NATIONAL BUREAU OF STANDARDS REPORT

9484

Development, Testing, and Evaluation of Visual Landing Aids
Consolidated Progress Report for the Period October 1 to December 31, 1966

By
Photometry Section
Optics Metrology Branch
Metrology Division
Institute for Basic Standards

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT		NBS REPORT
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Development, Testing and Evaluation of Visual Landing Aids

Consolidated Progress Report to

Ship Installations Division
and
Meteorological Division
Naval Air Systems Command
Department of the Navy

and to
Federal Aviation Agency

For the Period
October 1 to December 31, 1966

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Development, Testing, and Evaluation of Visual Landing Aids
October 1 to December 31, 1966

I. REPORTS ISSUED

Report No.	Title
9453	Development, Testing, and Evaluation of Visual Landing Aids, Consolidated Progress Report for Period July 1 to September 30, 1966
212.11P-85/66	Temperature Measurements of an L-850 Light with a 499-Watt Lamp
Memorandum Report	Malfunctioning Runway Identification Light
Memorandum Report	Three Flashtube Assemblies Submitted for Measurement by N.A.F.E.C.
Progress	Test Bed for Sperry-Rand Laser Visibility Meter October 10 to November 10, 1966.
Progress	Test Bed for Sperry-Rand Laser Visibility Meter August 19 to October 10, 1966.

II. VISIBILITY METERS AND THEIR APPLICATION

Shipboard Visibility Meter.

Work on this project has been delayed by the move of the Measurement Engineering Division to Gaithersburg. Most of the electronic parts for the prototype unit have been ordered. The mechanical design of the lamp-photocell assembly has been started. Parts of this unit should be ordered soon.

Backscatter Fog Detectors.

A draft of the final report on the backscatter fog detectors manufactured by Hoffman Electronics Corporation and tested at Arcata in 1965 was completed. After review several revisions will be made. The report, as revised, will include a summary of the work done at Arcata in 1966 to determine the fog detection capabilities as well as the earlier work in which the instruments were tested primarily as visibility meters. This report should be completed and issued during the next quarter.

Sperry Rand Laser Visibility Meter Tests.

The field testing at Arcata of the laser backscatter visibility meter was completed. This laser was developed by the Sperry Rand Research Center. The testing and evaluation were done by them under a contract with the Federal Aviation Agency (FAA) and the United States Weather Bureau. NBS furnished the test site and facilities and the atmospheric transmittance data for evaluating the laser data. The tests were intended to investigate the characteristics and design parameters that affect the development of an optimum laser backscatter system for determining atmospheric extinction coefficients. The test plan proposal called for obtaining approximately 1200 data points involving various arrangements and conditions. The installation of the instrumentation for the laser tests was completed during the previous quarter and included assembling the tower for the laser, installing the shelter, providing a mobile trailer house for working space, providing electrical power and communications, and installing transmissometers. Three transmissometers with 250-foot baselines were installed with the midpoint of the baselines at approximately 625, 1375, and 2125 feet from the laser and were identified as T-L1, T-L2, and T-L3, respectively (see figure 1). The transmittance indications were recorded as analogue traces of transmission and photographically as digital counts of the pulses for 55 seconds of each minute. At the start of this reporting period, all equipment was operating and awaiting suitable fog conditions for testing. Test conditions required atmospheric transmittances below 0.7 for 250-foot baselines.

All phases of the test program have been completed. Approximately 1000 data points were recorded. For some of the parameters which were tested at first, only 100 data points were obtained instead of the

scheduled 200 because there were doubts that sufficient atmospheric conditions suitable for testing would occur during the remainder of the fog season. For the parameters which were tested later, the scheduled number of data points were obtained. Testing was completed on November 5. The analogue records of the three 250-foot baseline transmissometers and the RVR 500-foot baseline transmissometer T-D, were furnished for correlating atmospheric conditions to the laser data. The filmed records of the counters were furnished as correlating data for analysis but a mechanical malfunction prevented the camera from recording the counter readings for much of the test data. This malfunction was not discovered until the film was developed. During most of the periods of testing, visual observations were made by NBS personnel along a 1900-foot range near the axis of the laser beam in conjunction with the task on fog variability studies. These visual observations were timed to agree with the times of observations for the laser studies. The visual range data were also made available for use in analysis of the laser data.

The laser equipment was dismantled and shipped to the Sperry Rand Research Center in December. Brief NBS progress reports were prepared for periods ending October 10 and November 10. A final report of the NBS work on this project is being prepared and should be completed in the next reporting period.

Fog Variability Studies.

Three 250-foot baseline transmissometers for the laser visibility project were installed in the vicinity of the earlier fog variability studies. The field units were placed on 14-foot stands. Visual range observations to correlate with the transmittance data from these new installations were desired, especially since the atmospheric conditions at the 14-foot height may be less affected by the earth and thus more stable than the conditions measured by the transmissometers on the 7-foot stands previously used. Also these visual observations could be timed to agree with the data from the laser for possible future comparisons.

