0	230	1	1
37	5	0	0	0	456	2	1
38	0	0	0	0	370	0	0
39	12	0	0	0	33	1	1
40	17	0	0	0	547	0	0

TABLE D-2. (Cont.)

OBSERVATION NUMBER (1)	NUMBER OF VICON ACTIVATIONS (2)	NUMBER OF ERRONEOUS LIGHT SELECTIONS (3)	NUMBER OF MULTIPLE VICON CLEARANCES (4)	NUMBER OF MULTIPLE VERBAL CLEARANCES (5)	OVERALL MESSAGE DURATION (SEC) (6)	VICON MESSAGE DURATION (SEC) (7)	NUMBER OF PILOT VICON RESPONSES (8)
41	7	0	0	0	584	3	2
42	16	0	0	0	516	1	1
43	15	0	0	0	677	0	0
44	11	0	0	0	728	0	1
45	15	0	0	0	320	0	0
46	10	0	0	0	330	0	0
47	14	0	0	1	416	0	0
48	12	0	0	0	404	0	0
49	1	0	0	0	486	0	0
50	8	0	1	0	456	0	0
51	8	0	0	0	655	2	2
52	11	0	0	0	666	0	0
53	3	0	0	0	626	0	0
54	16	0	0	0	557	0	0
55	5	0	0	0	554	0	0
56	7	0	1	1	653	1	1
57	12	0	0	0	542	0	0
58	13	0	0	0	1,246	0	0
59	1	0	0	0	550	0	0
60	9	0	0	0	526	0	0

TABLE D-2. (Cont.)

OBSERVATION NUMBER (1)	NUMBER OF VICON ACTIVATIONS (2)	NUMBER OF ERRONEOUS LIGHT SELECTIONS (3)	NUMBER OF MULTIPLE VICON CLEARANCES (4)	NUMBER OF MULTIPLE VERBAL CLEARANCES (5)	OVERALL MESSAGE DURATION (SEC) (6)	VICON MESSAGE DURATION (SEC) (7)	NUMBER OF PILOT VICON RESPONSES (8)
61	3	0	0	0	358	0	0
62	8	0	0	0	244	10	1
63	10	0	0	1	332	2	1
64	9	0	0	0	315	0	0
65	0	0	0	0	422	0	0
66	1	0	0	0	170	0	0
67	0	0	0	0	210	0	0
68	8	0	0	1	508	0	0
69	11	1	0	0	414	0	0
70	4	0	0	0	213	0	0
71	6	0	0	0	339	0	0
72	4	0	0	0	235	0	0
73	7	0	0	0	358	0	0
74	12	0	0	0	282	2	1
75	10	0	0	1	294	0	0
76	3	0	0	0	105	0	0
77	8	0	0	1	206	0	0
78	0	0	0	0	283	0	0
79	13	0	0	0	334	8	1
80	10	0	0	0	467	0	0

TABLE D-2. (Cont.)

OBSERVATION NUMBER (1)	NUMBER OF VICON ACTIVATIONS (2)	NUMBER OF ERRONEOUS LIGHT SELECTIONS (3)	NUMBER OF MULTIPLE VICON CLEARANCES (4)	NUMBER OF MULTIPLE VERBAL CLEARANCES (5)	OVERALL MESSAGE DURATION (SEC) (6)	VICON MESSAGE DURATION (SEC) (7)	NUMBER OF PILOT VICON RESPONSES (8)
81	10	0	0	0	549	2	1
82	0	0	0	0	572	0	0
83	15	0	0	0	548	1	1
84	8	0	0	0	202	1	1
85	0	0	0	0	316	2	1
86	14	0	0	0	498	3	2
87	8	0	0	0	300	3	1
88	12	0	0	1	625	0	0
89	0	0	0	0	367	3	1
90	8	0	0	0	840	0	0
91	11	0	0	1	440	0	0
92	4	0	0	0	788	5	1
93	3	0	0	0	480	0	0
94	5	0	0	1	749	1	1
95	5	0	0	0	178	0	0
96	9	0	0	0	384	0	0
97	0	0	0	0	492	0	0
98	8	0	0	0	488	0	0
99	0	0	0	0	324	0	0
100	0	0	0	0	833	0	0

TABLE D-2. (Cont.)

OBSERVATION NUMBER (1)	NUMBER OF VICON ACTIVATIONS (2)	NUMBER OF ERRONEOUS LIGHT SELECTIONS (3)	NUMBER OF MULTIPLE VICON CLEARANCES (4)	NUMBER OF MULTIPLE VERBAL CLEARANCES (5)	OVERALL MESSAGE DURATION (SEC) (6)	VICON MESSAGE DURATION (SEC) (7)	NUMBER OF PILOT VICON RESPONSES (8)
101	8	0	0	0	598	0	0
102	10	0	0	0	323	0	0
103	13	0	0	0	458	1	1
104	4	0	0	0	185	0	0
105	10	8	0	0	613	0	0
106	1	0	0	0	56	0	0
107	9	0	0	0	482	1	1
108	0	0	0	0	603	0	0
109	11	0	0	0	516	0	0
110	10	0	0	0	523	0	0
111	13	0	0	0	501	1	1
112	6	0	0	0	402	10	1
113	8	0	0	0	640	0	0
114	9	0	1	1	530	11	2
115	8	0	0	0	112	2	2
116	7	0	0	1	384	2	1
117	11	0	0	0	512	0	0
118	10	0	0	0	719	0	0
119	7	0	0	0	513	0	0
120	6	0	0	0	675	0	0
121	0	0	0	0	672	0	0

TABLE D-2. (Cont.)

OBSERVATION NUMBER (1)	NUMBER OF VICON ACTIVATIONS (2)	NUMBER OF ERRONEOUS LIGHT SELECTIONS (3)	NUMBER OF MULTIPLE VICON CLEARANCES (4)	NUMBER OF MULTIPLE VERBAL CLEARANCES (5)	OVERALL MESSAGE DURATION (SEC) (6)	VICON MESSAGE DURATION (SEC) (7)	NUMBER OF PILOT VICON RESPONSES (8)
122	0	0	0	0	512	0	0
123	10	0	0	0	470	0	0
124	6	0	0	0	1088	0	0
125	0	0	0	0	1600	3	1
126	0	0	0	0	550	0	0
127	7	0	0	0	770	0	0
128	8	0	0	0	1244	10	1
129	11	0	0	0	1378	0	0
130	14	0	0	0	650	0	0
131	9	1	1	0	540	0	0
132	17	0	0	0	838	1	1

TABLE D-3
LOG OF UNUSUAL OCCURRENCES

EVENT NO.:	1	ARRIVAL RWY:	24/33
DATE:	1-22-80	DEPARTURE RWY:	24
Z-TIME:	1412	WEATHER:	Good

OBSERVERS ACCOUNT: VICON inadvertently on

TIME	CHRONOLOGY OF EVENTS EVENT
14:12:20	Air carrier ABC instructed to position/hold on 33
14:13:15	34AK instructed to continue approach to 33
14:13:21	Air Carrier ABC requested confirmation of position/hold instruction, controlled confirmed
14:13:29	Pilot said he got the VICON lights
14:13:34	Controller surprised, said he did not activate the VICON
14:14:12	Air Carrier ABC is cleared to take off on 33

A small prop had departed on Runway 33 with VICON about 27 minutes earlier, and apparently did not break the beam.

TABLE D-3 (Cont.)

EVENT NO.:	2	ARRIVAL RWY:	6/33
DATE:	2-10-80	DEPARTURE RWY:	6/33
Z-TIME:	2015	WEATHER:	Good

OBSERVERS ACCOUNT: Near Collision of Aircraft on Takeoff

	CHRONOLOGY OF EVENTS
TIME	EVENT
20:15:39	4 XY is instructed to position/hold on Runway 33
20:15:40	Pilot for 4 XY acknowledges instruction
20:15:58	42 X pilot says he is ready for takeoff on 6
20:16:02	Controller instructs 42 X to hold short
20:16:03	42 X acknowledges
20:16:16	Controller clears 42 X for takeoff on Runway 33, activating Runway 33 (intersection Echo taxiway) VICON (incorrect runway)
20:16:29	4 XY says he's on Runway 33
20:16:43	4 XY is cleared for takeoff on 33, VICON issued for 33
20:16:44	4 XY acknowledges verbal takeoff clearance
20:16:55	Controller instructs 42 X to abort its takeoff
20:17:00	42 X acknowledges abort instruction
20:17:05	Controller instructs 4 XY to abort its takeoff
20:17:10	4 XY acknowledges and expresses frustration
20:17:15	Controller explains that other aircraft 'took off on him'

TABLE D-3 (Cont.)

EVENT NO.: 2

The incident cited above is the most serious occurrence encountered in the tapes analysis. It could have easily developed into a collision, had one of the two departing aircraft not aborted its takeoff upon instruction by the controller. If VICON were mandatory, 42 X would not have started its takeoff roll. He did not receive visual confirmation. The other aircraft (4 XY) initially did not receive verbal clearance, but got VICON clearance not meant for him (wrong location, but visible to him). 4 XY was subsequently cleared by both voice and VICON. It appears that the controller was somewhat confused with the similarity of the aircraft call names.

TABLE D-3 (Cont.)

EVENT NO.: 3
DATE: 1-8-80
Z-TIME: 1248

ARRIVAL RWY: 33
DEPARTURE RWY: 33
WEATHER: Good

OBSERVERS ACCOUNT: Pilot uncertain on takeoff clearance

TIME	CHRONOLOGY OF EVENTS EVENT
12:48:35	Air Carrier AB is cleared for takeoff on Runway 33
12:48:37	VICON is activated for Runway 33
12:49:14	Air Carrier XYZ is cleared to land on Runway 33
12:49:26	Air Carrier AB pilot asked if they were cleared to go, controller responded affirmatively

TABLE D-3 (Cont.)

EVENT NO.:	4	ARRIVAL RWY:	24
DATE:	1-8-80	DEPARTURE RWY:	33
Z-TIME:	1442	WEATHER:	Good

OBSERVERS ACCOUNT: Pilot requested VICON clearance

TIME	CHRONOLOGY OF EVENTS EVENT
14:42:00	Air Carrier ABC is cleared for takeoff on 24
14:42:08	Pilot asked for VICON confirmation
14:42:13	Pilot received VICON clearance

TABLE D-3 (Cont.)

EVENT NO.:	5	ARRIVAL RWY:	6
DATE:	1-4-80	DEPARTURE RWY:	6/33
Z-TIME:	2120	WEATHER:	Good

OBSERVERS ACCOUNT: Pilot uncertain of takeoff instruction

TIME	CHRONOLOGY OF EVENTS EVENT
21:22:24	Air Carrier ABC Heavy is cleared for takeoff on Runway 6 and cautioned to lookout for a small aircraft that just departed
21:22:32	VICON for Runway 6 activated
21:22:35	4 KA is cautioned for the heavy aircraft and instructed to taxi up to Runway 6
21:23:45	Air Carrier ABC asks for confirmation of his takeoff clearance, controller responds affirmatively

TABLE D-3 (Cont.)

EVENT NO.:	6	ARRIVAL RWY:	6
DATE:	2-28-80	DEPARTURE RWY:	33
Z-TIME:	2155	WEATHER:	Good

OBSERVERS ACCOUNT: Inadvertent VICON activation

TIME	CHRONOLOGY OF EVENTS EVENT
21:49:18	402 AK is cleared to go on Runway 33
21:49:28	Runway 33 VICON is activated
21:53:05	Air Carrier ABC is cleared for takeoff on 33 without VICON
21:53:23	Air Carrier XYZ is cleared to land on Runway 6 (intersects 33)
21:54:01	VICON for Runway 33 is activated
21:55:39	36 B instructed to position/hold on 33
21:55:47	36 B requested takeoff confirmation since he saw VICON lights
21:56:21	Runway 33 VICON is activated
21:56:27	Controller said it shouldn't be flashing and that it should be 'decommissioned as a piece of junk'
21:56:42	36 B is cleared for takeoff on Runway 33

Since verbal clearance is mandatory, 36 B did not take off in spite of observing the green lights. This incident points to the need of improving the integration of VICON into the ATC System.

TABLE D-3 (Cont.)

EVENT NO.:	7	ARRIVAL RWY:	24
DATE:	12-9-79	DEPARTURE RWY:	24
Z-TIME:	0008	WEATHER:	Good

OBSERVERS ACCOUNT: Pilot/Controller conversation about VICON

TIME	CHRONOLOGY OF EVENTS EVENT
21:08:34	Air Carrier ABC is cleared for takeoff on 24
21:08:36	VICON is activated for Runway 24, pilot acknowledged VICON after controller said VICON was on

TABLE D-3 (Cont.)

EVENT NO.:	8	ARRIVAL RWY:	6
DATE:	12-19-79	DEPARTURE RWY:	6
Z-TIME:	2250	WEATHER:	Good

OBSERVERS ACCOUNT: VICON Chatter

TIME	CHRONOLOGY OF EVENTS EVENT
22:50:31	Air Carrier XYZ is cleared for takeoff on Runway 33
22:50:31	Runway 33 VICON is activated
22:50:58	Pilot confirms observing green light

TABLE D-3 (Cont.)

EVENT NO.:	9	ARRIVAL RWY:	6
DATE:	12-27-80	DEPARTURE RWY:	33
Z-TIME:	1470	WEATHER:	Good

OBSERVERS ACCOUNT: Pilot Requested VICON

TIME	CHRONOLOGY OF EVENTS EVENT
14:47:30	An aircraft is cleared to land on Runway 6
14:47:35	Carrier DEF is given takeoff clearance on Runway 33 without visual confirmation
14:47:37	Carrier DEF pilot requests VICON clearance, gets visual confirmation for takeoff on Runway 33, and acknowledges observing the green lights

TABLE D-3 (Cont.)

EVENT NO.: 10
DATE: 12-6-79
Z-TIME: 2226

ARRIVAL RWY: 24
DEPARTURE RWY: 24
WEATHER: Good

OBSERVERS ACCOUNT: Aborted Takeoff

TIME	CHRONOLOGY OF EVENTS EVENT
22:26:48	Carrier JKL (heavy aircraft) gets takeoff clearance on Runway 24
22:26:18	Runway 24 VICON is activated
22:27:28	Carrier JKL pilot indicates that he has to abort his takeoff
22:27:30	Controller approves

It is not clear what had caused the pilot to abort his takeoff. He was, minutes later, given a second takeoff clearance and did depart

TABLE D-3

EVENT NO.:	11	ARRIVAL RWY:	33/24
DATE:	3-4-80	DEPARTURE RWY:	33/24
Z-TIME:	1914	WEATHER:	Fair

OBSERVERS ACCOUNT: A small aircraft in wrong takeoff position

TIME	CHRONOLOGY OF EVENTS EVENT
19:12:52	Controller clears small aircraft to land on Runway 24. Another small aircraft as well is on short final for Runway 33
19:14:09	43262 (small aircraft) gets verbal takeoff clearance for Runway 24, intersection Sierra taxiway
19:14:10	Runway 24 (intersection Sierra and Alpha taxiways) VICON is activated
19:14:16	Controller observes that 43262 is facing the wrong direction for a departure on Runway 24. He instructs him to hold, then to make a right 270° turn
19:15:31	43262 is verbally cleared for takeoff on Runway 24
19:15:33	Runway 24 (intersection Alpha and Sierra taxiways) VICON is activated

TABLE D-3 (Cont.)

EVENT NO.:	12	ARRIVAL RWY:	33
DATE:	3-3-80	DEPARTURE RWY:	33/6
Z-TIME:	0006	WEATHER:	Good

OBSERVERS ACCOUNT: Discussion about VICON

TIME	CHRONOLOGY OF EVENTS EVENT
23:59:51	Carrier MNO flight number 71 gets verbal takeoff clearance on Runway 33
00:01:12	Pilot uttered an unintelligible comment regarding VICON
00:01:13	Runway 33 VICON is activated

The pilot's transmission is unintelligible. He may have asked for the lights, since only one second after his transmission, VICON is activated.

APPENDIX E

FACILITY MAINTENANCE LOG DATA

Data on system corrective maintenance and modification have been extracted from the Facility Maintenance Logs (FAA form 6030-1) for the period 1 November 1979 through 31 March 1980. Data are listed by date in Table E-1. Statements in parentheses are not log entries but are added for completeness.

Routine preventive maintenance checks are not included as they do not add to the equipment operational performance picture and they greatly increase the number of entries to be reviewed. The daily preventive maintenance check takes five to ten minutes, and the weekly check about 30 minutes.

Data Acquisition System (DAS) repair information is included here, even though the DAS is not a part of the operational VICON system.

TABLE E-1. FACILITY MAINTENANCE LOG ENTRIES BY DATE

	November
1	Series of entries that DAS counters are not working properly.
2	Counters successfully repaired. Power loss.
8	Put runway 33 on microwave.
9	Repaired runway 33 microwave. Adjusted lamp intensity. Commercial power restored. Adjusted photocell.
10	Runway 33 would not shut off; adjusted circuitry. Runway 06 inop, first cluster. Repaired.
14	Runway 33 light did not go out. Adjusted monitor relay. Microwave on 33 doesn't catch every plane. Microwave OK.
15	Runway 33 won't shut off, even with override. Replaced monitor relay. System OK. Installed Butler board for monitor circuit in DAS.
16	Made mod to monitor board in DAS to overcome contact bounce.
19	Runway 33 intermittently not going off. Also, when 33L activated and override pushed, 33 comes on. (Repair not made)
20	Worked with NAFEC on 33 problem. NAFEC continuing effort. (Repair not made)
21	Installed new pole and control cable on 33 transmitter, and adjusted sensitivity. Runway 06 not working. Repaired fuse holder.
27	DAS - 2 counters malfunctioning.
28	Installed new matrix panel and checked out to see if all OK.
29	Installed solid state override pulse stretcher. Found 5 volt regulator bad. Reinstalled relay pulse stretcher Installed new Matrix Panel. OK

TABLE E-1. (Cont.)

	December
2	DAS tape alarm failed. Shredded tape all over. Cleaned machine, loaded new tape.
6	Tape recorder idler arm not returning to rest position, hence no alarm. (Repair not made)
10	Arrived with NAFEC personnel. Replaced spring on idler arm. OK
18	Runway 33 lights reported out. Receiver blowing fuses. Replaced receiver and P/S for runway 33.
23	DAS tape ran out - alarm on. Loaded tape. (Touch panel installed)
26	Changed 2 lamps on DAS panels. Found "Clear" button pushed on DAS - released. Now OK.
29	DAS tape alarm on. Loaded tape.
	January
13	DAS counters all on 0. P/S all good. Counters started during troubleshooting. OK.
18	DAS tape alarm on. Loaded tape.
22	Runway 06K panel light doesn't always work. Will advise day shift. Runway 06K light OK.
30	DAS tape ran out. Loaded tape.(Touch panel installed)
	February
5	Reset Squelch on receiver to stop continuous (DAS) tape feed. (Mimic panel reinstalled).
6	DAS tape ran out. Loaded tape.
18	Time unit not counting. DC power supply has no output voltage. Will advise comm. chief in A.M.
19	Found tape turned around and running. P/S working and CTR's working. All normal. Tape alarm not working, found wire in wrong terminal of semuan blk.
24	Tape alarming. Loaded tape.

TABLE E-1. (Cont.)

26	ATC (TS) advised me of a log entry of about a week and one-half ago concerning the "intensity" not working. (No indication of any action).
27	VICON local notam OTS for modification. NAFEC team installed a solid state controller in the VICON building last night from 2000 EST to 2400 EST. This controller, as is, replaces the timer cabinet, the pilot relay cabinet, and the pulser.
28	NAFEC team installed sun reflection shields on all 3 lights of light clusters on 6 and 33 takeoff points (lights 19 and 21).
	<u>March</u>
2	Tape out. Loaded tape.
7	ATC (AS) reports Runway 6 VICON lights too bright, cannot be adjusted. Connected Hi-Low wires in field for intensity, all operations normal.
14	VICON light cluster approach end Runway 33 damaged by State vehicle. Notified ANA-430.
15	VICON system OTS. Recorded count and checked tape.
16	VICON system OTS. Checked tape. No count on timers.
17	Found Runway 33 approach OTS and Alfa/Sierra not working. RTS VICON system except for A/S and approach of 33. Coordinated with Airport Manager for 1000 to 1200 (local) to take Runway 33 for repairs on 33. Runway 33 closed (1000 local) replaced as necessary parts for R/3 approach cluster. Completed repairs on R/3 lights and RTS. A/S started working? RTS full VICON system, operational AT (AS) advised.
22	Tape ran out. Loaded tape.
26	Tape in alarm. Loaded tape.
27	Alfa and Sierra lights OTS. (No indication of any action).
28	A/S light still OTS. Closed R/W 6-24 to repair damaged cluster A/S (1400 local). Repaired A/S cluster and RTS. Operation normal.

APPENDIX F

PILOT'S QUESTIONNAIRE COMMENTS

The comments submitted by the pilots in the bottom section of the Pilot's VICON Departure Questionnaire, Figure 8-1, are listed in Table F-1 by month.

TABLE F-1
PILOT'S QUESTIONNAIRE COMMENTS

OCTOBER

VICON seems of limited use to general aviation traffic but should be good for safety when pilots and controllers get used to the system.

Very good idea!

The system's greatest benefits would obviously come when there is confusion on radio transmission. We feel that money for VICON could be better spent on VASI's.

I didn't see the lights - they may have been OTS due to tornado or I may have missed them. I'll look again though and send you a new form when I do.

Was not aware of location for VICON. FSS was not sure of exact locations except Runway 33. Dep. Chart information sheet (Briefing Bulletin) has good explanation. Personnally, I think VICON has merit. Sometimes voice clearance not certain. I usually state "400 PM cleared takeoff 6" to be sure.

As indicated no beacon lights were seen when the voice takeoff clearance was given. I acknowledged the voice clearance and proceeded to takeoff. I didn't realize that the tower was supposed to be notified if no lights were seen.

Asked tower "no VICON lights?" Got no response - too busy to carry on any other casual conversation.

Apparently inoperative or not turned on.

1. A good system for poor or marginal visibility.

2. With visibility as it was and no big departure problems to distract one, it's effectiveness was much less important.

3. In other words, it is much more effective as the need for the system increases.

For evaluation purposes, we could judge the worth of the system better if we had seen both the not cleared for T/O, plus the clear for T/O which we viewed.

Was not aware of it.

I would have to try it several times to evaluate. My expectation is that it may be a needless duplication of the vocal release.

During the short time we were on tower frequency at BDL, we heard a lot of confusion as to the starting time and duration of the VICON lights. The FAA will have to work with the public quite a bit, I feel, if this system is to work. This system is not necessary. A verbal confirmation that the VICON has been seen back to the tower should not be required.

Co-pilot could not pick up lights right away.

Absurd - we do not speak with Spanish inflections to Dutch pilots in the conus.

This project is a ridiculous waste of the taxpayer's money.

Lights are small and hard to find. May need to be closer to approach end of the runway.

Very inconspicuous! Made 3 departures before I finally found where to look. Had to ask tower where to look.

Crew didn't think they are worth the trouble and cost of installation. If we didn't know they were there, I doubt we would have seen them. I think they would do a lot better at the hold point of the active runway.

Probably not worth the expense.

1. Excellent idea, should enhance safety.

2. Suggestions for improvement:

   a. Loss of light should cancel the clearance; this would enhance safety by giving visual backup to voice command T/O clearance could thereby still be cancelled even with loss of voice command by tower.

   b. Reference to 1) above; an even better system would be to have a red light right alongside the green light. The red light should be illuminated anytime T/O clearance is not authorized. That would remove any doubt as to whether T/O clearance had been issued.

This is an expensive waste of taxpayer's money. There is no adequate substitute for clearance readback, especially up to and hold short, position and hold, or cleared for takeoff. These repeats are too often omitted.

Excellent system. Lets get more of them.

I am opposed to the idea altogether!! Since voice comm. is controlling - looking for green light verification is unnecessary and distracting. The light serves no useful purpose and "Murphy's Law" awaits the uninformed as well as a "Violation." No thanks!!

Note: Lights came on before T/O clearance given. Debriefed with tower. Don't know exactly why!

It is unclear as to how the VICON receipt is to be confirmed to the tower.

I would like to see VICON much closer to the entrance from taxiway to the active runway.

A system should be used all the time, not only when the tower feels like it. But then I am only a general aviation pilot!!

Our aircraft was taxiing for T/O, prior to reaching R/W 06. A/C was cleared for T/O, VICON lights (green). Aircraft slow getting onto R/W and was told to hold position. T/O clearance cancelled. VICON lights GREEN! Then cleared for T/O with GREEN. I don't believe the lights help at all.

H-m-m-m-m-m!

Flew 3 days from here and on last flight, I found VICON.

We only saw VICON as an after-thought, sort of by accident. Lights seem to be too low, and only one light shows brightly. I'll look again next trip.

An excellent innovation.

The VICON lights have a tendency to blend in with other runway lights during night operations. Neither co-pilot or F/E saw the VICON lights until they were pointed out to them.

Best use would be during reduced visibility.

Good idea, but voice confirmation still necessary for takeoff clearance in case of other traffic.

Light cluster set a little too close to the ground - when lights are off, made it difficult to locate - with any snow, they will probably be covered up.

In as much as it does not alter any current legal requirements for takeoff clearance (I.E. still need verbal clearance), I am not sure I understand how it can expedite takeoff flow and exactly what function it serves.

This system would be a great help when the WX is at minimums. It's an excellent idea.

As located on Runway 33 at BDL, they are too far from the end of the runway and should be slightly raised on a standard to get them above the runway edge lights.

No help - just one more thing to think about and check.

We had to ask tower where the light was located as we taxied around corner after getting verbal T/O clearance. This did cause an increased workload, but over the long term, I believe that workload, understanding and expeditiousness will be improved. This will answer the question "Did it clear us for takeoff?" (sketch included)

I believe this is a good idea, but the present lights are not distinctive enough from the clutter of all the other lights (taxiway and runway). I would like to see something like this (sketch).

I think the green takeoff light would work better if it was:

1. Closer to departure end of runway.

2. Was higher (runway lights partially obscured it's distinctiveness).

3. Set up similar to stop light for cars, trains, etc. (i.e., a red light until A/C in T/O position, then a distinctive green for GO).

No need for such a system unless they are made more distinct or serve a purpose other than to verify controllers instructions.

NOVEMBER

My first experience with VICON - had to look hard to locate - expected it to be at 9-10 o'clock instead of 1130 and higher off the ground. VICON blended in with runway edge lites.

Early morning departure - sun reflecting on lights made them appear to be on - with T/O clearance they appeared to be brighter.

1. Lights are too low to the ground.

2. Light post should have an identifiable shape. It is difficult to locate when light is off.

This is a useless waste of money. Better spend it on collision advance systems. Besides, the very idea is faulty since it is susceptible to the type of malfunctions that can cause a misunderstanding as to clearance.

Method of response to tower is unclear at times.

Center light highest intensity. Side lights much lower - possibly due to a narrow angle lense installation.

Should be higher and closer to departure end of runway.

I suppose it will be OK once you get used to it. Right now, it acts more as a distraction. As you look for it, attention is slightly diverted from radio communications.

1. If in doubt, would clarify T/O clearance without further transmissions.

2. Is expenditure necessary/warranteed/foolproof???

3. Could feasibly lead the "accident looking for a place to happen" to the point of happening.

4. The thought has merit, but today's technology surely could do much more!

Couldn't see the lights because the sun was in our eyes. We didn't really look for the lights as we made a rolling takeoff.

I find the value of the VICON system questionable, considering the present needs of aviation.

Light blends in with grass. Recommend that lights be higher. As high as the VASI.

Delete!

People at flight service advised me that VICON was in service and gave me the form. I think that ground control should at least advise the general aviation pilot that VICON is available at the field. I feel it is an excellent additional safety tool.

As we become more used to system, it may be of more value.

TABLE F-1 (Cont.)

Why spend money on this??

I question whether this device will contribute appreciably to T/O clearance safety - possibility of increasing workload of cab operator unless it is perhaps voice actuated. I also wonder whether it would be usable in reduced visibility conditions.

We had to ask for the test so it is hard to really judge. We did not see the lights prior to taking the runway where I think they would be most useful - both sides of the taxiway just prior to taking the runway would be good. Green for clearance and red to stop and once on the runway, green for takeoff clearance and red for revocation of the clearance. (Note: If the light went out, I would question whether we still had takeoff clearance. I think if you are using the system, you will have the green light for "GO", if it went out, I would want to be confirmed verbally).

This would be a great help in places where there is a language difference between controller and pilots.

Very good. I would like them at all airports with towers. However, sometimes you are verbally cleared for takeoff and the VICON lites are not turned on, which results in a slight pause as you ask for VICON verification. Still an excellent system!

Increased workload some, as had to remember to look for VICON lights and make requested call. If used to system, it might be helpful.

Good concept.

Unable to verify VICON due to the fact that VICON signal blends in too much with terrain. If VICON signal were more prominent to catch pilots eye while on runway, he could be aware of VICON.

VICON location is useless in the event of snow. Also, any more "JUNK" on the runway is a hazard to safety.

Light cluster to low (close to the ground) to be effective from cockpit of light aircraft.

I felt the visual cue was inadequate. If this test is to continue, it may be wise to experiment with different light patterns and size.

My F/O and I both agreed that the intensity of the light (or lights) was so bright we thought there was only one light. I would like to see a background material of a standard size which would make for better recognition of VICON possible.

System is extraneous.

Morning sun directly behind us made it difficult to tell if they were on or off. Once they came on, very obvious. Might consider some type of shutter to prevent sun from reflecting off the green glass.

I would much prefer that any funds allocated for VICON be used instead for more VASI's and ILS approach facilities. Let's put the money on things that are needed!

I feel the lights could be located better. Possibly slightly higher or something so they do not blend in with the runways edge lighting. I like the idea though, many times we question in the cockpit whether or not we were cleared for takeoff, with the final checklist items being done. Hope it works out.

My first takeoff with VICON. The runway light intensity about equal to VICON, so before turning to green, not sure which lites they were. Objectively, it is a fine idea safety-wise. I think it would be better if it changed to green, then receive an oral clearance. Being my first takeoff, after receiving the verbal, there were two or three seconds scanning the area for green lites.

Lights are a good idea as backup to clearance. Should not be used as primary function.

VICON should be repositioned as it falls in the horizontal and longitudinal plan of the runway edge lites.

Workload. Increased - had to remember to look and verify - would become normal under frequent use. When lights are directly pointed at A/C you can see them well. But noticed they were hard to see as we rolled out of direct contact with each bulb, then easy to see as we rolled through next light beam.

Make every effort to locate this system in the same approximate spot at each runway on the same airport and then the value of this system could be significant as viewed from the cockpit.

We were cleared for takeoff prior to reaching runway. So it was a little difficult to quickly locate VICON lights. First time I had used them so didn't know where to look and what to look for.

VICON has been either not operational or not activated by the tower in recent visits to BDL. Flight service has not indicated any NOTAM on VICON during pre-flight briefings.

TABLE F-1 (Cont.)

Crew was preoccupied with cockpit duties, and did not concern themselves with VICON.

Have not seen the lights yet. Have made 3 T/O's at BDL since lights were installed.

Saw two boxes of three horizontally orientated pulsating red lights off to left side of runway. We were in position on the runway for about 3 minutes then cleared for T.O. The lights were still pulsating red as we passed them on T.O . roll.

Comments: 1) VICON lights might be confused with VASI lights, 2) Lights should be closer to aircraft if they are to be seen in very low visibility conditions. (Did not see VICON lights - saw VASI).

Really don't think we need it unnecessary extra expense, and added workload for the crew.

We were cleared for takeoff before we took the runway and did not have time to note the lights as we made a running takeoff. The concept is excellent but under circumstances like the above-stated, the VICON system has no useful value.

VICON lights were located too close to the ground. If they could be placed on a stand to elevate them it might be more helpful.

As I see VICON more, and know where it is, I have no trouble finding the lights. Once again, however, T/O clearance was received before we could see VICON, requiring a separate transmission to confirm VICON thus, the "slight impediment."

At first, I had difficulty locating the VICON lights but now that I have used them several times, it is no longer a problem.

Good shot! Keep up the good work.

Did not see light until well into takeoff roll. Felt light was mounted too low to see from my T/O position "on the numbers."

Money should be spent on VASI lights at nonprecision runways.

Waste of taxpayers money, pilots are able to get clearances OK if they listen. 747 accident, pilot error, the lights may have helped, but too many other circumstances involved.

TABLE F-1 (Cont.)

The location on Runway 6 was difficult to impossible to see from a 172 when holding short. They were readily visible once in position and hold.

If tower were not controlling traffic, then lights would have played important role. Because tower cleared me, lights were secondary.

Though the concept of "fail safe" or redundancy is generally a good idea, cost would enter into my consideration of VICON as a desirable addition. It might easily be helpful at very busy airports, but I don't consider it at all vital.

It is a good double check of T/O clearances but in 20 years of jet flying I really have not seen the need.

Would it be cost-effective??

Possibility of some confusion if lights and/or radio transmissions from tower failed. Do not think the lights add much and could cause problems.

I assumed the tower would turn the VICON lights ON, but we never saw them.

Useless things. Won't do anything but cost money and make extra work. Don't address any meaningful problem. Takeoff clearances not a problem at all - as for example, unauthorized runway crossings at busy airports. These lights should not be installed.

If more buzzers, bells, beepers, and lights would truly enhance safety, another green light or two could be in order. Personally, I prefer simplicity of systems with adequate backup systems. (A green light in the tower is just fine) or, save the money for a first class "proximity warning system."

A good backup, I suppose. But, if a person ignores the voice commands or is not paying attention, he will probably ignore the light. I have no objections to the light, but it will never substitute for alertness on part of the departing pilot.

System appears to be redundant to existing departure procedures. No apparent contribution to our operations.

Too many other lights at night - one light appeared brighter than others - lights too far away.

TABLE F-1 (Cont.)

Cleared for takeoff while turning onto runway. From this point, we could not see VICON. Therefore, verbal aknowledgement of T/O clearance was made without seeing VICON. Therefore, "VICON confirmed" report had to be a second transmission, made after alignment with runway. Also, VICON did not stand out from other lights. If it were not green, it would have been very hard to pick it out (sketch).
Suggest placing another set more visible at hold point to verify taxi clearance onto runway for T/O (sketch).
Sun was in our eyes which made locating lights somewhat difficult. To be of greater value, perhaps a row of lights across the runway that blinked (flashed) red until aircraft is cleared, then flashed green.
If I had not known about VICON previously, I would not have looked for it nor seen it. Furthermore, if I did see it, I would not have known what it meant. I think this holds true for any type of pilot regardless of licence type and ratings. The green light is flashed to quick - unless you are looking for it - you can easily miss it. It is a very good idea, but it needs improvement! Brighter and slower flash.
Good to confirm T/O clearance, however, is it cost-effective?
Night Departure - light rain. When cleared for T/O we were on the taxiway just prior to the runway. We forgot about VICON and did not see it, just continued taxiing and made a rolling takeoff. We have no idea whether VICON was turned on or not. Next time, we will ask.
Waste of time and money!
Did not see VICON lights on 24, but yesterday (11/7/79) used them on Runway 6 (approximately 1300 EDT) and found them very easy to see and recommend them.
System was new to me - accounting for a little confusion on my part. It was night and there were many lights on centerline, runway, VICON, etc. If pilots have some experience with it, it would serve as confirmation of the takeoff clearance. Maybe some red lights are needed to confirm canceling a takeoff clearance. A pilot would react faster to the lights than voice commands. A fast reaction time is needed to avoid accidents. I would be glad to answer more questions.
As first officer, difficult to see lites from other side of cockpit.

TABLE F-1 (Cont.)

Light would be distinctive if it were a strobe. Elevation of lights is too low.

Money would be better spent on VASI for 6.

Needs to be located closer to end of the runway. A blinking light would be more easily noticed.

Should be tested at busier airport.

We had an excellent VFR day, so VICON's assistance was difficult to judge. Will await an IRF day to fully evaluate the system. Looks like it will be a good, helpful system.

Had a difficult time locating the light initially. Perhaps it could be in a more prominent spot, not in line with the other runway lights.

Would be an excellent backup to verbal T/O clearance if a positive cut-off after a previous takeoff made the green light infallible.

A rotating beacon at the field is a much more desirable installation. Location: If located on the far side of the runway (outside of the radius of turn that the pilot is making while taxiing into position); 1) they would be much more easily observed by the pilot taxiing the aircraft; 2) they would not be lined up with the two red VASI's light array. This would allow a red/green GO/NO-GO arrangement. Contrary to popular belief, I do not think this would confuse too many pilots.

Need to be elevated somewhat for winter snow coverage.

1. Lights placed too low to ground; could be improved with possibly installing a background for lights.
2. Probably will be better with familiarity with system.
3. Initially, sign should be installed at departure end, stating this runway equipped with VICON.

Probably would not have seen lights if was not specifically looking for them.

Once before, I saw the lights in operation on one of my takeoffs, but the takeoff roll had already begun before we saw the lights, therefore, they caused a bit of confusion at that point. Other times, we have taken off and never noticed whether the lights had been used or not. I would suggest the lights be raised up and made more noticeable if they are ever to be effective. Perhaps they should be placed instead at the point where an aircraft would enter the runway, rather than after it is already in position.

Useless! If you have some excess money to spend, put a VASI on every runway.

Good idea! Should be more prominent and perhaps labeled.

Saw lights OK. Color not immediately perceptive as being distinctly different from what you would see as runway lights, or even taxi lights. Placement closer to takeoff end of runway might be better. Perhaps a different shape, such as a bar, might improve distinctiveness or perceptability. As we rolled forward on takeoff, the flashing lights were much easier to see. This was a daylight takeoff which probably would detract from the ease with which one could see the lights. Workload was increased only because of unfamiliarity and we had to pause to look for the lights and to be sure of what we were seeing. Should have no effect on subsequent takeoffs.

Too far down the runway. Difficult to see with sun on them.

The idea is excellent.

VICON system could possibly be set higher off ground (3 to 5 feet higher than at present).

Perceived only one light immediately as we rolled on to the runway.

Could be a valuable assist in times of heavy traffic and workload on both crew and controllers.

We found VICON to be a good adjunct to voice clearance, without definitive value. We are interested in the future intentions regarding VICON, i.e., does FAA intend to replace voice clearance with VICON?

This was the first time we saw this system in operation. There was some confusion as to where exactly the cluster of lights would be. When they did light up, all of the above-checked items apply.

Light location is in correct physical location; but they are in my opinion too small and too low intensity to be effective. I found myself hunting for them on takeoff. Possibly, I was expecting installation to be larger in size was reason for this.

Light is only visible when A/C is in takeoff position on the runway. In most instances the takeoff clearance is received while the A/C is still in the block. I would suggest that the light be turned around to be more visible to A/C in the runup block. This would preclude inadvertently taxiing onto the runway. (Most of my takeoff's are a rolling takeoff from the run-up block, that is when I would like to see the light, when I receive the takeoff clearance. Good idea!

VICON display characteristics: The light display was not distinct enough. It blended in with all the other lights. The intensity was about the same as the lights.

They need to be up off of the ground.

Should be on both sides of runway. When they started to flash, thought they went out, units are too close together.

Takeoff made on Runway 15 at BDL. Green lights of VICON located just to the right of red VASI bar. Had to look for green. Red was much more prominent.

Bradley tower reported VICON lights were inoperative.

Although I am in favor the concept of the VICON backup system, I think this expenditure for this system should be reconsidered in the list of priorities for needed equipment such as: collision avoidance, more VASI, and ILS and heads up displays.

Had to request lights for T/O. Note: Had weather been marginal, lights would have been very helpful and effective.

The shade of green was far too light. The only way I could differentiate between VICON and a runway light was by the flashing, but even the flashing was not very distinct.

DECEMBER

VICON on Runway 24 is located between the VASI which gives a red-green-red display from the takeoff position. This could be a bit confusing when operating in poor visibility conditions.

I strongly suggest the use of only one means of issuing takeoff clearance. Any possibility whatever of ambiguity ought to be avoided as well as any possibility of distraction of attention. If blind spots exist for radio reception on an airport, adding VICON is not the solution for issuing an unmistakeable clearance for takeoff.

Good idea, may be difficult for the first officer to see on some types.

If this test is to continue, I would like other lighting configurations. The present arrangement seems insignificant in relation to it's importance.

Could be more helpful in an area with limited tower visibility. I would prefer something of a more obvious nature such as following verbal clearance for T/O, the T/O is approved unless runway lights vary in intensity - high to low to high.
Green light was not easily seen since I was occupied in positioning, aligning etc., of aircraft for a rolling T/O.
Too many lights now.
Since this was my first observation of VICON, I saw what appeared to be the green lights ON, as I taxied into takeoff position. I had not received voice clearance for takeoff. After voice clearance, the lights got brighter, the weather was clear and bright. The sun must have reflected through the green lens making them appear on. I suggest using a shield over the units to compensate for sun glare.
A definite asset during a busy time in cockpit.
Good idea!
You have to search to find them. Need to be up a bit higher off the ground. Worthless, in my opinion.
Very little use, money could be better spent on some more useful aid.
I recommend this information all runways.
My only comment would be as to location. My opinion would be to locate the VICON light on the runway proper, possibly around the 500-foot location close to the center line. This location would make it difficult to miss it.
At night, the lights are difficult to see with all the runway edge lights on. Suggest VICON lights be raised higher and perhaps a few feet outside the runway lights.
What good is it??
If not turned on until plane is in position, would be more effective.
Suggest placing a second VICON cluster on the co-pilots side. Also, we would like to see a red light used in conjunction with the green light.
Lights not observed, probably due to cockpit workload, and size/visibility of lights. In other words, they can be seen if you look for them, but they don't intrude on your concentration if you don't.

After 6 T/O's from BDL this month, the crew observed VICON only 3 times. All T/O clearances were received (by radio) prior to positioning the aircraft on the runway, consequently, VICON was an unnecessary redundancy as cockpit procedures were uppermost in the attention of the crew.

VICON lites should be closer to takeoff point.

Saw only green lights and then only as we started takeoff roll. Never did see red light.

I feel that due to habit patterns, the lights are observed as an after-thought. In other words, when T/O clearance is given, the final items of T/O checklist are done; the crew is in a normal pattern, power is added and then, "Oh Yeah! There's the light!!"

The light was flashing green before we were cleared for takeoff verbally. Questioned the light and then were cleared for takeoff.

As stated before, endeavor to locate VICON lites at the same approximate location for each runway served, then we really have a working tool.

This is total bull! We don't need any more razzle-dazzle!! Keep things simple!

It was necessary to call tower for T/O clearance.

We didn't see the lights until we were passing them on takeoff roll. I guess if we knew exactly where to look, we would have seen them sooner. On this particular runway, it might be better if there was a light on the north side, so you could see it before entering the runway.

I would rather see the expense money used in perfecting landing systems such as ILS instead of non-precision approaches. (Also, at BDL I can't remember ever seeing a rotating beacon. Need it more, I would think).

I think in very poor visibility, that these lights would be useful. Also, I think that they should be located closer to the departure end of the runway, on the captain's side, because had we not asked for the lights, we would not have noticed them. If the lights were at the final hold yellow line, so that the Captain could see them both as he turned onto the runway and also as he lined up, I think that would be beneficial. Also ATIS information should include when and if the lights are in operation.

VICON not needed!

On each takeoff from BDL, we have received takeoff clearance prior to being in position on the active runway. Consequently, every takeoff made, all we ever observed was green lights. I get the feeling that if this is all we ever saw, some of us that havn't seen the lights change from red to green are losing the impact intended in the light system, that it is associated with a "go-no go" control system. In other words, without ever seeing the red light and consciously having to make a mental calculation, it is possible we are sub-consciously expecting to see green lights all the time and not associate it with a possible takeoff clearance.

Could be located closer to takeoff position. As is, might be difficult to see in low visibility conditions.

I think the lights could be located directly across from the taxiway you are entering runway from (sketch).

Cockpit workload just before takeoff is heavy. As a result the VICON system is not distinctive enough to get your attention, unless you are aware to look specifically for the lights. Perhaps, a constant red light, then green for takeoff clearance would make it more distinctive.

Would like to see VICON at all tower controlled airports. I felt sure when on takeoff roll, that I was cleared for takeoff.

Lights were there, but none of us ever saw them "ON"!

We advanced power and started moving after tower said "Flight 439 clear for takeoff". We didn't see any lights, then they came on after we had moved about 40 yards. F/O was flying and I, as Captain was too busy setting engine power. The lights distracted me from this task. They should come on at the same time verbal clearance is given, since afterwards both pilots are usually watching engine instruments for the first 100 yards of roll. I think a red stop light should work in conjunction with the green lights.

Although they are bright enough, you might make them bigger so they stand out. As they are now, if you didn't know they were there, you would probably miss them entirely.

Waste of taxpayer's money.

VICON lights are too small, sit too low. Regular traffic light would be far better, and would probably cost one tenth as much. Without a red light that changes to green, you don't know where to look for it. Lets not have overkill on this, please.

TABLE F-1 (Cont.)

Simple traffic lights at runways and intersecting taxiways would be a wonderful help. Stop studying and get Bond to start installing.

VICON lights were of no value tonight. The crew did not observe them, possibly because of preoccupation with anti-icing procedures.

If lights were placed further down runway, they would be more easily noticed.

Had to look for them to even find them. On other takeoffs missed seeing them entirely. They need to be a big set of lites several feet off the ground possibly with a high and low intensity for day and nite. I fly through BDL regularly and have only seen them when I made an effort to find them.

I have taken off 2 times on Runway 06 at BDL and I have never noticed the VICON system. I have read about it and I am aware, but in both instances, I have forgotten to look for the lights at the proper time. I will try harder the next time.

They are a help in knowing you understood the clearance, it's a very good double check. The problem I found is if I didn't know they were there, during the day I would never know they were there and in other instances I have looked for the green light when I had received the clearance and it was never lit. I again would like to say if they were used on a constant basis, they would be a great double check.

The sooner this ridiculous and costly system is abandoned, the better.

Difficult to see from right seat.

Have made over 20 takeoffs in both civilian and military aircraft within the past 2 months and have not yet seen the VICON lights.

feel the VICON lights will eliminate the possibility of any misunderstanding between tower and aircraft concerning takeoff clearance. There are times when communications problems (and they happen everyday) are not critical - starting your takeoff roll is not one of these times.

This was my 1st use of VICON system. I had to look for it. It did not stand out particularly. Perhaps by familiarization, through future use, it will be more apparent. I think this might be a good system and should be tested further.

VICON would have shown up better if it had been on the opposite side of the runway.

As pilots, we need this system like we need another hole in the head - it's a waste - time, money, effort, etc. You should be spending the money on DME's for ILS's (something that is REALLY needed - especially at BDL) instead of wasting it on something that is not needed, like this system.