A new visibility range was established for these visibility observations. This range, see figure 1, was 1900 feet long located very near the 250-foot baseline transmissometers. This range crossed the axis of the laser beam at a small angle far enough away from the laser for personal safety in the event that the pulses were observed directly. The observer was located on a stand at a fixed position with his eye level at approximately the same elevation as the transmissometers. The visibility targets were mounted on a vehicle to put the center of the target at the same elevation as the transmissometers. The daytime target was a 5-foot by 5-foot black target and the nighttime target was a 25-candela lamp mounted in the center of the black target. The target was moved along the range by the driver of the vehicle as directed by the observer using two-way radio communications. The visual range was determined from the location of the vehicle when the target was at the observer's threshold.

The observations were made at the same time as the laser shots. For all but one test period, the observations were made at two-minute intervals.

During this quarter, 485 observations were made with 287 of these in daylight and 198 at night. The visual ranges ranged between 285 feet and the limit of the range at 1900 feet. Simultaneous transmittances from the three transmissometers showed marked differences as was the case when the transmissometers were mounted on seven-foot stands. Even in dense fog the transmittance continually changed both with time and location. The variations in transmittance were greater when the visual range of the targets exceeded 1200 feet. Transmittances at the times of the visual observation have been tabulated. (Values of transmittance averaged over 30 seconds or a minute instead of point readings may be more suitable for correlation with observations.)

Transmissometers.

Routine maintenance was carried out for the seven transmissometer installations which included the three 250-foot baseline units. The phototubes had to be replaced on two units because of decreasing sensitivity. Elapsed time meters were installed to record the amount of time that the runway visual range (RVR) transmissometer --500-foot baseline-- is below 0.5 transmittance. The elapsed time for day and night are recorded separately. These times are logged periodically to provide an accurate record of the low visibility conditions at Arcata without having to review transmissometer records or FAA Flight Service Station (FSS) observations. From November 17 to December 31 there were 7 hours in daytime and 17 hours at night with transmittances less than 0.5.

In addition to the low visibility elapsed time records, elapsed time meters have been installed to record the amount of time the airport is on instrument flight rules (IFR) as determined from the FAA-FSS observers energizing special lights on the airport which indicate that IFR conditions exist and to record the amount of time the runway lights are operated on intensity step 5. These amounts of time were needed for evaluating the RVR operation. From October 18 to December 31 there were 295 hours of IFR conditions indicated and 98 hours with the lights on step 5.

"Forward-Scatter" Fog Detector.

A fog detector in which fog density is determined from measurements of flux scattered in the forward direction has been purchased from the Thomas A. Edison Instrument Division Laboratories for tests for suitability for use as a visibility meter. The instrument consists of a small projector using a low-wattage mercury-vapor lamp and the reflector for a type PAR-56 lamp. The receiver is located about 3 feet ahead of the projector and aligned to view the source. However, the source is shielded so that no direct light falls on the receiver. The photosensitor of the receiver is in effect a photosensitive Geiger-Mueller tube. Photoelectrons initiate discharges in

this tube. The discharge current through this tube is then smoothed and is measured either with a sensitive conventional-type moving coil meter or an electronic voltmeter. Preliminary tests indicate that the stability of the instrument is marginal.

III. AIRFIELD LIGHTING AND MARKING

Temperature Rise Test of Type L-850 Light with 500-Watt Lamp.

Measurements of the temperature rise of a type L-850 light when using a 499-watt lamp as the source were completed. The results of this test are given in NBS Test Report 212.11P-85/66, Temperature Measurements of an L-850 Light with a 499-Watt Lamp. This light and base were mounted in a 30-inch by 30-inch concrete pad. The lamp was energized continuously at rated current for 48 hours. The temperatures at several points were recorded. Temperatures exceeding 560°F were reached, but there was no apparent damage to the light. (Note: The units furnished for this test had two important discrepancies. The nameplate on the top assembly indicated that this was a type L-845 light. There was no reference mark on the base to indicate the proper orientation of the base during installation.)

Taxiway Lighting Standard.

A few visual observations were made of the legibility range of taxiway guidance signs in fog conditions.

Improved Cable-Fault Locating Set.

An analysis has been made of some of the circuits in both the Detector Unit and the Test Generator. This analysis has resulted in some circuit modifications. The practical result of the analysis was to increase the safety margin built into the circuit so that degradation of circuit components would be less likely to upset circuit operation. A start was made on preparing the final report.

Model of Open-Grid Approach Light.

The design of the model of an open-grid approach light has been completed, and a full-scale plywood model of the light is under construction. The model will be used to determine the photometric characteristics of a light of this type.

Type L-850 Semiflush Runway Lights.

Three type L-850 semiflush runway lights were received after a considerable delay enroute from Structural Electric Products Corp., Windsor Locks, Connecticut. Since it was learned at the National Bureau of Standards prior to beginning the tests that the units failed to meet the hook impact tests at the Naval Air Test Center, Patuxent River, Maryland, photometric tests of this light have been cancelled.