Have yet to see VICON.

Waste of money and time.

JANUARY

I had made a mental note to look for the VICON during both taxi and runup but forgot as I got clearance to take off. They were just another green light on the field at night as I started the takeoff roll, and I didn't even realize they were associated with the VICON system until I was almost past them. They need to be more distinct. Why not have them at the hold point?

Would prefer red and green lights. The potentially catastrophic event where a plane takes off without clearance could be avoided by use of VICON.

Looking forward to more airports using this system.

Lights should be larger; not distinctive enough.

Due to unfamiliarity with VICON system (only this installation) and distraction due to vehicle near runway we did not observe the light on this takeoff.

Lights were inoperative - fixture was difficult to pick out - should have an accent background panel - would be difficult to see in sunlight. Why not a 3-light fixture -red, remain clear of runway; yellow, taxi into position (pilots discretion) - green, clear for T/O. (Most everyone understands traffic lights).

Prior to receiving (verbal) takeoff clearance, the VICON lights were on. We questioned the tower and was told the previous aircraft had probably not "broken the beam" which would have turned the lights off.

At the gate, we got out our "paperwork" on VICON and reviewed how we would handle it. When the time came (when we were cleared for takeoff), we had completely forgotten about it - it wasn't till we had been airborne for 10+ minutes before any one of us even thought of VICON, we then all discussed it, but none of us could remember even seeing it.

TABLE F-1 (Cont.)

System seems like it would work well in reduced visibility, but on days when the visibility is good, the system seems redundant. The see and avoid rule for VFR flight, seems more practical for everyday operations. I can see the system as a useful one when the visibility is less than 2 or 3 miles, where its intended purpose would prevent the type of situations that was the inspiration for the VICON system.

Seems like a waste of time and money. The lights were OUT!

Unless a pilot knows that a VICON is present, he would have never have seen the lights. I feel that the system is an overreaction to an incident and is of no significant value, especially on a cost versus benfit comparison.

We had to ask where it was. We then had to ask that it be turned on. During these distractions, we missed part of our normal takeoff preparations (these were picked up by the check list). All in all, in my opinion, it was more of a distraction than of any possible help. This system is not po itioned such that it would be of value in preventing unauthori d taxiing onto the runway or unauthorized takeoff.

Little far down runway. Closer to tak([illegible]f poi.t.

Waste of funds!

I think it is worthwhile.

VICON on Runway 24 is poorly located. It snould be on the opposite side from the runway entrance taxiway so that it can be readily seen prior to reaching runway alignment to confirm rolling takeoffs.

In the day-to-day ATC system, any system that can add to clearification of pilot/controller communication is a God-send.

I used these lights during a period of time in which BDL was not busy. The lights might make the takeoff clearance clear during a busy period. However, if not all runways at all airports have VICON I personally feel it will cause confusion. If I am unsure I ask, which sometimes irritates the tower, but at least I am sure before rolling.

Seems like more trouble than it is worth.

Worked very nicely, but operations didn't give us one of these forms, so next trip I asked why not?? Was told that program had been discontinued and that this was on the ATIS. Since it had worked so nicely, I question this!

TABLE F-1 (Cont.)

On sentence six of the back side of this page is the word OCCULTING rather than OSCULATING. This just confirms my belief in what the quality of help is now forced upon our system by , the clone!!

Had to remind tower to give us the green lite, after being cleared for takeoff!

Tower does not always use lights.

I feel VICON neither adds nor diminishes takeoff, safety clearances, or procedures.

Cleared position and HOLD with VICON indicating cleared for takeoff. DC-9 departing Runway 33.

On landing on Runway 06 I did not see the VICON lights, although I was aware that they were there. I had forgotten about them. Condition at the time was (IFR C-1,000', visibility 1 mile). At takeoff time, I then saw the VICON lights. It seemed that their location was too far down the runway. I did not see the taxi VICON lights. I like the idea of VICON lights!

Upon arrival at BDC and after being cleared to land, the green light was noted. The tower advised that the green light was only used for takeoff verification. It seemed that the aircraft which had departed prior had not triggered the device which shut off the light or had departed from an intersection further down the runway than the shut off device. This could lead to a problem, should the next aircraft receive a garbled message and confirm by the light remaining on, that the garbled transmission was a takeoff clearance!

Suggest locating VICON lights in flush mounted on runway center line.

My attention to the VICON lights was only after a remark by another crew member. I recall that they were not particularly distinctive and due to their seemingly significant displacement from the runway threshold area, I initially mistook the assembly for a VASI installation. My earlier recognition of the installation on Runway was more favorable.

This was an instrument training flight. My student and I were very impressed with the fact that we received the visual display. At New Haven, an hour before, we were cleared onto the runway but did not receive the clearance and held short. Meantime, the tower waved off an approaching plane thinking we were on the runway (Runway 2). They cannot see runway end from tower. Had the VICON been there and in operation, we would certainly have been in touch with the tower.

It is hard to remember to look for VICON lights because they don't attract your attention. When you do look for them, they can be spotted in good weather and have a good strong light intensity for confirmation, even on a bright day.

I feel that these lights are a help in confirming takeoff clearance. I feel that this procedure will improve safety at all major airports when in effect.

Fixture difficult to find; hard to see in bright sunlight.

Didn't remember to look for it!

FEBRUARY

I think VICON is superfluous, leaving room for error. If confusion results, a plane may sit, causing a "go around" or worse, a landing on top of another.

While taxiing, I thought to watch for it, but during actual departure, didn't see it (forgot to look specifically for it, so don't know if it was working or not)! Again, was not offered form in operations, had to ask for it myself. While they gave it to me, they again said that the program had been discontinued. Has it??

I don't think the lights are worthwhile, if the cost is very much, at any but the very busy airports. I think Chicago, ORD, is the place they would be useful and should be tested.

Captain comment - might be positively effective if used at all airports. F/O comment - is a waste of money!

I think the VICON lights should also be installed in the holding area. This would automatically tell the pilot he has been cleared from holding area to the active runway, and the VICON lights on the left side of the active would, as it presently does, clear the pilot for takeoff.

VICON should be closer to end of runway.

Position of lights should be closer to takeoff position. The captain had made four departures here last month and never saw them. Only saw them today because we were looking for them. There should be an identifying sign with the lights. A series of green sequenced flashers on the runway center line would be much more effective.

TABLE F-1 (Cont.)

Did not really catch my eye. Had to make an effort to look for the lights, not knowing their exact location. I think something like a green or red rotating beacon would be more easily identified.

Difficult to see in bright sunlight. Suggest a better fixture.

Sometimes difficult to notice during daylight hours. Suggest increased intensity during daytime. One factor which I believe leads to misunderstanding is when an aircraft has been told to taxi into position and hold, just after another aircraft has been cleared for takeoff. Due to the timing sequence on the VICON, the lights may continue to blink for several seconds, leading one to think he has been cleared for takeoff, even without oral confirmation by the tower. I suggest that the time sequence be shortened, or that the lights should not turn off automatically, but by the controller through use of a spring loaded switch. This would prevent misunderstanding, and would also increase the controllers awareness.

How can you evaluate when VICON must be continually requested during daylight hours?

Great at night!

Lights were all right this time as we had to hold in position. Still need to hear from tower.

Hard to remember to look. Extraneous, unnecessary expense.

The light should be seen before taxiing onto the runway.

First time to use it - lights so low to ground they were difficult to find, creating a very slight confusion at takeoff roll. Possibly, they might be a little too far down the runway. It was my impression that they would be located visually as you turn into position from the taxiway. And, for a moment or two, I couldn't find them.

I am in the habit of listening for a positive clearance. Light not really visible until after takeoff roll has begun (sketch).

Could be a little further removed from other runway lights.

Might be better if lights were where I am looking, on the centerline similar to touchdown zone lights.

I have never seen anything that resembles this system.

Don't see the need for this.

In about 50 takeoffs from BDL, I have never seen the VICON lights.

Eliminate the program!

Have yet to see the VICON lights!

I have not used this system. Its presence is not apparent. I suggest that the tower remind the pilot of the VICON for a period of time until they become accustomed to its presence.

I have never seen the VICON lights yet. I always seem to forget to look for them. That's just it, I have to look for them. It seems that this system degrades the efficiency of the airport operations. Waste of taxpayers money!

No value!

Useless!

Never noticed VICON lights!

Have never seen the above stated VICON lights!

Why do we need light signals when we have a radio? The idea of VICON is good, but I don't feel this is the answer, as it is set up at BDL.

Cleared for takeoff while still on taxiway. No lights turned on!

Increase size and move closer to takeoff point.

I was able to read green light from previous aircraft when told to position and hold. This could have been interpreted to mean a takeoff clearance. The light seemed to stay on too long.

If the installation is expensive, then we can see no real advantage or effect on the safe operation of this flight.

They are a waste of time and cause too many calls between tower and aircraft.

No new comments after umteen questionaires.

Not impressed!

OK!

Rolling takeoff, so lights seen after actual start. Co-pilot did spot the lights first, as he is in position to look the other way - across the cockpit. Same opinions as in my first report!

TABLE F-1 (Cont.)

Too late to change. I am used to listening for clearance; I have many other things to look for on takeoff, such as: runway clear, engines coming up, lined up, etc. Tower man said he doesn't use it!

APPENDIX G
SUPPLEMENTARY MAGAZINE ARTICLE

The following article, "The Amazing Shrinking Call Sign", is included because it independently confirms the statements by controllers and pilots of the need to use standardized phraseology and communication procedures.

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APPENDIX G

The Amazing Shrinking Call Sign

. . . And other airborne oddities that hinder our air-to-ground communications.

by Capt Charles M. Westenhoff

1868 Facility Checking Squadron (AFCS)
Rhein-Main AB, Germany

Reprinted from THE MAC FLYER

Incomplete call signs are one of the biggest headaches to controllers and pilots alike. When Kent 53 acknowledges instructions with a brief "five-three," it's amazing how many other five-threes suddenly appear. When Hank 17 shortens the title to "Hank," all the other Hanks in the world are suddenly talking to the same controlling agency — all on the same frequency. Predictable results include wrong aircraft changing frequency, accepting a clearance, making a turn, climbing or descending. On occasion this results in grave unpleasantness.

The other side of the coin is when you call up on a common-use frequency and don't specify who you're addressing. Sometimes you don't know just who all uses that particular frequency. If you simply call "Tower, Save 633, five south for landing," you may hear a deluge of arrival instructions from every airport within one-hundred miles.

It's especially important to specify who you're addressing because all those ground agencies can't hear each other. So if you never get who you're talking to straight, the wrong tower could talk to you all day — or at least long enough to spoil your confidence. If you don't care who answers, state "any tower," "any metro," etc. Then whoever answers should identify themselves.

Common-use frequencies have some other built-in problems. Because of antenna position, the controller usually can't hear the other ground agencies on the same frequency. They can't (1) hear the other tower telling you to make a right 360 and hold west of the field, (2) tell you it wasn't them that told you to do that, (3) override other transmissions on the frequency to tell you to break immediately to avoid the incoming 16-ship, same altitude.

In essence, a little misunderstanding can go a long way. The more precise you are in your communication, the more careful you are in identifying yourself and the controlling agency, the less chance of confusion and its attendant gray hairs.

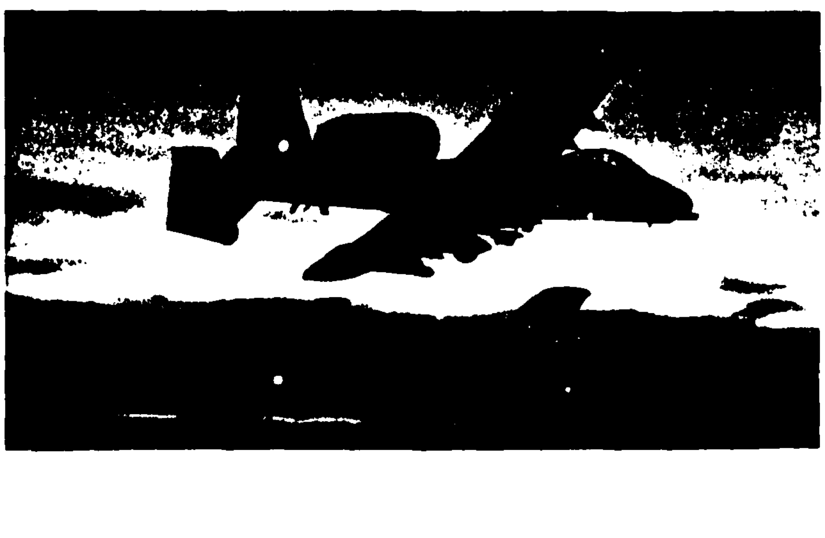
Other potential sources of confusion are the specific words and phrases we use in plane-to-ground communication. Some should be used with great care. Recently, an arriving aircraft reported that he was "clearing the runway." An aircraft waiting to depart keyed on the word "clear," and thought he was cleared to roll. This made things a bit crowded where the arrival was turning off the active and resulted in a very close call.

Except to verify flight clearances, takeoff, approach, landing and other times when a "read back" is required, why use the word "clear" over the radio? Everytime you say it, someone else may think they have received the clearance they are eagerly anticipating, and act accordingly.

Similarly, the forward-thinking crewmember will say "arrival" and "departure" rather than over-use the words "landing" and "takeoff." Try saying, "When may we expect departure?" instead of "When will we be cleared for takeoff?" or "May we follow the arriving A-7?" rather than "Are we clear to follow the landing A-7?"

Another phrase to avoid is "not in sight." If the first part of your transmission is clipped for any reason, you've just told the controller the exact opposite of what you meant. So use words like "traffic in sight" and "negative contact" to be clear in meaning.

With a little thought, our radio communications can say exactly what we mean, as well as let the world know that we are professionals. Thinking before pushing that mike button goes a long way toward smoothing our path along the airways and airwaves.



APPENDIX H

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APPENDIX C

VICON RELIABILITY ANALYSIS (VITRO)

(This document was reprinted in its entirety for presentation in this appendix.)

REPORT NO. FAA-RD-80-61

VISUAL CONFIRMATION (VICON) SYSTEM RELIABILITY ANALYSIS

WIND SHEAR SYSTEMS INTEGRATION PLAN, TASK D-1

C. W. HAMBY
J. R. DEMATTIO

February 1980

Task Report

Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161.

Prepared for
U.S. DEPARTMENT OF TRANSPORTATION
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16. Abstract

This study supports the system reliability area of the VICON Operational Evaluation Program. VICON is the FAA's VIsual CONfirmation system which visually confirms that an aircraft awaiting takeoff has been verbally cleared for takeoff by the airport controller. Specific objectives of the study are:

- Evaluate system failure modes and identify critical system components.
- Evaluate the need for concept or design modifications needed to support reliability objectives for the production system.
- Provide inputs to the VICON maintenance and spares recommendations.
- Determine the sensitivity of system reliability/availability values to design and spare parts options.

It is found that the predicted availability of the VICON system as installed at Bradley International Airport is 99.94% for the seven month test period. It is also found that the number of spare parts to provide a 99% assurance that there will be no degradation of VICON system performance due to a lack of spare parts over 6 months is predicted to be sixty-three total spares covering twenty-seven different component types. Thirty percent of the spares are required for the controller's operating switches.

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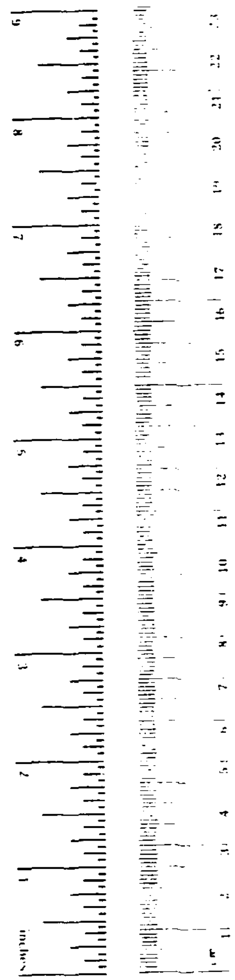
METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

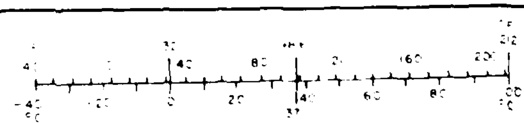


TABLE OF CONTENTS

I. INTRODUCTION

A. Background

The VICON system is a visual backup for the air traffic controller to confirm his/her vocal clearance to pilots waiting to take off and to prevent any possible misunderstanding of the controller's instructions.

VICON was developed primarily to avoid catastrophes such as the 1977 runway collision of two Boeing 747s at Tenerife Island in which over 550 persons were killed.

VICON consists of clusters of three, pulsing, green lights located at takeoff positions along the left side of runways. The lights are mounted on 14-inch-high frangible tubes, and one or more of the lights will always be visible to pilots of aircraft on taxiways or runways.

After giving voice clearance to an awaiting aircraft, the controller pushes a button which activates the appropriate VICON lights. When the pilot sees these lights, visual confirmation is complete. The VICON lights will then be turned off automatically when the aircraft breaks an electronic beam across the runway or by a timing device. The timing device would be adjusted according to airport traffic conditions.

The initial development testing of the VICON system was done at the NAFEC/Atlantic City Airport. The operational evaluation is being conducted at Bradley International by NAFEC in support of the FAA's Air Traffic Service.

The operational evaluation is intended to accomplish the following:

1) Determine pilot and controller reactions to the VICON concept and its implementation.

2) Evaluate design alternatives.

3) Assess system reliability.

4) Provide cost data for various configurations.

5) Evaluate system installation problems.

This study is in support of the system reliability area of the Operational Evaluation Program.

B. Study Objectives

The overall objectives of this study are twofold, i.e. 1) to provide reliability inputs to support system trade-offs studies and 2) to provide reliability recommendations for the VICON Technical Data Package (TDP).

A TDP is required for each R&D program which is intended for inclusion in the F&E program. The reliability inputs to VICON TDP are particularly important since certain failure modes of the system could impact safety.

Specific objectives to be addressed in this study are as follows:

- Evaluate system failure modes and identify critical system components.
- Evaluate the need for concept or design modifications needed to support reliability objectives for the production system.
- Provide inputs to the VICON maintenance and spares recommendations.
- Determine the sensitvity of system reliability/availability values to design and spare parts options.

II. SUMMARY

A. Definition of System Failure

In order to define system failure, it is first necessary to establish a precise statement of the mission of the VICON system. While the ultimate mission of VICON is to confirm voice takeoff clearances to the pilot, the primary mission of the Bradley installation is the collection of data on pilot and controller reactions to VICON and on the suitability of the hardware design under actual field conditions. Furthermore, it is intended that the VICON tests conducted at Bradley will place a minimum of additional burden on tower personnel.

The system failure definition is based on the concept of minimizing the burden to tower personnel in remembering which runways have VICON capability and which do not without being overly restrictive to the point where loss of a relatively small portion of the system places the entire system out of operation. The definition for this study is:

SYSTEM FAILURE

> The VICON system is failed whenever two or more runways are failed, except in the case when exactly two runways are failed there is no failure if the runways are reciprocal.

This study also evaluated a secondary level of failure, i.e., runway failure. In this case, the failure definition is based on the anticipated takeoff utilization at Bradley International; i.e., the majority of total takeoff operations will occur from the ends of the runways. However, the majority of the General Aviation takeoffs will be from runway intersections.

The definition for this study is:

RUNWAY FAILURE

> VICON is failed on a given runway whenever VICON clearances cannot be given to 15% or more of the anticipated departures for the total runway or whenever 50% or more of the VICON lamp clusters are out of service regardless of the percentage of departures effected.

This means that loss of the end lamp cluster or loss of one half or more of all lamp clusters is defined as a failure for VICON for any given runway.

B. Predicted Vicon Reliability/Availability

The predicted availability of the VICON system as installed at Bradley is 99.94% which means that the Bradley VICON can be expected to be capable of performing its defined mission of data collection during 99.94% of the seven month test period. Based on a total 4032 hours of data collection time during the test period, VICON can be expected to be operational during all but two (2) hours. The lack of VICON during this two (2) hour period will result in loss of only 0.31% of the total takeoff data points expected to be available during the test period.

The reliability of the VICON system has no bearing on its ability to perform the defined data collection mission; however, it can be noted that the Bradley VICON installation has a minimum reliability of 99.998% with respect to the granting of any single VICON clearance. In other words, a VICON clearance can be expected to be interrupted by equipment failure once in every 100,000 clearances or once every 30 months at Bradley International.

None of the components of the Bradley VICON System have predicated availability values that are excessively low; however, in the case of component reliability, the lamp clusters have a predicted reliability that is an order of magnitude less than the reliability of all other system components combined. This is a reflection of the high failure rate for the individual lamps that was provided by the lamp supplier. This failure rate is based on the aggregate behavior of the lamps in many applications, not necessarily similar to VICON usage. It is anticipated that the Bradley test will provide a more accurate estimate of lamp reliability in the VICON System environment to permit a final determination to be made as to whether or not a reliability problem exists.

C. Major Problems

The Bradley VICON System has eleven critical components. Failure of any one of these eleven components will result in failure of the entire system of 21 departure points, while failure of any of the remaining non-critical components will cause failure of a single departure point. Design changes have been recommended (Chapter IV) to eliminate all single points of failure. Implementation of these changes would increase the availability of the Bradley System from 99.94% to 99.99% with a negligible effect on single clearance reliability.

D. Sparing

The number of spare parts required to provide a 99% assurance that there will be no degradation of VICON system performance due to a lack of spares over a period of six (6) months, has been predicted. Sixty-three total spares covering twenty-seven different component types are needed with approximately 30% of the spares being required for the controller's operating switches.

It is interesting to note that the runway lamps do not dominate the spare parts picture, despite the fact that the lamp failure rate is two orders of magnitude greater than the next largest component failure rate. The override switch, runway activation switches, microwave detectors, fuses for the 48 VDC supply and the departure activation switches are all spared at a higher level than the lamps.

This situation is a direct result of the definition of provisioning protection level as the probability of no system failure due to a stock outage. Consequently, the number of spares assigned to each component is a function of both component failure rate and the impact of component failure on system performance. The high failure rate of the lamps is essentially offset by the relatively minor impact on system performance of the failure of a lamp while the catastrophic system impact of the failure of components such as the override and activations switches results in these components being heavily spared even though they have lower failure rates.

The spares provisioning analysis presented here is essentially an example of the technique rather than an actual sparing recommendation since the spares complement given in Chapter IV is valid only for the VICON System configuration at Bradley. Installations at other locations or even modification to the Bradley System would necessitate a new analysis being made.

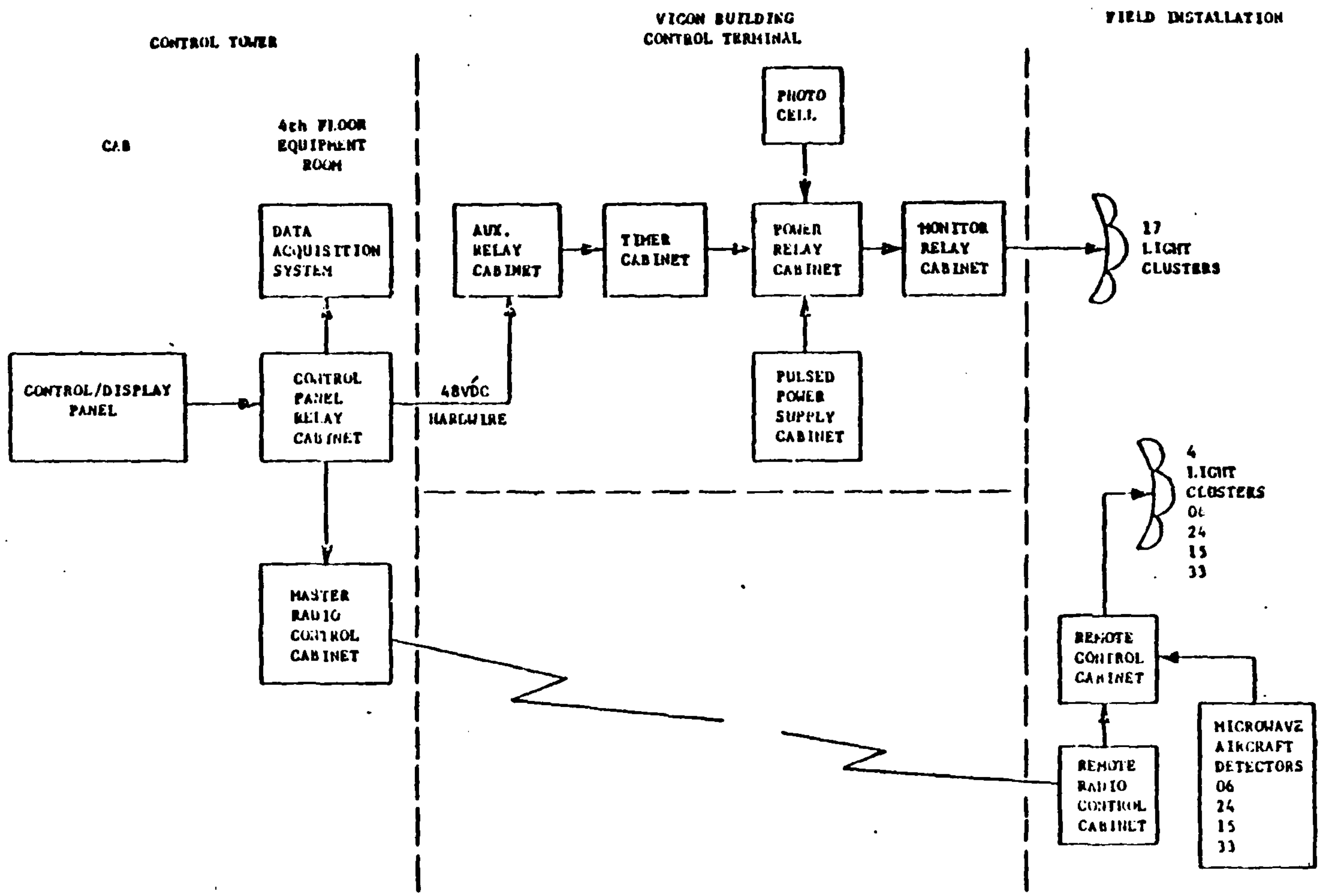
III. SYSTEM DESCRIPTION

A. Functional Description

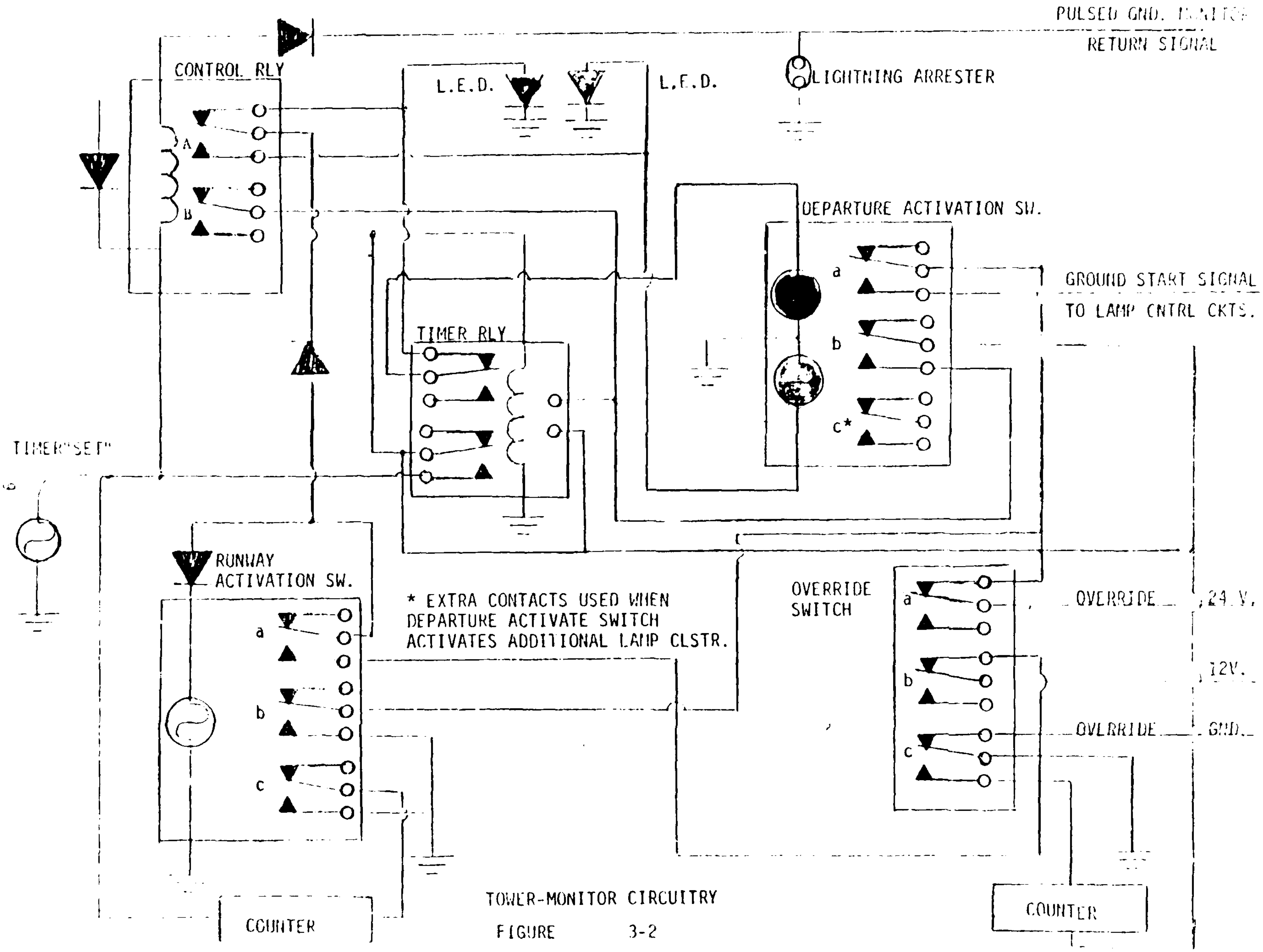
The VICON System, as installed at Bradley International Airport, consists of twenty one (21) lamp clusters located at runway takeoff positions and the control and monitoring devices necessary to ensure proper system operation.

As depicted in Figure 3-1, the VICON System can conveniently be thought of as consisting of three major component groups: (1) the operator control and monitoring equipment located in the control tower; (2) the lamp clusters located along the runways; and (3) the interconnecting circuits that transfer control and monitor signals between tower and lamps supply power to the lamps and provide for automatic lamp shut off following aircraft departure. The Bradley installation utilizes two type of interconnecting circuits: a hard-wire system and a radio-link system. Figures 3-2, 3-3, and 3-4 are simplified schematics of the operator control and monitoring equipment, the hard-wire interconnecting system and the radio-link interconnecting system. Figure 3-5 shows the lamp power circuitry.

Figure 3-2 shows the operation of a typical control and monitor circuit used by the controller to operate one of the VICON lamp clusters and to verify that operation has occurred. The sequence of events leading to the turn-on of a VICON lamp cluster begins with the operation of the runway activation switch for any of the six runways at Bradley. When actuated, the runway activation switch enables all of the departure activation switches associated with a particular runway by using contact set "b" to establish a ground on the moving element of contact set "a" of each depature activation switch. Operation of a runway activation switch also transmits 12VDC through contact set "a", to illuminate an amber indicator lamp

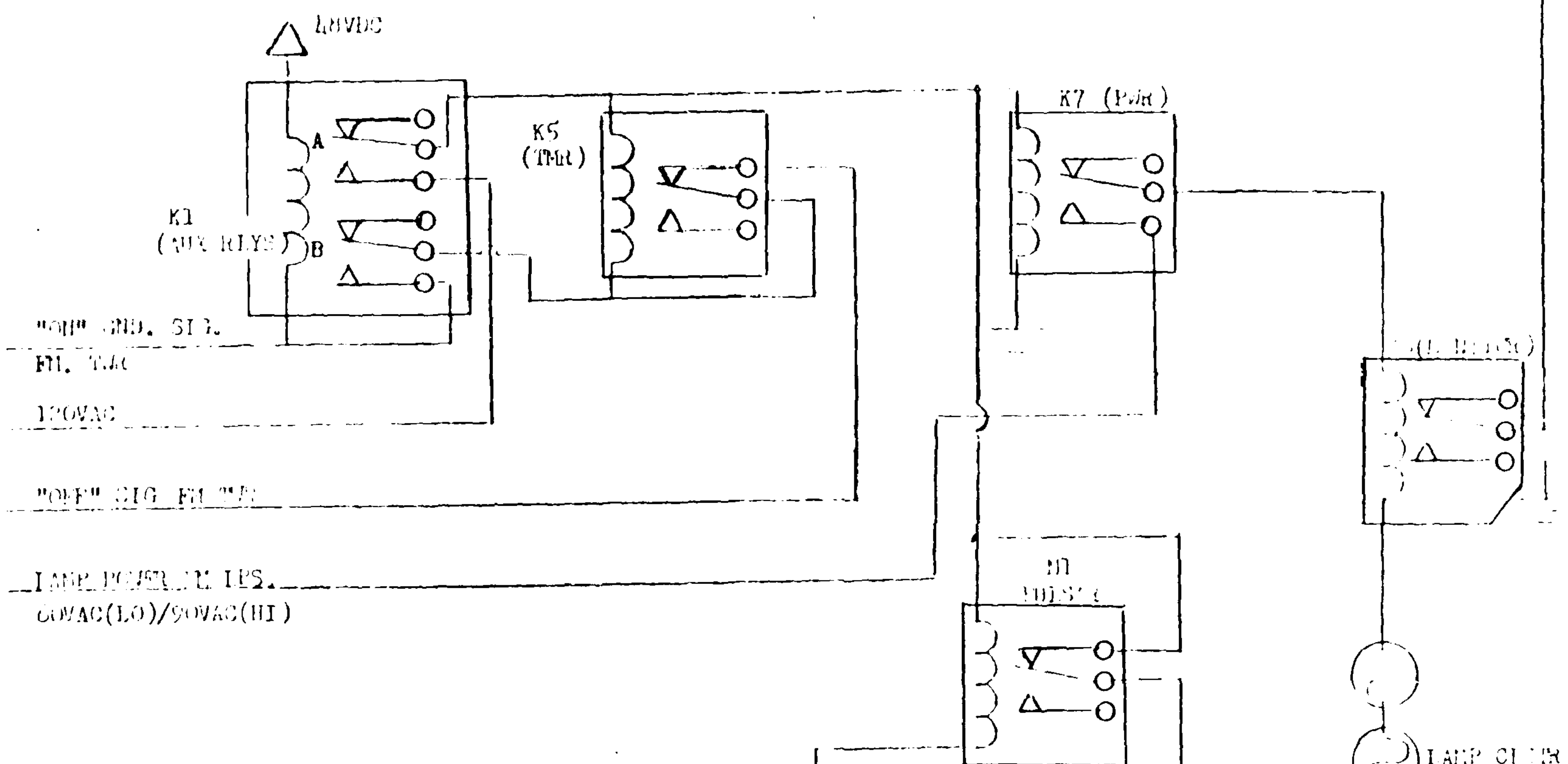


Block Diagram of VICON System
Figure 3-1



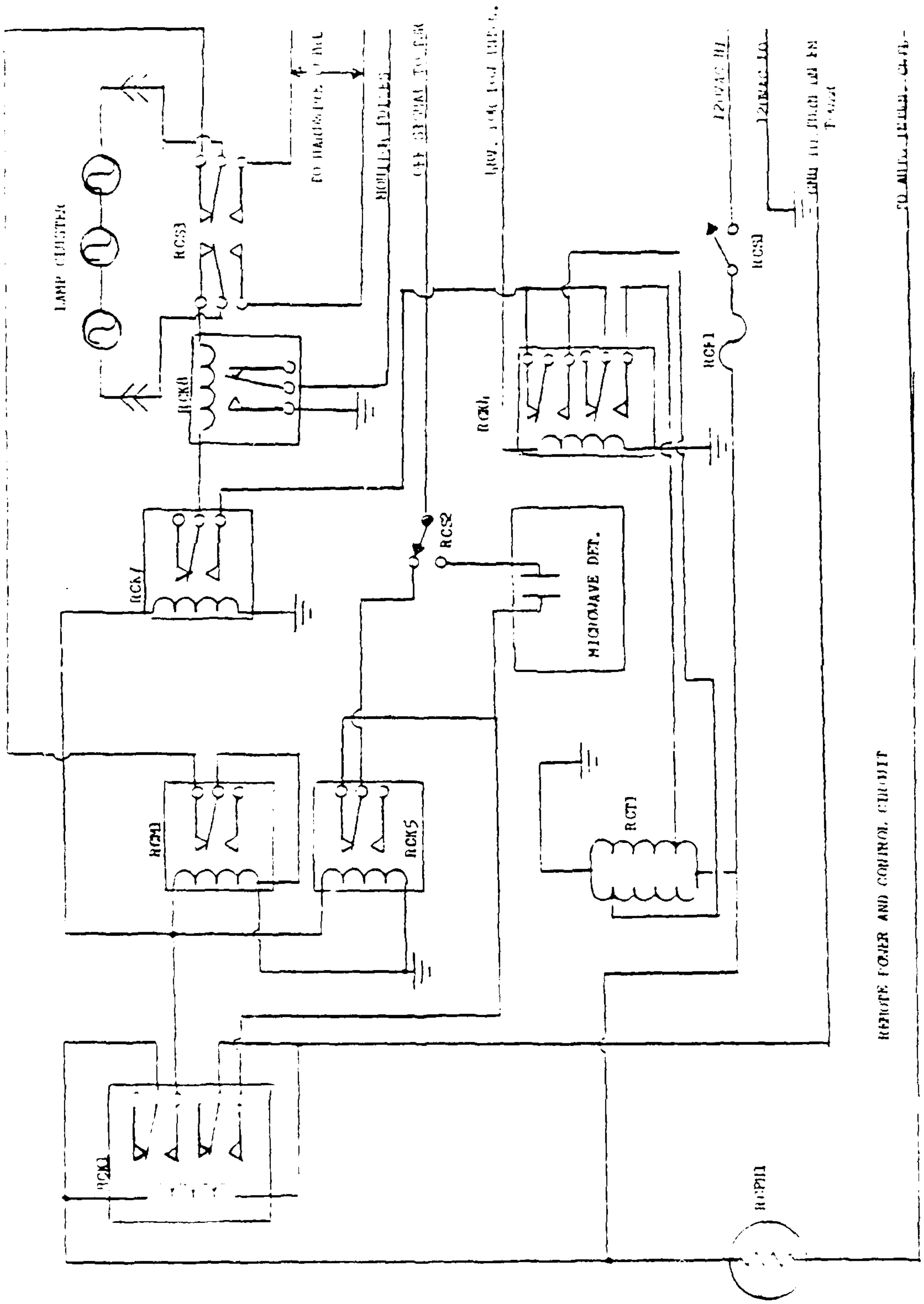
TOWER-MONITOR CIRCUITRY

FIGURE 3-2



CONTROL CIRCUIT COMMON TO ALL LAMP CLUSTERS
OTHER THAN RUNWAY END UNITS.

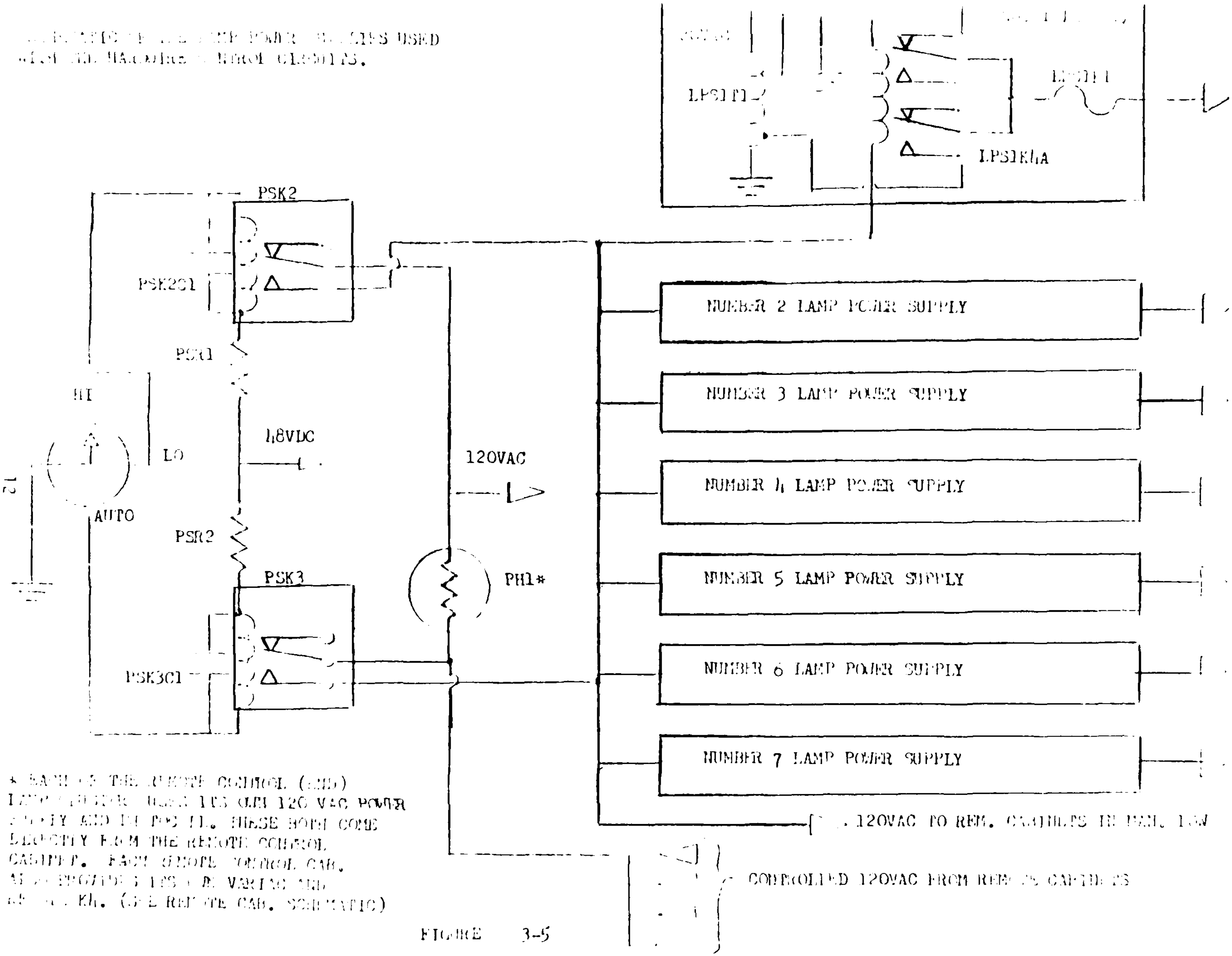
FIGURE 3-3



REMOTE POWER AND CONTROL CIRCUIT

FIGURE 3-4

SCHEMATIC OF THE LAMP POWER SUPPLIES USED
WITH THE HARDWIRE CONTROL CIRCUITS.



* EACH OF THE REMOTE CONTROL (RMD) LAMP HOLDERS HAS ITS OWN 120 VAC POWER SUPPLY AND ITS PH1. THESE BOTH COME DIRECTLY FROM THE REMOTE CONTROL CABINET. EACH REMOTE CONTROL CAB. ALSO PROVIDES ITS OWN VARIAC AND ... (SEE REMOTE CAB. SCHEMATIC)

FIGURE 3-5

in the runway activation switch to provide a positive indication of the runway activated for VICON control. A set of lamps contained in the departure activate switches are illuminated to indicate the specific departure points along the runway at which VICON clearances may be given. A duplicate indicator panel is located in the equipment room to provide maintenance personnel with indications of runway and departure point status. Note that the 12VDC to the controller's indicators passes through contacts of both the control relay and the timer relay while the 12VDC to the equipment room indicators passes through the control relay contacts only. Finally, operation of a runway activation switch places a ground (through contact set "c") on a counter that is not a component of the VICON system but a part of the test installation at Bradley that is being used in the evaluation of VICON.

To illuminate any VICON Lamp cluster on a runway that has been activated for VICON, the controller operates the departure activation switch associated with the intended departure point, thereby sending a start signal (ground) to one (or two) lamp control circuits through contact set "a" (and "c"). Contact set "b" switches +24VDC to start the timer relay which immediately transfers both sets of contacts until the expiration of its timing period, when they are returned to the diagrammed position (see Figure 3-2). Transfer of timer contact set "a" interrupts the 12VDC supply and extinguishes the amber indicator lamp in the departure activation switch. Transfer of contact set "b" provides +24VDC to the control relay enabling it to respond to the monitor return signal (pulsating ground) from the lamp control circuits. The monitor return circuit supplies a succession of ground pulses, corresponding to the pulsating operation of a lamp cluster, which results in the control relay being alternately energized and de-energized. The alternating operation of contact set "a" of the control relay causes the green indicator lamp in the associated departure activation switch to flash and also causes the yellow and green indicators in the equipment to light alternately. When the set time expires, the timer relay returns both set of contacts to the position shown in Figure 3-2, de-energizing the control relay and re-lighting the amber indicators in the departure activation switch and in the equipment room.

The turn-off of a VICON lamp cluster is normally accomplished automatically by the lamp control circuitry; however, the controller can exercise manual turnoff control by operating the override switch. Contact set "c" opens to interrupt ground to the lamp control circuits and turns off all lamp clusters. Contact set "a" and "b" interrupt the 24 VDC and 12 VDC lamp to darken all indicators as an indication of override operation.

Figure 3-3 shows the hard-wire control circuit used with all of the VICON lamp clusters installed at Bradley. The "ON" signal from the tower is a momentary ground that operates the appropriate auxillary relay (K1). The closing of contact set "B" of K1 establishes a holding circuit to ground through the closed contacts of timer (K5) and through normally closed contacts of the override switch in the tower. Operation of contact set "A" supplies 120VAC to the power relay (K7) and the pulser (M1). Operation of K7, in turn, supplies 60VAC/90VAC lamp power to the lamp cluster through the monitor relay (K8) coil. Pulser (M1) alternately opens and closes its contacts as long as it is energized. This operation of the pulser alternately energizes and de-energizes the four parallel pulser relays K9A, B, C, D which in turn supply a pulsating ground to the lamp cluster causing the lamps to flash. This pulsating ground is also fed to the monitor relay (K8) whose contacts transmit a pulsating ground on the monitor return line to the tower. When the timer (K5) completes its cycle, the contacts open to de-energize the auxillary relay which in turn de-energizes the power relay and the pulsar to shut off the lights and the monitor return signal. Shut off can also be accomplished by the "off" signal transmitted manually from the tower which consists of interrupting the ground to the holding circuit of K1.

Figure 3-4 shows the lamp control circuit used with the radio link. The auxillary relay (RCK1), power relay (RCK7), timer (RCK5), pulser (RCM1) and monitor relay (RCK8) perform exactly the same functions as in the hard wire system. The differences between this system and the hardwire system are: (1) turn-on and manual turn-off signals are transmitted via radio rather than wire; (2) the pulser controls lamp ground directly instead of through a set of relays; (3) the timer (RCK5) can be switched out of the circuit, via RCS2, and replaced by the microwave detector which senses aircraft passage and opens the ground to RCK1 to shut off the lamps; and (4) it contains its own power supply. The power supply operation is the same as described for the hard wire system in the next paragraph. Note that lamp clusters with radio-link control can be switched to hardwire control through RCS3 if desired.

Figure 3-5 shows the lamp power supply associated with the hardwire lamp control systems. Note that the intensity switch shown here also controls the intensity of the power supplies used with the radio-link control systems. The power supply provides either one of two voltages to the lamp clusters in accordance with the lamp intensity required by ambient light conditions. When the lamp intensity switch is set to HI, relays PSK2 and PSK3 have no connection to ground and are therefore de-energized so that relays LPS1K4A through LPS7K4A in the seven lamp power supplies are also de-energized and the high voltage output of the seven auto transformers (LPS1T1 through LPS7T1) are connected to the lamps. When the intensity switch is set to LO, relay PSK2 is activated which in turn energizes relays LPS1K4A through LPS7K4A to connect the lower voltage output of the auto transformers to the lamps. Placing the intensity switch in the Auto position de-energizes PSK2 and energizes PSK3 so that photo cell PH1 controls relays LPS1K4A through LPS7K4A and the voltage to the lamps.

B. Physical Description

Figure 3-6 shows the location of each of the twenty one (21) VICON lamp clusters at Bradley International Airport; the arrows at each cluster indicating the take off direction of aircraft controlled by the cluster. Clusters 18, 19, 20 and 21 have both radio link and hardwire control circuits while all others have only the hardwire control.

Each of the VICON locations has a cluster of three lamps,(see Figure 3-7), with one lamp parallel to the runway edge at 0^{o} elevation, one lamp at 30^{o} to the runway edge and 6^{o} elevation and one lamp at 60^{o} to the runway edge and 12^{o} elevation.

The lamp control circuits, power supplies and radio equipment associated with locations 18, 19, 20 and 21 are mounted in weather proof cabinets adjacent to the runways near the lamp sites, with the photo cell that controls lamp intensity situated atop the lamp control enclosure. The microwave detector units (Figure 3-6), associated with location 18, 19, 20 and 21, are situated on either side of the runway so that during takeoff the aircraft will pass between the detectors.

The components of the hardwire lamp control circuitry are mounted in five (5) cabinets all housed within a single building, located at the site identified as ASR on Figure 3-6. Like components are mounted together in the same cabinet with all auxillary relays in one cabinet, all timer relays in another cabinet, the power relays together in the third cabinet, the monitor relays, pulsar and pulsar relays occupying the fourth cabinet and all power supply components residing in the fifth cabinet.

VISUAL CONFIRMATION OF VOICE TAKEOFF CLEARANCE

VICON

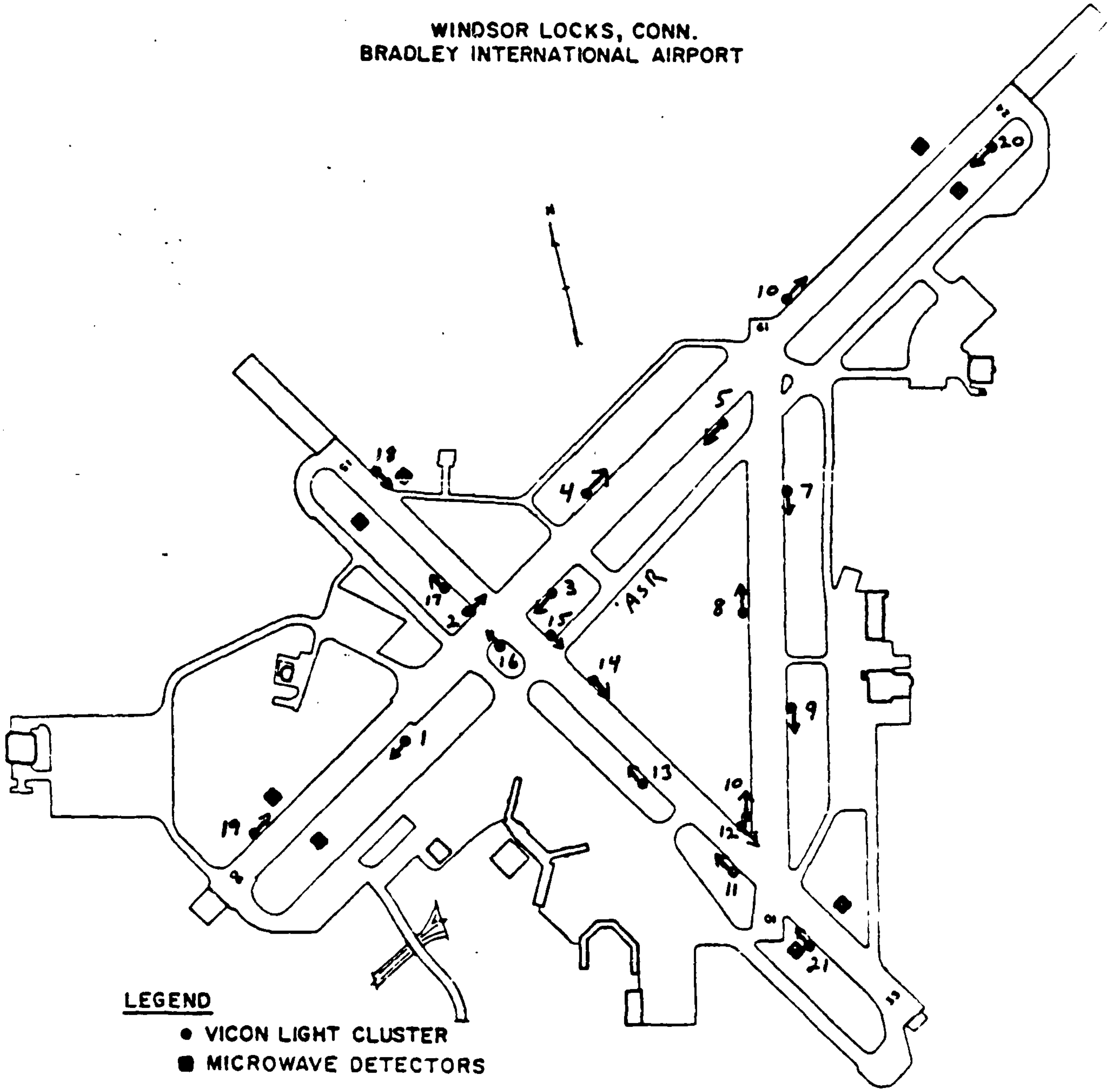


Figure 3-6

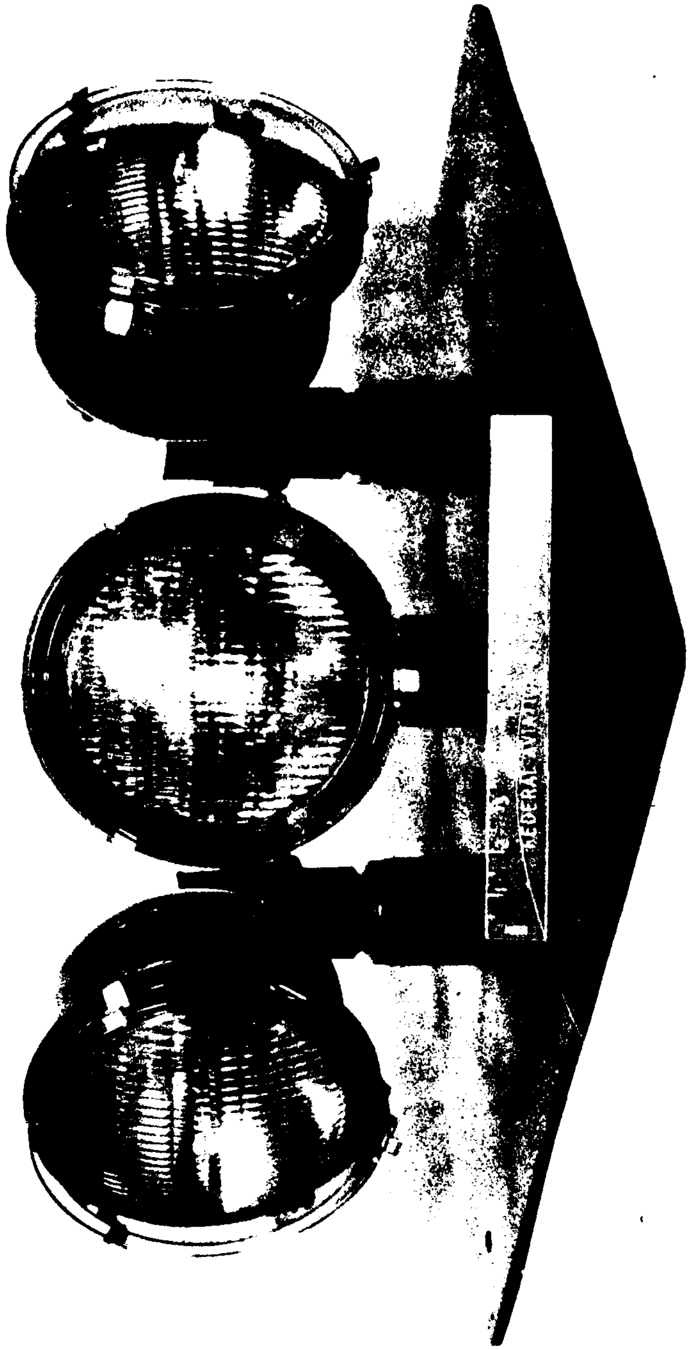


Figure 3-7. Light Cluster

Figures 3-8 and 3-9 shows the controller's panel containing the override switch, the runway activation, and the departure activation switches and their built-in monitor lights. The panel shown in Figure 3-8 with the switch/indicators arranged in the same pattern as the lamp clusters on the runways, is called the mimic panel. The matrix panel (Figure 3-9) in which the various switches/indicators are arranged in rows, will also be employed during the test program. The matrix panel conserves space and may be practical for complex runway patterns, such as would be present at Chicago O'Hare. The two panels are functionally identical. The associated control relays and timer relays are mounted in a cabinet located in the tower equipment room. This cabinet also contains duplicate runway and lamp cluster status indicators. The master radio unit used to control and monitor lamp clusters 18, 19, 20 and 21 and the data acquisition and recording equipment are also located in the tower equipment room. The data acquisition and recording equipment are not part of basic VICON system being evaluated.

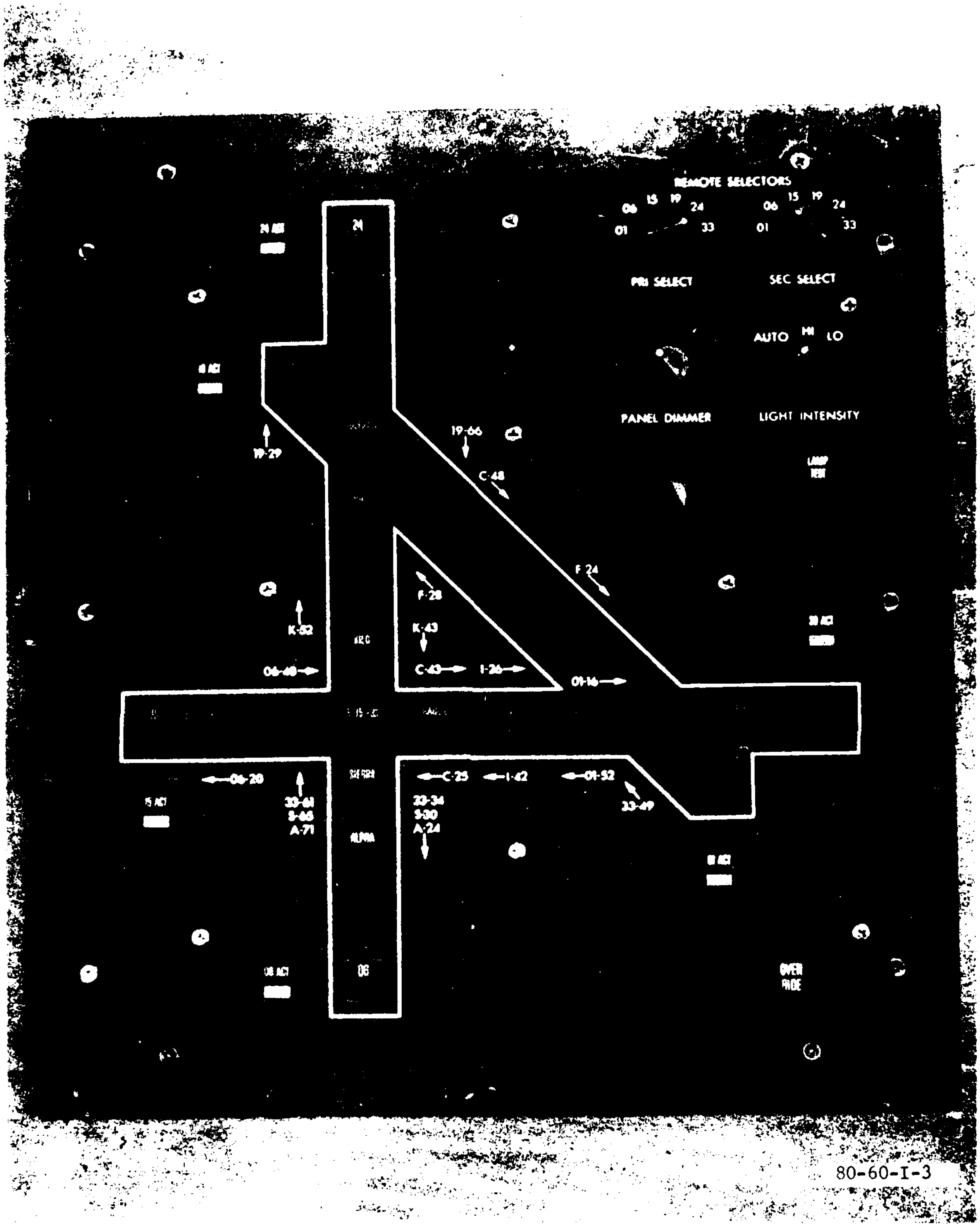


Figure 3-8. Mimic Type VICON Control Panel With Switch Identification

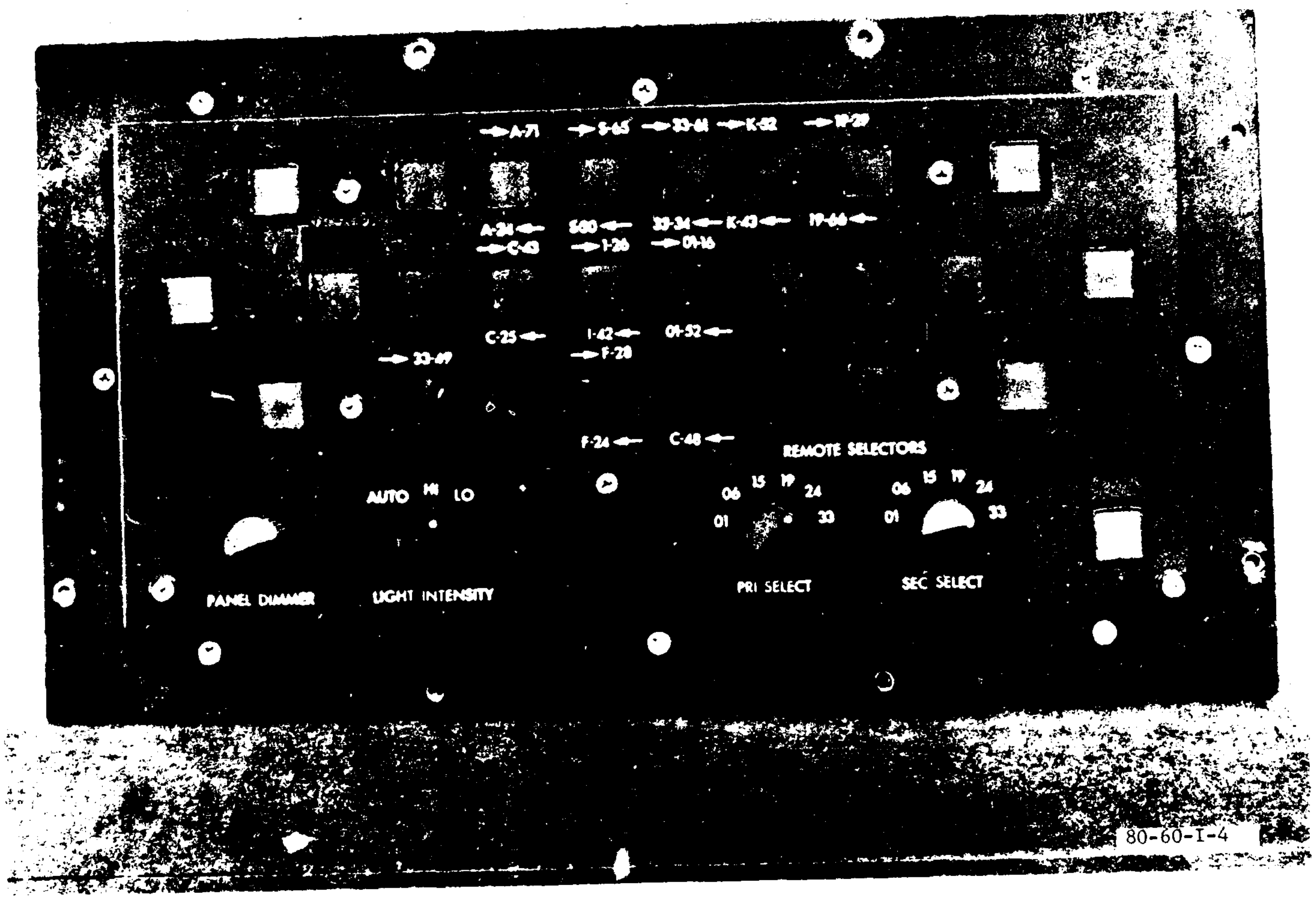


Figure 3-9. Matrix Type VICON Control Panel With Switch Identification

IV. ANALYSIS

A. Fault Tree Methodology

1. General Description

a. Introduction. Fault Tree Analysis (FTA) is a particular application of formalized deductive logic for safety systems which depicts the inter-relationship of component states or their combinations that can result in the occurrence of a specified undesired system state defined as the top event of the Fault Tree. The Fault Tree considers only those component states that might contribute to the system failure, as opposed to a system reliability (availability) model which considers every component state in the system. Consequently, for a complex system, the Fault Tree often provides a simpler and more efficient means of determining system reliability or availability than the use of the totally descriptive system model.

b. Fault Tree Construction. Construction of a Fault Tree begins with the definition of the top (undesired) event of the tree. The events which constitute direct causes of the top undesired event are shown in a manner displaying their logical relation to this undesired event. The causes of the second tier events are in turn shown logically related to each of the second tier events. This process is continued until a set of sequences of events are developed linking the top event to each of the basic causes of interest or basic events that appear at the bottom of the Fault Tree, typically the failure of a component such as a capacitor, relay or transistor.

Since the elements of a Fault Tree are the same for all types of events and systems being analyzed, a standard set of symbols may be used to represent such events and operations. The symbols used in this report are those most commonly in use today and include the rectangle, the diamond, the circle, and the triangle, together with the logic symbols for AND and OR gates.

The rectangle defines an event that is the output of a logic gate and is dependent on both the inputs to the gate and the type of the gate.

The circle represents an event considered basic to a given Fault Tree and is used here to represent inherent failures of system elements. The diamond is used to represent an event, other than the failure of an elementary component, which is purposely not developed further; and will always indicate the limit of resolution of a given Fault Tree. Hence, either a circle or a diamond will be the final symbol in any branch of a Fault Tree.

The triangle, with an identifying letter or number, is used as a transfer symbol to avoid repeating sections of the tree. The Transfer-Out symbol represents all of the sequences appearing between the symbol and the bottom of the tree on the page where the symbol appears and indicates that these sequences form a part of another tree appearing on a different page. The Transfer-In symbol indicates that a branch appearing on another page is connected at the point of the symbol. The Transfer-In symbol includes the page location of the referenced branch.

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VISUAL CONFIRMATION OF VOICE TAKEOFF CLEARANCE (VICON) OPERATIO--ETC(U)
FEB 81 J J MAURER, B CASTLE, E DOWE, B HUGHES
UNCLASSIFIED FAA-CT-80-60-1 FAA-RD-80-114-1 NL

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Logic symbols (AND and OR) are used to depict the dependence of an event on the occurrence of one or more other events. The AND gate symbol is used to portray the situation in which the output event will occur only when all of the input events co-exist while the OR gate symbol represents the case in which the output event will occur if any one or more of the input events occur.

c. Quantitative Fault Tree Evaluation. Evaluation, as used here, refers only to the calculation of the probability of occurrance of the top event of the tree although Fault Trees may also be evaluated qualitatively to determine sets of basic events that will cause the top event to occur.

Fault Tree evaluation is performed in three steps: (1) reduction of the tree to a form free of dependencies, (2) assignment of probabilities of occurrance to each of the basic events at the bottom of the tree, and (3) combination of the probabilities upward according to the logic of the tree to produce the probability of the top event.

The reduction of dependencies essentially consists of the repeated application of the following rules of Boolean Algebra:

$A + A = A$ (input event A OR input event A is equivalent to output event A)

$A \cdot A = A$ (input event A AND input event A is equivalent to output event A)

$A + 1 = 1$ (input event A OR input One is equivalent to output One)

$A + A \cdot B = A(1 + B)$

$= A$ (input event A OR input event A AND input event B is equivalent to output event A).

These rules are used to eliminate repeated events that occur in various branches of the Fault Tree so that when numerical probabilities are assigned, the probability of any single, independent, event is used only once in the system/equipment analysis. Reduction of the Fault Tree can also be accomplished by the method of minimal cut sets, a technique typically used in qualitative tree analysis.

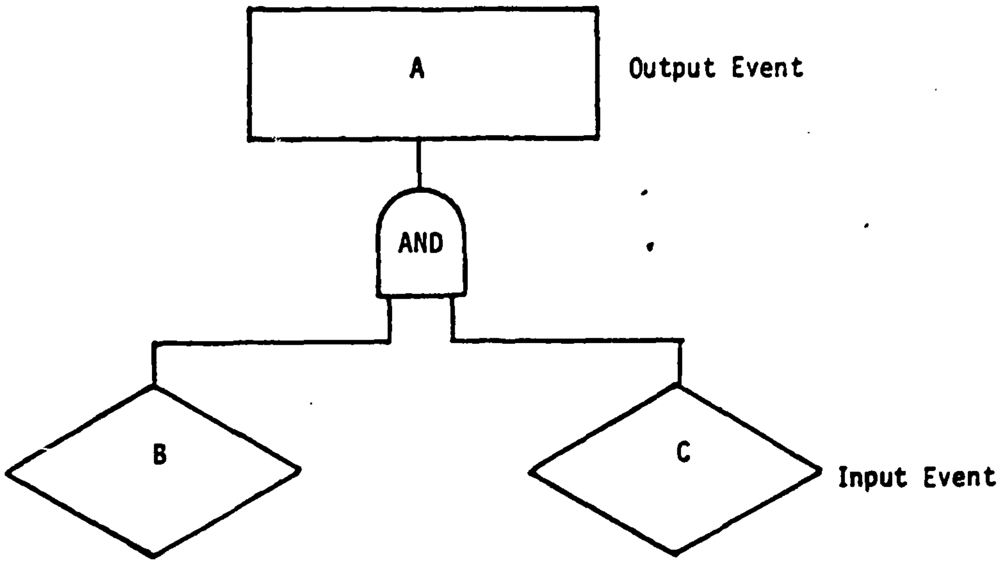
Probabilities are combined across gates according to two simple rules:

- The probability of the output event of an AND gate is the product of the probabilities of the input events.
- The probability of the output event of an OR gate is the sum of the probabilities of the input events.

It should be noted that while the computational method for AND gates is exact, the method given for OR gates is an approximation whose accuracy depends on both the value of the input probabilities and the number of inputs to the gate. Accuracy decreases with increasing input probabilities and with increasing number of inputs; however, the input failure probabilities typically encountered in any reasonably reliable equipments are sufficiently small so that nearly unrestricted use may be made of this approximation without unreasonable error.

These computational rules are derived from basic theorems of probability covering the probability of independent events and the probability of the union of events. These theorems apply to any number of events but are best illustrated by considering the case of two events or two inputs to a given gate.

An AND gate symbolizes the situation in which all input events must co-exist for the output event to occur so that in the tree



event A will occur if and only if events B and C occur simultaneously. Probability theory states that the probability of two independent events both occurring is the product of their individual probabilities so that if B and C are independent and

$$P(B) = .05$$

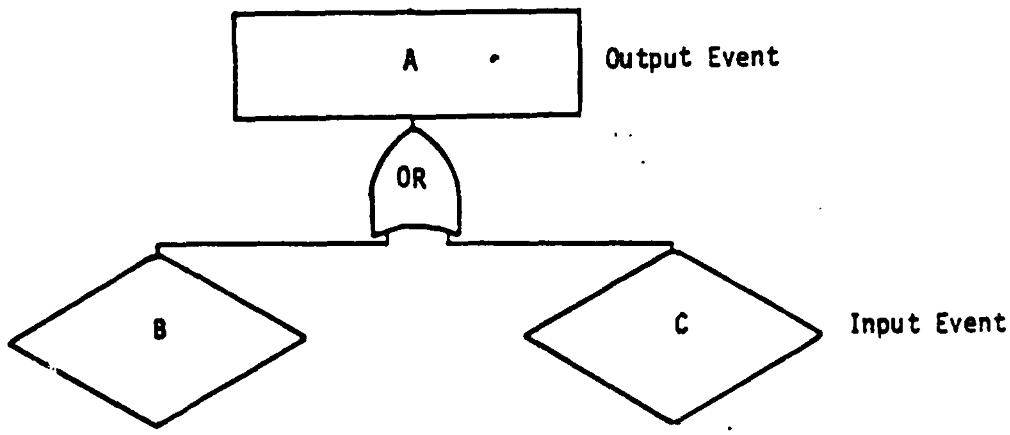
and

$$P(C) = .03$$

then

$$P(A) = P(B) \cdot P(C)$$
$$= .0015$$

An OR gate symbolizes the situation in which one or more input events must exist for the output event to occur so that in this tree



event A will occur if event B occurs or event C occurs or both events B and C occur; i.e., event A is the union of events B and C. Another well known theorem of probability states that the probability of the union of two events is the sum of the probabilities of each of the individual events minus the probability that both events occur. If the two events are independent then the probability that both occur is the product of their individual probabilities of occurrence, or

$$
\begin{aligned}
P(A) &= P(B) + P(C) - P(B)P(C) \\
&= .05 + .03 - (.05)(.03) \\
&= .0785
\end{aligned}
$$

It can be shown that this formula extends to any number of input events so that for three independent input events

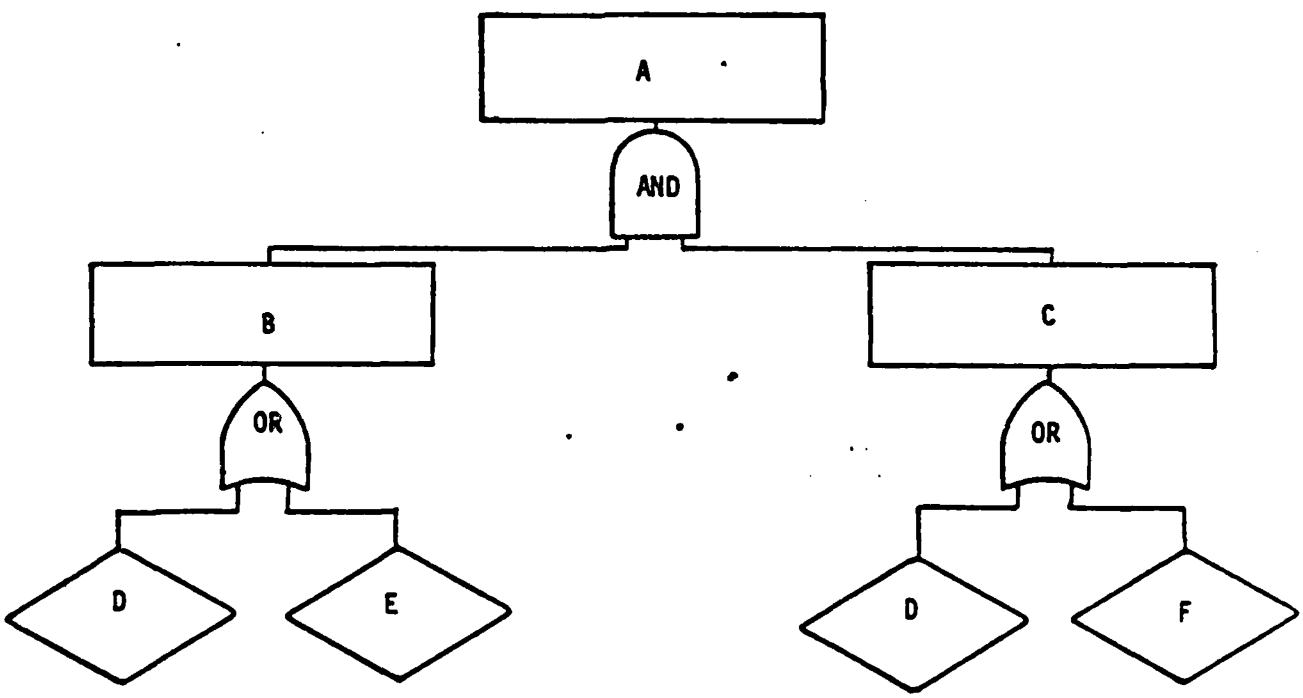
$$
\begin{aligned}
P(A) = P(B) + P(C) + P(D) - P(B)P(C) - P(B)P(D) - P(C)P(D) \\
+ P(B)P(C)P(D)
\end{aligned}
$$

and for four events

$$
\begin{aligned}
P(A) &= P(B)+P(C)+P(D)+P(E) - P(B)P(C) - P(B)P(D) \\
&- P(B)P(E) - P(C)P(D) - P(C)P(E) - P(D)P(E) \\
&+ P(B)P(C)P(D) + P(B)P(C)P(E) + P(B)P(D)P(E) \\
&+ P(C)P(D)P(E) - P(B)P(C)P(D)P(E)
\end{aligned}
$$

Clearly, use of the exact formula with a large number of input events results in a lengthy and tedious calculation that is quite subject to error. It is far more convenient to use the approximation stated previously, i.e., the probability of the output event of an OR gate is the sum of the probabilities of the input events. The error in this approximation depends on both the number of inputs and the value of the input probabilities. For example, with the two input case, illustrated there is a 5% error in P(A) when P(B) = P(C) = .1 and 1/2% error if P(B) = P(C) = .01. If, however, the input probabilities are all equal at .01, the error is 1/2% for two inputs, 1% for three inputs, and 1.5% for four inputs. While no absolute statements can be made concerning the accuracy of this approximation, past experience has shown errors of 1% or less can be expected in the Fault Trees of typical complex systems of eletronic components. Maintenance of a reasonable error level in using this approximation is aided by the fact that in the typical Fault Tree the larger numbers of inputs to an OR gate occur near the bottom of the tree which in turn implies lower values of input probabilities.

It must be noted that the computational forms given here for combining probabilities across both AND and OR gates require all input events to be mutually independent. The structure of the Fault Tree will often conceal dependencies, particularly if the tree is analyzed a branch at a time, making it imperative that a Boolean reduction be routinely made the first step of every Fault Tree analysis. For example, in the tree



consideration of each gate separately does not reveal any dependencies; i.e., the inputs to the AND gate are B and C, the inputs to one OR gate are D and E, and the inputs to the other OR gate are D and F; however, looking at the tree as a whole, the inputs to the AND gate are not independent since both ultimately contain the event D. Application of the algorithms for combining probabilities across gates yields:

$$P(A) = P(B) \cdot P(C)$$

$$P(B) = P(D) + P(E)$$

$$P(C) = P(D) + P(F)$$

hence

$$P(A) = [P(D) + P(E)] \quad [P(D) + P(F)]$$

which if

$$P(D) = .02$$

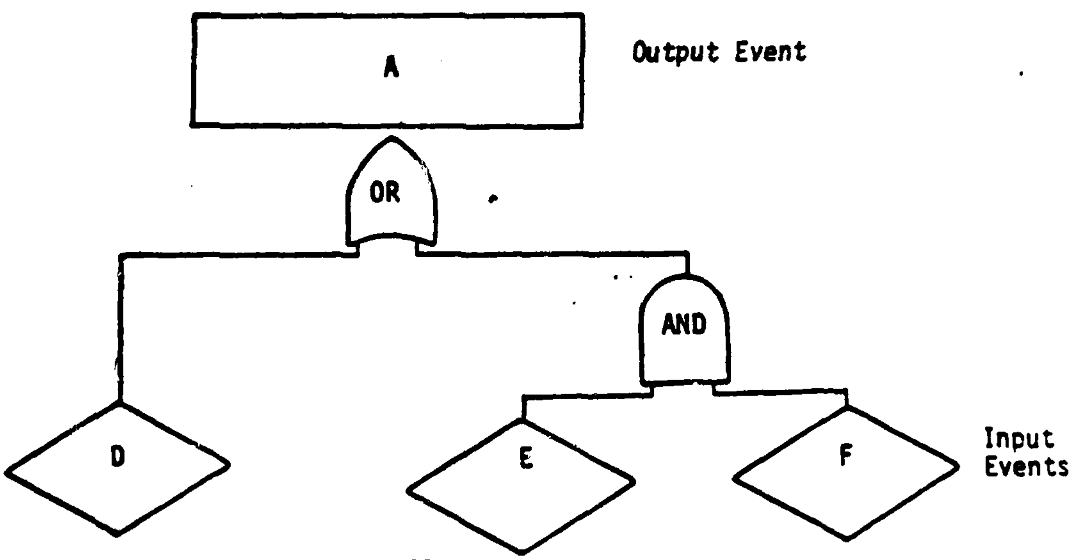
$$P(E) = .03$$

$$P(F) = .01$$

results in

$$P(A) = .0015$$

If, however, a Boolean reduction of the tree is performed, the resultant tree has the form



which contains no dependencies. Hence the correct value of the probability of event A is

$$P(A) = P(D) + P(E)\,P(F)$$

$$= .0203$$

The 93% error obtained in this example by combining probabilities involving dependent events makes clear the importance of reducing the tree before performing these calculations.

2. Application to VICON

a. Tree Construction. The application of Fault Tree Analysis to the determination of the reliability of the VICON System begins with the construction of a Fault Tree that is based on the definitions of system failure and runway failure given in Section II. A.

Construction is begun by stating the basic undesired event at the top of the tree, i.e., the VICON system is unavailable for use. From the definition of system failure and the runway configuration at Bradley (see Figure 3-6) it can be seen that the VICON system is failed if any of the following twelve pairs of runways are simultaneously failed: (1, 6), (1 & 15), (1 & 24), (1 & 33), (6, 15), (6, 19), (6,33), (15,19), (15,24), (19, 24), (19,33) and (24, 33). This is reflected in the Fault Tree (see Appendix B, Figure 1) by having a twelve input OR gate to represent system failure, each input in turn being an AND gate whose two inputs correspond to one of the noted runway pairs. The gates involved are the OR gate TOP and the AND gates G-3 through G-14. Gates G-1 andG-2 are dummy gates necessary to the proper operation of the computer program used in plotting the fault trees, they are not related to any element of the VICON system and have no effect on the analysis. The other inputs to gate TOP (C1 and C2) occupy their positions in the tree as a result of preliminary analysis rather than as a result of basic tree construction principles; hence, they will be discussed in subsequent paragraphs of this section.

Development of the next level of the Fault Tree follows directly from the departure point utilization statistics for Bradley. For example, in the case of runway 06, the runway is failed when any two of the four lamp clusters (2, 4, 5, and 19) are out of service, since these failures constitute a 50% loss in total lamp clusters. This is shown in the Fault Tree by OR gate 26 and AND gates 27 through 32. Runway 06 is also failed whenever cluster 19 alone is failed since this cluster will handle 93% of the departures from runway 06. This situation is represented in the tree by showing gate 26 and loss of cluster 19 in an OR combination (gate 25). The lamp cluster failure combinations needed to produce a runway failure are determined in a similar fashion for each of the other five runways.

Development of the tree is completed by analyzing the system and diagramming all the possible causes for the failure of each of the 21 lamp clusters. Taking cluster 10 as an example, this cluster will fail whenever any of the three major elements shown in Figure 3-1 fail; i.e., the lamp cluster itself, the control and monitoring equipment and the interconnecting circuitry. This is represented on the lamp cluster fault tree (Figure 11 in Appendix B) by showing the lamp cluster (G-56), the tower-monitor circuit (G-250) and the control circuit (G-195) connected by an OR gate (C-55) at the top of the lamp cluster tree. G-145, G-184 and G-202 are also connected to the top of the tree even though these items are shown in Figures 3-1 through 3-5 as a part of the lamp control circuit. These items are shown separately since they are common to all lamp clusters; i.e., there is only one intensity selector, one pulser and one 48 VDC supply for the entire VICON system; the remaining items in Figure 11 are related only to lamp cluster 10. This separation of common and unique items in the lamp cluster 10 tree is made in the interest of computer utilization efficiency. The separation permits calculation involving the common items to made once and included in all lamp cluster trees by reference rather than repeating these computations twenty-one lines.

Continuing through the tree, component relationships shown by Figures 3-2, 3-3, 3-4 and 3-5 are translated into the failure logic of the tree. In the simplest case, the lamp cluster (G-56) fails whenever any one of the three series filament lamps fails. Even in the legs of the tree containing larger numbers of components, the failure relationship is essentially that of a lamp cluster failing whenever any associated component fails. The only major exceptions is in the lamp intensity circuit where AND gates G-147, G-148 and G-149 are used to reflect the fact that intensity is lost only if both manual and auto intensity control are failed simultaneously.

This fault tree development procedure is followed for every branch of the tree until each branch ends at the component level at which repair is normally made, as dictated by the maintenance policy established for the Bradley installation. This results in a wide variation in the complexity of the components found at the ends of the various branches. For example, the branch from G-707 terminates in simple items (fuses) which cannot be further subdivided and in complex items (power supply) which could be broken down further if the repair philosophy of VICON required power supply repair instead of replacement.

When all branches of the tree had been carried to the level at which repair is accomplished, the fault tree design was complete.

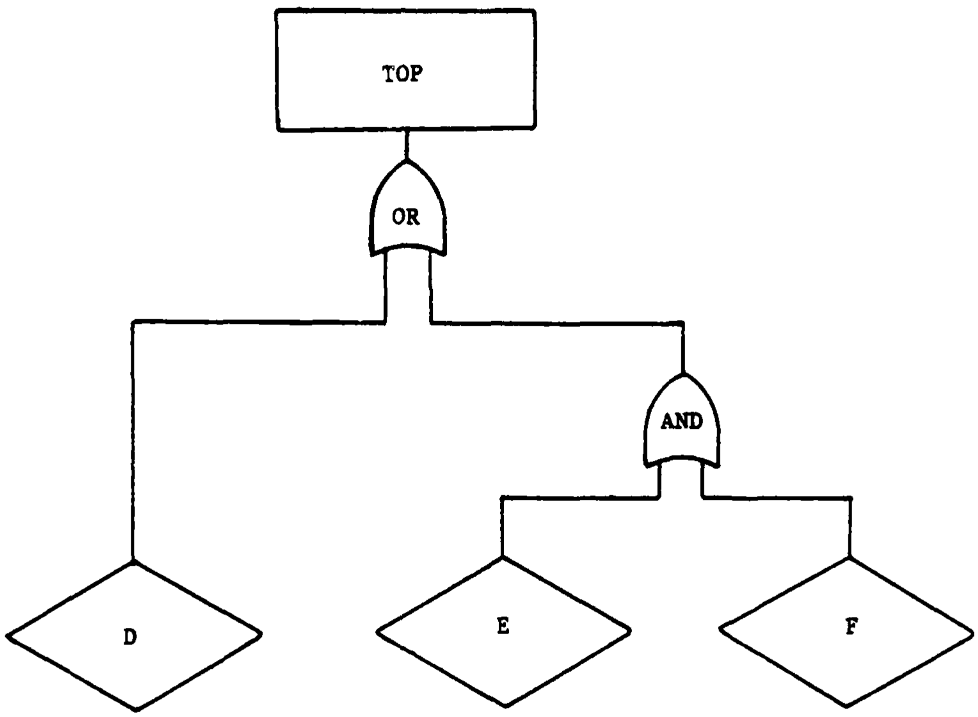
b. Analysis

The analysis of the VICON fault tree was conducted in three steps: (1) a preliminary manual analysis, (2) a computerized qualitative analysis and (3) a computerized quantitative analysis. The preliminary analysis was performed solely for the purpose of expiditing the computerized analyses and the computerized plotting of the trees. The qualitative analysis was conducted to assess the relative impacts of the failures of various components on total system performance. The results of this analysis were used to locate weaknesses in the design configuration, determine the need for reduncancy and identify critical components for use in the spare parts stock level analysis. The quantitative analysis consisted of a numerical assessment of the reliability (or availability) of the VICON system.

(1) Preliminary Analysis -- The preliminary analysis consists of a manual inspection of the initial fault tree construction to identify those components, if any, that are common to all branches of the tree. These common components are deleted from all branches and replaced by a single entry to the top gate of the tree. (The two power supplies shown at the top of Figure 1 of Appendix B are such components in the VICON system). This rearrangement drastically reduces the number of steps in the computerized analysis. Note that the preliminary analysis need not be exhaustive, the computerized analysis will function without any preliminary analysis.

(2) Qualitative Analysis -- The qualitative analysis consisted of the reduction of the fault tree to its minimal cut sets.

A cut set of a fault tree is defined as any set of elementary events whose occurance cause the top event to occur. In terms of the VICON system a cut set is any component or collection of components whose failure causes the system to fail. A cut set is minimal, if it cannot be reduced and still insure the occurance of the top event. As an illustration of cut sets and minimal cut sets consider the following fault tree.



The cut sets of this tree are (D), (D, E), (D, F), (D, E, F), (E, F). The minimal cut sets are: (d),(E,F). Cut sets (D,E), (D, F), (D, E, F), are not minimal since they can be reduced; i.e., element E, removed from (D, E), element F from (D, F) and E and F from (D, E, F) and the top event will still occur.

The toal number of cut sets for a fault tree the size of the VICON tree may well number in the hundreds of thousands making it impossible to determine them by manual inspection and impractical to find all of the cut sets even with a large digital computer. It is not, however, necessary to find all of the cut sets of a fault tree to determine the system reliability or to analyze the system for design changes to improve reliability. The number of cut sets required for the calculation of system reliability depends on both system configuration and component type and application; this will be discussed in the section on quantitative analysis. For qualitative analysis, cut sets are enumerated according to size beginning with sets of size one, and continuing until the analyst has sufficient information to determine the impact on system reliability. The number of classes of cut sets that must be obtained varies with the parameters of the system and must be established by the analyst for each system.

Determination of all cut sets of size one and size two is sufficient for the qualitative analysis of the VICON system. Reference to Table 1 in Appendix A shows that the VICON Fault Tree reduces to 11 cut sets of size one and 6432 cut sets of size two. The existence of cut sets of size one means that there are components in the VICON system whose failure, with all other components operating, will cause the entire VICON system to be inoperative. The number of these components, eleven, is small enough to permit consideration to be given to redesign in each of these eleven areas. The 6432 cuts sets of size two represent situations in which two components must fail simultaneously for system failure to occur, and should therefore be considered satisfactory. Furthermore, consideration of 6432 areas for design change is not a modification but a complete redesign. Hence, the qualitative analysis for VICON is limited to cut sets of size one.

Each of the cut sets of size one was reviewed to determine the hardware relationships that cause system failure to result from a failure of single component and to assess the feasibility of a design change to eliminate the dependence of the system on a single component.

Components A1-48V, T1-48V, 48V X 1, 48V X 2, 48VF1 and 48VF2 are all part of the 48VDC supply used for the relays of the hardwire control system; they are respectively the power supply, an external input transformer for the power supply, the input circuit breakers for the power supply and the output fuses for the power supply. Failure of any one of these components will cause loss of the hardwire control relays in all twenty-one lamp circuits. Lamp clusters 18, 19, 20, and 21 will operate, via radio-link only, with the 48VDC supply failed; however, under the definitions of runway and system failure being used, the system would be considered failed. The simplest and most cost effective method of improving system reliability in this area is to add another complete set of those six components to create two parallel 48VDC supply systems.

Items C1 and C2 are also power supplies, C1 being the lamp/indicator supply for the tower monitor circuits while C2 is the 24VDC supply for the relays in the tower monitor circuit. Loss of C1 will cause the loss of all indicator lamps making it impossible for the controller to verify system operation and resulting in a system failure. Loss of C2 will make the control and timer relays inoperative in the tower control circuitry for all twenty-one lamp clusters, also a system failure. As in the case of the 48VDC supply, it is recommended that dual redundant systems be used for both lamp/indicator and relay supplys.

M1 is the pulser which is used to apply pulsating ground to the lamp clusters in order that the lamps flash when operating; however, since all lamp grounds in the hardwire control system are controlled by the same pulser, loss of M1 makes all twenty-one hardwire control circuits inoperative. The four lamps with radio-link will remain functional on radio-link only, but the system is by definition failed.

In order to eliminate the total system dependence on a single pulser, it is recommended that the system be modified to use a separate pulser in the ground circuit of each lamp cluster, or if it is desired to keep the hardwire and radio-link controls as independent as possible, two pulsers will be necessary for each lamp having dual control. If individual pulsers are used for each lamp cluster, the three pulser relays now used to divide the current load are no longer necessary and should be eliminated.

The intensity selector switch, S29, controls the intensity of every lamp cluster on the field, hence failure of this switch will effect the operation of all clusters; the effect depending on the failure mode of the switch. The switch can fail in five modes; (1) maintain lamps at high intensity regardless of desired operation (2) maintain lamps at low intensity, (3) preclude lamps being operated at low intensity, (4) preclude automatic intensity selection and (5) preclude manual inteusity selection. Hence, while switch failure will effect all lamp clusters, failure will occur only if ambient light conditions exist which require a particular lamp intensity for VICON operations, a situation which has not yet been evaluated. It is therefore recommended that no change be made in this area.

The override switch, S27, is used by the controller to cancel any or all of the VICON lamp clusters that are operating. The effects of the failure of this switch on system operation depend on the mode of the failure. If the switch fails so as to lose electrical continuity or mechanically so that once operated it will not return to the normal position, the holding circuit ground will be lost (hardwire and radio-link) to all lamp clusters and the system will be totally inoperative. If, however, the switch fails mechanically so that it cannot be operated, the controller loses the override control function and any VICON lamp cluster that has been turned on will remain illuminated until shut off by either the timer or the microwave detector. The later failure mode could lead to an aircraft receiving an unintended VICON clearance; however, for this to occur the controller must make an error in granting a clearance at the same time that this failure mode exists. For this situation to result in an unintended take off, the pilot in command of the aircraft must also commit an error and take off without voice clearance.

Circuit modification can be made in this area to reduce the probability of one failure mode or the other, but not both. If it is desired to reduce the probability that an open switch will make all lamp clusters inoperative the single override switch should be replaced by individual override switches for each runway. This modification would have two draw backs: (1) it will add slightly to operator inconvenience and (2) it will increase the probability of the granting of an unintended VICON clearance due to switch failure. On the other hand, if it is desired to reduce the probability of an unintended VICON clearance, the single override switch should be replaced by two such switches in series providing for both an override and an emergency override function.

It is impossible to make a complete assessment of this situation on the basis of qualitative analysis alone and data are not available on the probabilities of human error making a quantitative analysis of the situation impossible. It is suggested, however, that since two simultaneous failures (one component, one human error) are needed to cause an unintended clearance and an additional human error needed for unintended take off, the failure closed mode of the switch can be ignored. Hence, it is recommended that the decision to use one or six override switches be based on the operator convenience factor; the single switch being retained the use of six switches presents an unacceptable degradation in convenient operation.

There is one additional design change to be considered that results from engineering analysis rather than analysis of the fault tree. The flashing of the monitor lights that indicate lamp cluster operation to the controller are controlled by a different shut-off timer than the one that controls the flashing of the VICON lamps themselves. It is recommended that the same device be used to control both the lamp cluster and the tower indicator to preclude the possibility of an erroneous indication resulting either from component failure or human error in setting the times.

(3) Quantitative Analysis - The quantitative analysis of the VICON fault tree serves to: (1) obtain a numerical measure of overall system ability to perform its intended function, and (2) provide a numerical assessment of the impact on system performance of each of the design changes recommended in the qualitative analysis section.

As the first step in computing a numerical index of VICON system performance it is necessary to define an appropriate system level measure that is related to determinable component characteristics. It can be noted from the definition of runway failure that the key to VICON performance is the state (functioning or non-functioning) of one or more lamp clusters at the time these clusters are called upon for use. It is immaterial in terms of this definition when a lamp cluster entered the state (functioning or non-functioning) in which it is found when it is asked to operate. In other words, a non-functioning lamp cluster counts equally in assessing runway (and system) failure whether the cluster failed days, hours, or moments before an attempt to use the lamps. Conversely, the cluster counts equally as a success whether it has never failed since installation or whether it was repaired only moments before an attempt to use it to grant a VICON clearance. This characteristic is known technically as Availability and is formally defined as; The probability that a device is in an operable and committable state at any instant in time when it is desired to use the device. Availability can be assessed at any device level; system, equipment or individual component and is related to the device characteristics of reliability and maintainability through the expression

$$A = \frac{MTBF}{MTBF + MTTR} \qquad (1)$$

where

A = Availability

MTBF = mean time between failures, a measure of device reliability

MTTR = mean time to repair, a measure of device maintainability

From this equation it can be seen that availability measures the proportion of total time during which the VICON system is capable of operation, taking into account both the frequency of failure (MTBF) and the speed with which a failed item can be restored (MTTR). The importance of using Availability as the measure of performance for any repairable item rather than Reliability, defined as the probability of no failure in a given time, can be seen by comparing the Availability and Reliability values for a single component of the VICON system, one of the lamps. The manufacture of these lamps quotes their MTBF to be 1000 hours and the MTTR has been estimated to be 1 hour. Lamp reliability is determined from

$$R = e^{-\left(\frac{1}{\theta}\right) t}$$

where

R = Reliability

θ = MTBF

e = 2.7183

t = time in hours

(This equation assumes exponentially distributed failure times, the customary assumption in the case of electronic/electrical devices). Using time periods of one day, one month and six months:

R_1 day = 0.9763

R_1 month = 0.4868

R_6 month = 0.0133

Lamp availability is, however:

$$A = \frac{1000}{1000 + 1} = 0.9990$$

regardless of the length of time the lamp has been operational.

VICON System Availability is determined by using the logic of the fault tree to combine the unavailabilities of the individual components into a system unavailability figure whose complement is the desired numerical value.

Unavailabilities are determined for each component of the VICON System as the complements of values calculated by equation (1) using MTBF and MTTR values obtained from various sources. Component MTBF values were obtained from the supplies of the components when possible or from published tables of generic failure rate (the reciprocal of MTBF) such as MIL-HDBK-217. Vendor data are considered to be superior when available as they are more likely to reflect current state of the art than information published in handbooks having lengthy revision cycles. The failure rates in MIL-HDBK-217 do offer the advantage of being quite conservative so that their use involves no danger of over estimating the VICON System's capabilities. Component MTTR values were determined from estimates made by personnel experienced in maintaining the VICON System at Bradley and the predecessor system at NAFEC.
This method is considered superior to the handbooks values since MTTR is so highly dependent on system configurations that handbook values are crude approximation at best. Table 4-1 lists the major components of the VICON System with their failure rates and MTTR values together with the source of

TABLE 4-1

SOURCES OF FAILURE RATES

COMPONENT	No. Used	Repair Rate (Repair/Hour)	Failure Rate (Failures/10^6Hr)	Source of Failure Rates
Twr-Microwave Switch	4	0.67	0.011	Mil-HDBK-217C
300-33086 Microwave Detector	4	0.40	50.290	Omni-Spectro (Manufacturer)
91760-002 Master Transceiver	1	1.00	46.474	Computed Based on MIL-HDBK-2176
91760-002 Remote Transceiver	4	0.67	46.474	"
20-20 Runway Act. Switch	6	0.33	66.670	Manufacturer's Spec.
20-20 Override Switch	1	0.33	66.670	"
20-20 Departure Act. Switch	20	0.33	66.670	"
156-146100 Twr Control Relay	20	0.33	0.300	MIL-HDBK-217C
a43-01a Twr Timer Relay	20	0.33	0.790	"
1N 3613 Diode	59	0.33	0.036	"
Rem-pri Sel Switch	2	0.33	0.670	"
Rem-pri Act Switch	2	0.33	0.011	"
6263b 0-20 Volt Pwr Supp.	1	1.00	21.097	Hewlett-Packard (Manufacturer)
62024e 24 volt Pwr Supp.	1	1.00	7.358	"
AU-5894 48 Volt Pwr Supp.	1	1.00	43.45	NAVSHIPS 9382

TABLE 4-1

SOURCES OF FAILURE RATES

COMPONENT	No. Used	Repair Rate (Repair/Hr)	Failure Rate (Failures/10^6Hr)	Source of Failure Rates
Q6-6-PAR-562 Runway Lamp	63	1.00	1,000	GE (manufacturer)
REM-HDWE SEL. SWITCH	4	0.67	9.011	MIL-HDBK-217C
Intensity SEI, SWITCH	1	0.30	0.670	"
MR 5498-48VDC Auto Cmtl Relay	1	0.67	0.300	MIL-HDBK-217C
MV 5498-48VDC Lon Cntl Relay	1	0.67	0.300	"
KR 5498-48VDC Relay	23	0.67	0.300	"
Pbtb-365 .5 mfd Capacitor	25	0.67	0.031	"
At-15 Master (ASR) Photocel	1	0.67	0.031	Vitro Labs Reliability & Availability Analysis for solid state system sequence, September 1977
At-15 Remote Photocel	4	0.50	0.031	
100 w., 2 watt resistor	25	0.67	0.016	MIL-HDBK-217C
Kaa 20 Lamp P-S Fuse	7	1.33	0.100	"
Kaa 20 remote lamp fuse	4	1.33	0.100	"
W10G2 Lamp P-S Variac	7	0.67	0.106	"

TABLE 4-1

SOURCES OF FAILURE RATES

COMPONENT	No. Used	Repair Rate (Repair/Hour)	Failure Rate (Failure/10^6 Hr)	Source of Failure Rates
PRD11ayo hi-lo sel relay	7	0.67	1.000	MIL-HDBK-217C
PRD11ayo power relay	21	0.67	1.000	"
PRD11ayo remote power relay	4	0.50	1.000	"
PRD11ayo remote hi-lo relay	4	0.50	1.000	"
PRD11ayo pulsar power relay	4	0.67	1.000	"
10601eelb Master (ASR Pulsar	1	0.67	0.300	"
10601eelb Remote Pulsar	4	0.50	0.300	"
Mov-130V Surpress	46	0.67	0.720	"
Cub51-70120 timer relay	21	0.50	0.790	"
Cub51-70120 remote timer relay	4	0.50	0.790	"
112 XAX 1195 Monitor Relay	21	0.67	0.300	"
Fusetron 2a for 48 Volt Fuse	2	0.67	0.100	"
48 Colt P-S Transformer	1	0.67	0.053	"
Kupllal5-120V Remote Aux. Relay	4	0.50	0.300	"
112 xax 595 Rem. monitor relay	4	0.50	0.300	"
W8g2 Remote Variac	4	0.67	0.106	"
Remote Power Switch	4	0.67	0.011	"
48 PS Volt Circuit breaker	2	0.67	2.000	"

the failure rates. It should be noted that wire and cable are not included in this list. It is recognized that these items do fail; however, true random failures of these items are so rare as to be marked by failures originating from lot peculiar quality problems, human errors by installation and maintenance personnel and acts of nature. Any estimate of failure rates for wire and cable will therefore be representative of a particular production lot and a particular installation not of wire and cable behavior in general. The impact of neglecting wire and cable in the calculation of VICON System availability will be negligible provided wire and cable were thoroughly inspected prior to installation and properly tested following installation.

Once component unavailabilities have been determined, system unavailability is obtained by using the combinatorial rules given in Section A.1 of this chapter (multiplication of AND gate inputs and addition of OR gate inputs) in the reduced tree described by the minimal cut sets. From the definition of minimal cut sets, it can be seen that a fault tree constructed of all the minimal cut sets is equivalent in logic to the original tree and is also free of dependencies thereby allowing use of the computational rules of Section A-1 of this Chapter. The equivalent cut set tree is constructed by taking the OR combination of all cut sets, where cut sets of more than one component are represented by the AND combination of all components in the set. Consequently, the system unavailability value is obtained by summing the unavailabilities across all cut sets, the cut set unavailabilities having first been found as the product of the unavailabilities of their components. The figures across any line of appendix A represent; in the first column, the cumulative unavailability due to all cut sets appearing from the top of the table through the indicated line; in the second column, the unavailability of the cut set on the indicated line; and in the remaining columns, the unavailabilities of each component in the cut set on that line. The final number in the first column of figures (0.0005364569) is the system value and corresponds to a system availability of 99.94%.

It should be remembered that the numerical value of VICON System availability reported here is based on the particular installation at Bradley International Airport and on the definition of system failure given in Chapter 3, which is in turn based on a primary mission of data collection rather than aircraft control. Since the system failure definition used is also reasonable when referred to the aircraft control mission, the 99.94% availability figure obtained may also be considered valid for an operational system installed at Bradley. Availability as a measure of VICON System performance does not, however, give any consideration to the situation of inadvertent granting of a VICON clearance. Final analysis of any operational VICON System should include an assessment of the inadvertent clearance situation.

It can be seen from Appendix A that the 11 cut sets of size one contribute approximately 25% of the total system unavailability with the remaining 75% of the unavailability being associated with the 6432 cut sets of size two. It is therefore reasonable to concentrate on those hardware items associated with the size one cut sets in any effort to improve system availability through design change. The results of the qualitative analysis reported in the preceding section have in fact recommended design changes associated with 10 of the 11 size one cut sets. To assess the impact of these recommendations, the changes are considered in three groups: (1) use of dual redundant power supplies instead of single units now used, (2) redundant power supplies plus change to individual pulsers for each lamp cluster and (3) both changes (1) and (2) together with use of individual override switches for each runway. To determine the numerical impact of change (1) it is only necessary to note that this change will reduce the unavailability contribution of each power supply component to one-half its present value; subtracting one-half of the unavailability contribution of the eight power supply items raises system availability forms its present value of 99.94% to 99.95%. The added effect of the recommended pulser change can be approximated by noting that with the change the pulser will no longer appear as a cut set of size one but as cut sets of size two corresponding to all possible combinations of pulser failures with each of 12 other components over each of 12 possible runways pairs or 144 cut sets of size two. This will result in an increase in system availability to at least 99.97%, (approximated using combination of pulser and highest failure rate component). Finally the override switch modification will have the same general effect as the pulser modification and will increase system availability to at least 99.99%. Care must be taken in interpreting these figures since what appears to be only a modest improvement in system availability (99.94% to 99.99%) is actually the result of an 83% reduction in the current system unavailability, a sufficiently significant achievement to verify the importance of the recommended design changes.

The reliability of the VICON System is not a basic factor in assessing the performance of the Bradley installation in collecting assessment data; however, the reliability associated with the granting of an individual VICON clearance is of interest with regard to assessing the validity of the data collected at Bradley and in forecasting the ability of an operational VICON System to provide clear, unambiguous information to departing aircraft.

Using the failure rates given in Table 4-1, the total failure rate for those items necessary to the operation of any single lamp cluster is 3477.17 X 10^{-6} failures per hour. Assuming that the average VICON clearance operation requires 20 seconds, the probability of no failure occuring while the clearance is in process is 99.998%. Hence, it can be expected that one failure will occur in every 50,000 clearances.

The Bradley installation contains two cases of competing design concepts in simultaneous operation for test purposes; timer vs. microwave detector for system shutoff and hardwire vs. radio link for the interconnecting circuit between operator controls and lamp clusters.

Reliability comparisons for each pair of competing concepts provide one basis for selecting the concepts to be preferred in an operational VICON system.

Comparison of the timer vs. microwave detector is made simply on a component basis while comparison of the hardwire vs. radio link systems is made on the basis of the aggregate of all components needed for the operation of any one single lamp cluster.

The reliability of the timer over a period of 20 seconds is 99.9999996% while that of the microwave detector is 99.9999721%. Hence, in terms of clearance operations, the timer can be expected to cause 1 failure every 250,000,000 operations while the microwave detector will cause 1 failure in approximately 300,000 operations. A similar comparison of the two control systems shows the hardwire system to have a 20 second reliability of 99.9981477% while the radio link value is 99.9980959%. This corresponds to approximately 1 failure in 54,000 operations for the hardwire system and 1 failure in 53,000 operations for the radio link.

Availability comparisons shows a similar result with timer = 99.999 vs. microwave detector = 99.990% and hardwire = 99.62% vs. radio link = 99.61%.

It is clear that the timer offers a clear cut advantage over the microwave detector in terms of reliability and availability while the hardwire and radio control links have approximately the same impact on VICON reliability and availability.

B. Spare Parts Provisioning

This analysis determines the number of spare parts that should be stocked for each component in the VICON system in order to insure that the inherent availability of VICON is not degraded for lack of necessary spares to make needed repairs. It should be noted that the spares provisioning analysis performed is dependent on both the system configuration and the particular components used to implement it. The analysis included here is therefore strictly valid only for the VICON system currently installed at Bradley. However, it provides an illustration of the method for sparing any VICON system and could be used to spare the Bradley system if it were converted to operational status without major changes.

The basis of the analysis performed is the computation of what is termed the PROVISIONING PROTECTION LEVEL for the total VICON system based on a started provisioning period and an assumed set of spares. System provisioning protection level (protection level) is defined as the probability that no system failure remains unrepaired for lack of a spare part or alternatively as the probability that the number of failures in a provisioning period does not exceed the number of spares in stock. (Provisioning period is any selected time span, normally established in response to logistic considerations such as vendor lead time, shipping time, on site spares storage limitations and supply budget cycles). Protection level is computed for different spare part inventories until an inventory is found that provides the desired protection level for the assumed provisioning period.

System protection level is computed from the protection levels of each individual component in the system based on the reliability model of the system. For example in a simple three element series system such as

the system protection level is the product of the protection levels of three components or

$$PLsys = PL_A \times PL_B \times PL_C$$

In a redundant system such as

the system protection level is determined according to the rules for determining system reliablilty so that

$$PLsys = PL_A - (2PL_A - PL_B^2)\, PL_C$$

In this analysis the VICON system has been considered as a fully series system even though this is not true in the functional sense; i. e., there is redundency in the use of radio-links and hardwire control to certain lamp clusters and in the use of both timer and microwave detector shut off in the lamps. The functional redundancy in VICON is, however, provided by different hardware items not by identical sets of redundant hardware as is more common in redundant systems. Hence, VICON must be considered as a series system for sparing in order that spares be made available for all of the component types employed.

Component protection level is computed for each item by computing the probability that the number of failures of a given component during the provisioning period is equal to or less than the number of spares assigned to the given component. This computution is made using the failure rates shown in Table 4.1, the selected provisioning period and the assumption that component failurers have a Poisson destribution so that

$$PL = \frac{(N\lambda t)^X e^{-N\lambda t}}{X!}$$

where

N = number of parts of a given type in system

λ = part failure rate of a given part type

t = part operating hours in the provisioning period

X = number of spare parts in stock

N and λ are as shown in Table 4.1 and t was determined as follows

It is assumed, for the purpose of the spares analysis as follows, that the VICON system at Bradley would be required to function 18 hours per day every day and it was further assumed that a component was "operating" whenever it was subjected to an applied voltage regardless of whether or not there was current flow. Under these assumptions there are three different values of t that apply to VICON components;

(1) t_1 = 18 hours per day for components such as power supplys, auxillary relays, etc,

(2) t_2 = 1.74 minutes per day for components such as lamps, monitor relays, etc. that function only when a particular lamp cluster is functioning and

(3) t_3 = 36.51 minutes per day for the pulser and pulser relays that operate when any lamp cluster is functioning . Timer t_2 and t_3 were calcuated on the bases of an anticipated 23,000 total operations during the seven month test period and an "on" line for each lamp cluster operation of 20 seconds.

The initial calculation for each component is made with X = o (no spares) and the results combined to determine an initial system protection level. The system protection level is compared to the desired value and if less than the desired value spare parts are added to the inventory according the following rules:

1. Determine component with lowest individual protection level, add one spare for this part and recompute component and system protection levels.

2. Stop if system protection level is equal to or above the desired value, otherwise repeat step (1).

This procedure essentially operates to add spares for the worst component until either the desired system protection level is altered or the component being considered is no longer the worst. In the later case, attention is turned to the new worst component and the process repeated until the desired protection level is achieved.

This procedure will specify the spare parts needed to insure a given system protection level; however, in so doing it may well indicate that no spares are to be stocked for items that have very high reliability. The absence of such spares may be undersiriable in the case of components whose loss will have catastrophic results, regardless of the fact that the component has very high reliability; e. g., the pulser in the VICON system whose loss causes the loss of the entire system. The sparing level computation program provides a means for compensating for this situation by allowing selected components to be declared "critical". When this option is exercised the complete analysis is first made in the normal fashion and all spares assigned to achieve the desired system protection level, then all "critical" components are checked to insure that at least one spare has been provided and additional spared allocated as needed. All of the spares analyses made on VICON generate recommended spares lists both with and without "critical" component consideration.

The spares computation program is implemented to print out intermediate results begining with the achievement of a system protection level of 50% and providing an additional output for each 5% increment in system protection level until the desired result is obtained. This operation is illustrated by Table 4-2A which is the output associated with a VICON spares analysis at a 90% system protection level over a one (1) month provisioning period.

The initial page of this Table shows the VICON components coded as No. 1, 2, ..., 46 with the zero spares protection level for each component and the number of components installed listed immediately below the code number. The resulting system protection level of 25.29% is also given at the left margin. It should be noted that the there lowest component protection levels are 48% (No. 41), 80% (No. 40) and 89% (No. 38).

The second page of this table shows that a total of 2 spares had to be allocated to raise the system protection level above 50%. Displayed here for each component code number are the component protection level achieved by the first spares assignment and the number of spares of each component provided in this assignment. In accordance with the procedure previously discribed this spares allocation was achieved by allocating spares to the component with the highest failure rate. (No. 41) until its protection level exceeded that of No. 40, then treating No. 40 to bring the system value above 50%.

The remaining pages of Table 4-2A show the successive spares allocations necessary to achieve 5% increments in system protection level up through the desired value of 90%. At this point the sparing allocation without consideration of critical components is complete.

Table 4-2B displays the results of adding the "critical" component spares to the results of 4-3A where the VICON critical components were selected by including all of the components identified by the qualitative analysis as producers of size one cut sets together with all other components having a total population of one in the system. This essentially adds only the two insensity selection relays to the size one cut set items. The protection level value shown in this table are the achieved levels rather than the normal desired values shown in table 4-3A. Nine sparing analyses have been made of the Bradley VICON system representing the combination available from three different system protection levels, 90%, 95%, and 99% and three different provisioning periods, one month, 3 months, and 6 months. The results of these nine analyses are presented in Table 4.3A without use of the critical component opition and again in Table 4.3B with the addition of critical component consideration.

TABLE 4-2A

PROB. GOAL FOR EQUIP .9000

PHASE 1
PROBABILITY .25285[illegible]

PART OR PART TYPE RELIABILITY AND THE ASSOCIATED NUMBER OF PARTS — TOTAL PARTS 470

NU=	1	2	3	4	5	6	7	8	9	10
	.99962622	.99983263	.99983263	.99998271	.99999440	.99777043	.99997044	.97604644	.98824687	.99590266
	1	1	1	1	1	2	1	1	1	1
NU=	11	12	13	14	15	16	17	18	19	20
	.99988842	.97444088	.96348161	.94497073	.99999976	.99615681	.99956787	.99993086	.99977648	.99960947
	2	1	1	63	4	23	25	4	25	7
NU=	21	22	23	24	25	26	27	28	29	30
	.99977684	.99958611	.99610150	.99998122	.99999642	.99777043	.99992418	.99999881	.99815327	.99998498
	4	7	7	21	4	4	4	4	46	21
NU=	31	32	33	34	35	36	37	38	39	40
	.99599714	.95999374	.99933058	.95995881	.99976349	.99997544	.95999976	.89382303	.90146803	.79994559
	4	21	4	4	4	4	4	4	4	6
NU=	41	42	43	44	45	46	47	48	49	50
	.47519088	.99665731	.99122220	.99881530	.99925256	.99998772				
	20	20	20	59	2	2				

EQUIPMENT RESULTS

PROV. PROB.	PART OR PART TYPE PROV. PROB. AND THE ASSOCIATED NUMBER OF SPARES										TOTAL SPARES
.53941774	NO= 1 .99562622 0	NO= 2 .99983263 0	NO= 3 .99983263 0	NO= 4 .99998271 0	NO= 5 .99999440 0	NO= 6 .99777043 0	NO= 7 .99997044 0	NO= 8 .97604644 0	NO= 9 .98829687 0	NO= 10 .99590266 0	2
	NO= 11 .99981842 0	NO= 12 .97440088 0	NO= 13 .96348161 0	NO= 14 .94497073 0	NO= 15 .99999976 0	NO= 16 .99615681 0	NO= 17 .99956787 0	NO= 18 .99993086 0	NO= 19 .99977648 0	NO= 20 .99960947 0	
	NO= 21 .99577684 0	NO= 22 .99958611 0	NO= 23 .99610150 0	NO= 24 .99998122 0	NO= 25 .99999642 0	NO= 26 .99777043 0	NO= 27 .99992418 0	NO= 28 .99999881 0	NO= 29 .99815327 0	NO= 30 .99998498 0	
	NO= 31 .99999714 0	NO= 32 .99999374 0	NO= 33 .99933058 0	NO= 34 .99995881 0	NO= 35 .99976349 0	NO= 36 .99997544 0	NO= 37 .99999976 0	NO= 38 .89382303 0	NO= 39 .90146863 0	NO= 40 .97850269 1	
	NO= 41 .82875180 1	NO= 42 .99665731 0	NO= 43 .99122220 0	NO= 44 .99881530 0	NO= 45 .99925256 0	NO= 46 .99998772 0	NO= 47	NO= 48	NO= 49	NO= 50	

NU= 1 .99962272 0	NU= 2 .99983263 0	NU= 3 .99983263 0	NU= 4 .99998271 0	NU= 5 .99999440 0	NU= 6 .99777043 0	NU= 7 .99997044 0	NU= 8 .97604644 0	NU= 9 .98829687 0	NU= 10 .99590266 0
NU= 11 .99988842 0	NU= 12 .97450088 0	NU= 13 .76348161 0	NU= 14 .94497073 0	NU= 15 .99999976 0	NU= 16 .99615681 0	NU= 17 .99956787 0	NU= 18 .99993086 0	NU= 19 .99977648 0	NU= 20 .99960447 0
NU= 21 .99977684 0	NU= 22 .99558611 0	NU= 23 .99610150 0	NU= 24 .99996122 0	NU= 25 .99999642 0	NU= 26 .99777043 0	NU= 27 .99992418 0	NU= 28 .99999881 0	NU= 29 .99815327 0	NU= 30 .99998498 0
NU= 31 .99999714 0	NU= 32 .99999374 0	NU= 33 .99933059 0	NU= 34 .99999881 0	NU= 35 .99976349 0	NU= 36 .99997544 0	NU= 37 .99999976 0	NU= 38 .89382303 0	NU= 39 .90146863 0	NU= 40 .97850269 1
NU= 41 .96028274 2	NU= 42 .99865731 0	NU= 43 .99122220 0	NU= 44 .99881530 0	NU= 45 .99925256 0	NU= 46 .99998772 0	NU= 47	NU= 48	NU= 49	NU= 50

[illegible]

NU= 1	NU= 2	NU= 3	NU= 4	NU= 5	NU= 6	NU= 7	NU= 8	NU= 9	NU= 10
.99962622	.99783263	.99983263	.99978271	.99999440	.99777043	.99997044	.97604644	.98829607	.99590266
0	0	0	0	0	0	0	0	0	0
NU= 11	NU= 12	NU= 13	NU= 14	NU= 15	NU= 16	NU= 17	NU= 18	NU= 19	NU= 20
.99988842	.97440088	.96348161	.94477073	.99999976	.99615681	.99956787	.99993086	.99977648	.99960947
0	0	0	0	0	0	0	0	0	0
NU= 21	NU= 22	NU= 23	NU= 24	NU= 25	NU= 26	NU= 27	NU= 28	NU= 29	NU= 30
.99977684	.99950611	.99610150	.99998122	.99999642	.99777043	.99992418	.99999881	.99815327	.99998498
0	0	0	0	0	0	0	0	0	0
NU= 31	NU= 32	NU= 33	NU= 34	NU= 35	NU= 36	NU= 37	NU= 38	NU= 39	NU= 40
.99999714	.99999374	.99933058	.99979881	.99976349	.99997544	.99999976	.99415243	.90146863	.97850269
0	0	0	0	0	0	0	1	0	1
NU= 41	NU= 42	NU= 43	NU= 44	NU= 45	NU= 46	NU= 47	NU= 48	NU= 49	NU= 50
.96028274	.99665731	.99122220	.99881530	.99925256	.99998772				
2	0	0	0	0	0				

```
.76727910   NU=      1   NU=      2   NU=      3   NU=      4   NU=      5   NO=      6   NO=      7   NO=      8   NO=      9   NO=     10
            .99962622   .99981263   .99981263   .99998271   .99999440   .99777043   .99997044   .97604644   .98829687   .99590266
                    0           0           0           0           0           0           0           0           0           0
            NU=     11   NU=     12   NU=     13   NU=     14   NU=     15   NU=     16   NU=     17   NU=     18   NU=     19   NU=     20
            .99988842   .97440088   .96348161   .94497073   .99999976   .99615681   .99956787   .99993086   .99977648   .99960947
                    0           0           0           0           0           0           0           0           0           0
            NU=     21   NU=     22   NU=     23   NU=     24   NU=     25   NU=     26   NU=     27   NO=     28   NO=     29   NU=     30
            .99977684   .99958611   .99610150   .99978122   .99999642   .99777043   .99992418   .99999881   .99815327   .99998498
                    0           0           0           0           0           0           0           0           0           0
            NU=     31   NU=     32   NU=     33   NU=     34   NU=     35   NO=     36   NO=     37   NO=     38   NO=     39   NU=     40
            .99999714   .99999374   .99933058   .99999881   .99976349   .99997544   .99999976   .99415243   .99497795   .97850269
                    0           0           0           0           0           0           0           1           1           1
            NU=     41   NU=     42   NU=     43   NU=     44   NU=     45   NU=     46   NU=     47   NU=     48   NU=     49   NU=     50
            .96028274   .99665731   .99122220   .99881530   .99925256   .99998772
                    2           0           0           0           0           0
```

.83826653

NU= 1 .99962822 0	NU= 2 .99983263 0	NU= 3 .99983263 0	NU= 4 .99998271 0	NU= 5 .99999440 0	NU= 6 .99777043 0	NU= 7 .99997044 0	NU= 8 .97604644 0	NU= 9 .58829687 0	NU= 10 .99590266 0
NU= 11 .99988842 0	NU= 12 .97440088 0	NU= 13 .96340161 0	NU= 14 .99845749 1	NU= 15 .99999976 0	NU= 16 .99615681 0	NU= 17 .99956787 0	NU= 18 .99993086 0	NC= 19 .99977648 0	NU= 20 .99960947 0
NC= 21 .99977084 0	NC= 22 .99958611 0	NU= 23 .99610150 0	NU= 24 .99998122 0	NU= 25 .99999642 0	NU= 26 .99777043 0	NU= 27 .99992418 0	NU= 28 .99999881 0	NU= 29 .99815327 0	NU= 30 .99998498 0
NU= 31 .99999714 0	NU= 32 .99999374 0	NU= 33 .99933058 0	NU= 34 .99999881 0	NU= 35 .99976349 0	NU= 36 .99997544 0	NU= 37 .99999976 0	NU= 38 .99415243 1	NU= 39 .59497795 1	NU= 40 .97850269 1
NU= 41 .99290401 3	NU= 42 .99665731 0	NU= 43 .99122220 0	NU= 44 .99881530 0	NU= 45 .99925256 0	NU= 46 .99998772 0	NU= 47	NU= 48	NU= 49	NU= 50

.89[illegible]

NU= 1 .99962222 0	NU= 2 .99983263 0	NU= 3 .99983263 0	NU= 4 .99998271 0	NU= 5 .99999440 0	NU= 6 .99777043 0	NU= 7 .99997044 0	NU= 8 .97604644 0	NU= 9 .98829667 0	NU= 10 .99590266 0
NU= 11 .99908842 0	NU= 12 .99966949 1	NU= 13 .99932486 1	NU= 14 .99845749 1	NU= 15 .99999976 0	NU= 16 .99615681 0	NU= 17 .99956787 0	NU= 18 .99993086 0	NU= 19 .99977648 0	NU= 20 .99920947 0
NU= 21 .99977684 0	NU= 22 .99958611 0	NU= 23 .99610150 0	NU= 24 .99998122 0	NU= 25 .99999642 0	NU= 26 .99777043 0	NU= 27 .99992418 0	NU= 28 .99999891 0	NU= 29 .99815327 0	NU= 30 .99998498 0
NU= 31 .99997714 0	NU= 32 .99999374 0	NU= 33 .99933058 0	NU= 34 .99999881 0	NU= 35 .99976349 0	NU= 36 .99997544 0	NU= 37 .99999576 0	NU= 38 .95415243 1	NU= 39 .99497795 1	NU= 40 .97850269 1
NU= 41 .99290401 3	NU= 42 .99665731 0	NU= 43 .99122220 0	NU= 44 .99881530 0	NU= 45 .99925256 0	NU= 46 .99598772 0	NU= 47	NU= 48	NU= 49	NU= 50

9

```
.91362122   NU=       1   NU=       2   NU=       3   NU=       4   NU=       5   NU=       6   NU=       7   NU=       8   NU=       9   NU=      10      10
            .99962622    .99983263    .99983263    .99998271    .99999440    .99777043    .99997044    .99971074    .99829687    .99590266
                    0            0            0            0            0            0            0            1            0            0
            NU=      11   NU=      12   NU=      13   NU=      14   NU=      15   NU=      16   NU=      17   NU=      18   NU=      19   NU=      20
            .99984842    .99966949    .99932486    .99845749    .99999976    .99615681    .99956767    .99993086    .99977648    .99960347
                    0            1            1            1            0            0            0            0            0            0
            NU=      21   NU=      22   NU=      23   NU=      24   NU=      25   NU=      26   NU=      27   NU=      28   NU=      29   NU=      30
            .99977694    .99958611    .99610150    .99998122    .99999642    .99777043    .99992418    .99999881    .99815327    .99998498
                    0            0            0            0            0            0            0            0            0            0
            NU=      31   NU=      32   NU=      33   NU=      34   NU=      35   NU=      36   NU=      37   NU=      38   NU=      39   NU=      40
            .99999714    .99999374    .99933058    .99999881    .99976349    .99997544    .99999976    .99415243    .99497795    .97850263
                    0            0            0            0            0            0            0            1            1            1
            NU=      41   NU=      42   NU=      43   NU=      44   NU=      45   NU=      46   NU=      47   NU=      48   NU=      49   NU=      50
            .99297401    .99665731    .99122220    .99881530    .99925256    .99998772
                    3            0            0            0            0            0
```

TABLE 4-28

.93116196

NU= 1 .99999984 1	NU= 2 1	NU= 3 1	NU= 4 1	NU= 5 .99999994 1	NU= 6 .99999750 1	NU= 7 1	NU= 8 .99971074 1	NU= 9 .99993122 1	NU= 10 .99999160 1
NU= 11 1	NU= 12 .99966949 1	NU= 13 .99932486 1	NU= 14 .99845749 1	NU= 15 .99999976 0	NU= 16 .99615681 0	NU= 17 .99956787 0	NU= 18 .99993086 0	NU= 19 .99977648 0	NU= 20 .99960947 0
NU= 21 .99977684 0	NU= 22 .99958611 0	NU= 23 .99610150 0	NU= 24 .99998122 0	NU= 25 .99999642 0	NU= 26 .99777043 0	NU= 27 .99992418 0	NU= 28 .99999881 0	NU= 29 .99815327 0	NU= 30 .99978498 0
NU= 31 .99999714 0	NU= 32 .99999374 0	NU= 33 .99933058 0	NU= 34 .99999881 0	NU= 35 .99976349 0	NU= 36 .99997544 0	NU= 37 .99999976 0	NU= 38 .99415243 1	NU= 39 .99497795 1	NU= 40 .97850269 1
NU= 41 .99290401 3	NU= 42 .99065731 0	NU= 43 .99122220 0	NU= 44 .99881530 0	NU= 45 .99925256 0	NU= 46 .99998772 0	NU= 47	NU= 49	NU= 49	NU= 50

20

TABLE 4.3A

RECOMMENDED SPARES WITHOUT CRITICAL COMPONENT CONSIDERATIONS

PROVISIONING PERIOD	No. of Spares								
	1 Month			3 Months			6 Months		
DESIRED PROTECTION LEVEL	.90	.95	.99	.90	.95	.99	.90	.95	.99
COMPONENT									
Intensity Selswitch	0	0	0	0	0	1	0	0	1
kr549848vdc auto cntl relay	0	0	0	0	0	0	0	0	0
kr549848vdc low cntl relay	0	0	0	0	0	0	0	0	0
at-15 master (asr) photocel	0	0	0	0	0	0	0	0	0
1060leelb master (asr) pulsar	0	0	0	0	0	0	0	0	0
q0260 48 volt p-s ckt brea	0	0	1	0	1	1	1	1	1
48 volt p-s transformer	0	0	0	0	0	0	0	0	0
au-5894 48 volt pwr supp	1	1	1	1	1	2	1	2	2
626 lb 0-20 volt pwr supp	1	1	1	1	1	1	1	1	2
62024e 24 volt pwr supp	0	0	1	1	1	1	1	1	1
91760-002 master transcel	0	0	0	0	0	0	0	0	0
20 20 override switch	1	1	1	1	1	2	1	2	2
fusetron 2a for 48 volt psfuse	1	1	1	1	2	2	2	2	3
q6.6par562 runway lamps lamp	1	1	2	2	2	2	2	3	3
rem-hdwe sel. switch	0	0	0	0	0	0	0	0	0
kr549848vdc aux pilot relay	0	0	1	0	1	1	1	1	1
pbtb-365 .5microfarad capacito	0	0	0	0	0	1	0	0	1
at-15 remote photocel	0	0	0	0	0	0	0	0	0
100-, 2 watt resister	0	0	0	0	0	0	0	0	1
kaa20 lamp p-s fuse	0	0	0	0	0	1	0	0	1
kaa20 remote lamp fuse	0	0	0	0	0	0	0	0	1
w10g2 lamp p-s variac	0	0	0	0	0	1	0	0	1
prdllay0 hi-lo sel relay	0	0	1	0	1	1	1	1	1
prdllay0 power relay	0	0	0	0	0	0	0	0	0
prdllay0 remote power relay	0	0	0	0	0	0	0	0	0
prdllay0 remote hi-lo relay	0	0	1	0	1	1	1	1	1
prdllay0 pulsar pwr relay	0	0	0	0	0	0	0	0	0
1060leelb remote pulsar	0	0	0	0	0	0	0	0	0
mov-130v surpress	0	0	1	0	0	1	1	1	1
cub51-70120 timer relays	0	0	0	0	0	0	0	0	0
cub51-70120 remote timer relays	0	0	1	0	0	0	0	0	0
112xax1195 monitor relays	0	0	0	0	0	0	0	0	0
kup11a15120v remote aux, relay	0	0	0	0	0	1	0	0	1
112xax595 rem monitor relay	0	0	0	0	0	0	0	0	0
w8g2 remote variac	0	0	0	0	0	0	0	0	1
remote power switch	0	0	0	0	0	0	0	0	0
twr microwave switch	0	0	0	0	0	0	0	0	0
300 33086 microwave detector	1	1	2	2	2	3	3	3	4
91760-002 remote transcel	1	1	2	2	2	3	3	3	4
20 20 runway act switch	1	2	3	3	3	4	4	5	6
20-20 departure actswitch	3	3	4	6	7	8	10	11	12
156-14a100 twr control relay	0	0	1	0	1	1	1	1	1
a43-01a twr timer relay	0	1	1	1	1	1	1	1	2
1n1613 diode	0	0	1	0	0	1	0	1	1
rem pri sel switch	0	0	0	0	0	1	0	0	1
rem pri act. switch	0	0	0	0	0	0	0	0	0

TABLE 4.3B

RECOMMENDED SPARES WITH CRITICAL COMPONENT CONSIDERATION

PROVISIONING PERIOD	No. of Spares 1 Month			3 Months			6 Months		
ACHIEVED PROTECTION LEVEL	.93	.96	.992	.91	.96	.993	.91	.96	.993
COMPONENT									
Intensity Selswitch	1	1	1	1	1	1	1	1	1
kr549848vdc auto cntl relay	1	1	1	1	1	1	1	1	1
kr549848vdc low cntl relay	1	1	1	1	1	1	1	1	1
at-15 master (asr) photocel	1	1	1	1	1	1	1	1	1
10601eelb master (asr) pulsar	1	1	1	1	1	1	1	1	1
q0260 48 volt p-s ckt breaker	1	1	1	1	1	1	1	1	1
48 volt p-s transformer	1	1	1	1	1	1	1	1	1
au-5894 48 volt pwr supp	1	1	1	1	1	2	1	2	2
626 lb 0-20 volt pwr supp	1	1	1	1	1	1	1	1	2
62024e 24 volt pwr supp	1	1	1	1	1	1	1	1	1
91760-002 master transcel	1	1	1	1	1	1	1	1	1
20-20 override switch	1	1	1	1	1	2	1	2	2
fusetron 2a for 48 volt psfuse	1	1	[illegible]	1	2	2	2	2	3
q6.6par562 runway lamps lamp	1	1	2	2	2	2	2	3	[illegible]
rem-hdwe sel. switch	0	0	0	0	0	0	0	0	0
kr549848vde aux pilot relay	0	0	1	0	1	1	1	1	1
pbtb-365 .5microfarad capacito	0	0	0	0	0	1	0	0	1
at-15 remote photocel	0	0	0	0	0	0	0	0	0
100-, 2 watt resister	0	0	0	0	0	0	0	0	1
kaa20 lamp p-s fuse	0	0	0	0	0	1	0	0	1
kna20 remote lamp fuse	0	0	0	0	0	0	0	0	1
wl0g2 lamp p-s variac	0	0	0	0	0	1	0	0	1
prdllay0 hi-lo sel relay	0	0	1	0	1	1	1	1	1
prdllay0 power relay	0	0	0	0	0	0	0	0	0
prdllay0 remote power relay	0	0	0	0	0	0	0	0	0
prdllay0 remote hi-lo relay	0	0	1	0	1	1	1	1	1
prdllay0 pulsar pwr relay	0	0	0	0	0	0	0	0	0
10601eelb remote pulsar	0	0	0	0	0	0	0	0	0
mov-130v surpress	0	0	1	0	0	1	0	1	[illegible]
cub51-70120 timer relays	0	0	0	0	0	0	0	0	0
cub51-70120 remote timer relays	0	0	1	0	0	0	0	0	0
112xax1195 monitor relays	0	0	1	1	0	0	0	0	0
kupl1a15120v remote aux, relay	0	0	0	0	0	1	0	0	1
112xax595 rem monitor relay	0	0	0	0	0	0	0	0	0
w8g2 remote variac	0	0	0	0	0	0	0	0	1
remote power switch	0	0	0	0	0	0	0	0	0
twr-microwave switch	0	0	0	0	0	0	0	0	0
300-33086 microwave detector	1	1	2	2	2	3	3	3	4
91760-002 remote transcel	1	1	2	2	2	3	3	3	4
20-20 runway act switch	1	2	3	3	3	4	4	5	6
20-20 departure actswitch	3	3	4	6	7	8	10	11	12
156-14c100 twr control relay	0	0	1	0	1	1	1	1	1
a43-01a twr timer relay	0	1	1	1	1	1	1	1	2
1n3613 diode	0	0	0	0	0	1	0	1	1
rem-pri sel switch	0	0	0	0	0	1	0	0	1
rem pri act. switch	0	0	0	0	0	0	0	0	0

APPENDIX D

STRUTHERS-DUNN PROGRAM DIRECTOR MODEL 3001 ENVIRONMENTAL TESTS

(This document was reprinted in its entirety
for presentation in this appendix.)

Project No. 143-152-300
Report No. 80-21
February 8, 1980
Struthers-Dunn
Program Director
Model 3001
Environmental Tests

General:

This report presents the results of functional tests of one Struthers-Dunn Program Director, Model 3001, during and following exposures to temperature and humidity extremes. The tests were requested by Mr. Bret B. Castle, ANA-410.

Material Submitted:

1. One Program Director, Model 3001, manufactured by Struthers-Dunn Company.

2. One test assembly, consisting of 21 small incandescent lamps with 21 corresponding activate switches and one override switch.

3. One 48 volt power supply.

Test Sequence:

The following test sequence was performed by Mr. Michael Petri, ANA-410, at appropriate times to assess the performance of the Program Director, Model 3001, while subjected to the test environments.

1. Light nos. 1, 2 and 3 were activated and then timed out, thus checking that the clocks and counter resets were functioning properly.

2. Lights 4, 5 and 6 were activated, then override was pressed; thus turning all 'ights off. This demonstrated that the override function worked properly by turning off all lights and resetting the counters.

3. Lights 7, 8 and 9 were activated and timed out.

4. Lights 10, 11 and 12 were activated and then reset.

5. Lights 13, 14 and 15 were activated and timed out.

6. Lights 16, 17 and 18 were activated and then reset.

7. Lights 18 and 19 were turned on, then switches 20 and 21 were pressed to make sure the lockout feature was operating. Then another light was pressed to make certain the lockout feature only locked out lights 20 and 21.

8. Lights 20 and 21 were turned on, then switches 18 and 19 were pressed to make sure the lockout feature worked properly. Another light was pressed to make certain only lights 18 and 19 were locked out.

9. The 48 volt power supply was turned off, then back on, to insure that the automatic reset was working.

10. Many switches were pressed to check that only three lights could be turned on at any one time.

11. Light no. 2, showing the 20 second countdown, was activated to check the liquid crystal display for legibility.

Test Methods and Results:

On January 31, 1980, the "Director" was placed in a Tenney Engineering Environmental Chamber, Model 27STR-50206, and the test sequence performed at room ambient temperatures. Power was then shut off on the "Director" and the chamber temperature lowered to -12°C, until the test unit temperature reached -10°C (2-1/2 hours) and the chamber temperature then held at -10°C for an additional hour. Test sequence was then run within 15 minutes of applying power to the "Director."

Following the tests at -10°C, the chamber temperature was increased with power applied to the "Director" and its temperature monitored. The test sequence was repeated at 0°C, 10°C, 20°C, 30°C, and 40°C. The test unit and chamber were then turned off and allowed to return to room ambient conditions for 3 days.

On February 4, 1980, all sources of moisture in the chamber, including the chamber wet bulb instrumentation, were closed off. The "Director" was turned on and the chamber temperature raised to 50°C, with the chamber "breathing" room ambient air. The test sequence was performed seven times at hourly intervals during the day, and again at 0830 on February 5. From dewpoint and wet and dry bulb measurements of the room ambient air over the period, the relative humidity in the chamber was calculated as approximately 3 percent.

On February 5, following the test sequence, the "Director" was turned off and the humidity instrumentation and controls for the chamber turned on. The relative humidity, as indicated by wet and dry bulb temperature differential sensors, was maintained at an average of 93 percent with excursion between 92.5 percent and 98.5 percent, for 24-1/2 hours at 50°C.

On February 6, at 1100, the "Director" was turned on and the test sequence performed. The chamber was then shut off and opened to room air for an hour and a half. The chamber was then closed and the temperature of the "Director" dropped to -17.7°C, and the test sequence performed at 1516. The chamber was then allowed to return to room ambient conditions overnight and the equipment returned to ANA-410 for further operation.

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The "Director" worked properly during all performances of the test sequence. At low temperature, the liquid crystal display was sluggish in the transitions of its active segments; the 1/10 second digit being practically undistinguishable for some observers, and the tens of seconds digit distinguishable but not sharp in contrast against the background.

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Frank J. Bain, ANA-151

Checked by: Bret Castle

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