PAR-56 Lamps for MC-2 Type Prismatic Semiflush-Mount Runway Lights.

Two tasks covering test procedures for, and improved performance of, both the MC-2 type prismatic semiflush-mount runway lights and the PAR-56

type lamps used therein have continued at the National Bureau of Standards for the last five years. (For control purposes the two tasks have been combined.)

Information was received by letter from the Multi Electric Manufacturing Company late in 1965 that they were substituting an off-focus type 6.6-ampere, 200-watt PAR-46 lamp for the PAR-56 and greatly improving the performance of the lights. An investigation was started at the NBS which showed that there had been a gradual deterioration of the performance of the 6.6-ampere 200-watt PAR-56 lamps over a period of years. Two factors were separated from among many: (1) the stippling of the lamp covers in current use was "heavier", that is, with a coarser texture, while a "light" stipple was envisioned in the original design and (2) the filaments were operating at lower-than-design color temperatures. Both of these factors tended to decrease the intensity of the lamps.

A change (in 1966) to a PAR-56 lamp using an iodine-cycle inner lamp with a filament operating at a higher efficiency and a change to a clear glass cover produces a significant increase in initial peak intensity and lumen maintenance. Lamps of this type are now in production, but none of the newer production run lamps have been recieved at NBS for test to date.

Compilation of Intensity Data.

After reviewing the initial accumulation of material for inclusion in NBS Report 9350, Compilation of Intensity Distribution of Airport Lights, it was evident that some of the material should be updated. Work on the compilation was temporarily suspended in favor of more urgent work.

6.6-Ampere, T-14, Iodine-Cycle Lamp for C-1 Runway Lights.

The lamps received at the National Bureau of Standards in January, 1966, provided too narrow a beam when mounted in the C-1 light fixture. Work was suspended on this task pending development of a quartz-iodine lamp with C-13 filament that would provide a wider vertical beam. The task was suspended when it was learned from the lamp company working on the development that the present cost of such a lamp ($18-20) would make it economically unfeasible.

Three lamps are presently used in the C-1 light, a 75-hour, a 150-hour, and a 500-hour. For a number of years efforts have been made to replace these lamps with a lamp having a 300-hour life. Informed agreement to use a 300-hour lamp has now been obtained, and the technical data required to amend the lamp specifications has been prepared.

Three Experimental Condenser-Discharge Lights from NAFEC.

Three experimental flush-mount condenser-discharge light assemblies and two power supplies were received from the National Aviation Facilities Experimental Center in Atlantic City, New Jersey for tests. A memorandum

report was issued.

A one-inch high projection MC-2 type light with a type 4337 flashtube gave a triple-peaked intensity distribution in the vertical plane with one peak below horizontal. The peak effective intensity was 450 candelas with a vertical spread at the 50% points of 27°. The horizontal spread was 33°.

An L-843 type light modified to accept a type 4337 flashtube gave a single-peaked vertical intensity distribution with a maximum effective intensity of 460 candelas. The vertical spread was 20°, and the horizontal, 60°.

A one-inch-high projection MC-2 type light with a FT-34/HP (PAR-56) flashtube gave a triple-peaked vertical distribution with two maxima of 775 candelas (effective intensity), a vertical beam spread of 30° and a horizontal spread of 33°.

PAR-64 Iodine-Cycle VASI Lamps Made After the Tolerance on Filament Placement Was Tightened at the Factory.

At a conference held with representatives of the Air Force and a lamp manufacturer, it was tentatively agreed that, if manufacturing tolerances on the PAR-64 iodine-cycle VASI lamps could be tightened to keep the beam peak within ±0.5° (in a vertical plane through the lamp axis), the lamps could be installed directly in the VASI unit without the "aiming" operation now being used. A group of ten lamps made to this tolerance was tested at NBS and found satisfactory. These lamps were in a sense "handmade" in that the filaments were hand positioned while the beam was being projected. Subsequently a group of eight lamps selected from a factory production were measured at NBS. The eight lamps included four lamps within the ±0.5° tolerance and four that had deviations ranging from -1.4° to +1.0° (measured at 50 inches in front of the lamps.) They were placed in turn in a one-lamp VASI simulator for measurement. Three of the lamps within tolerance were considered satisfactory while the fourth tended toward a single peak rather than the characteristic double peak. (This effect may have indicated a slight misplacement of the filament in the direction of the lamp axis.)

Another conference was held with representatives of the lamp company. The differences between the two groups of lamps were discussed and possible changes in manufacturing procedures outlined.

As many of the lamps as were still available were subsequently returned to the manufacturer for further evaluation.

A new sample group of factory production lamps with tightened mechanical tolerances will be furnished to NBS for test early in 1967. These lamps will be measured to evaluate the quality control of the factory as it relates to the performance of the lamps in the VASI unit.

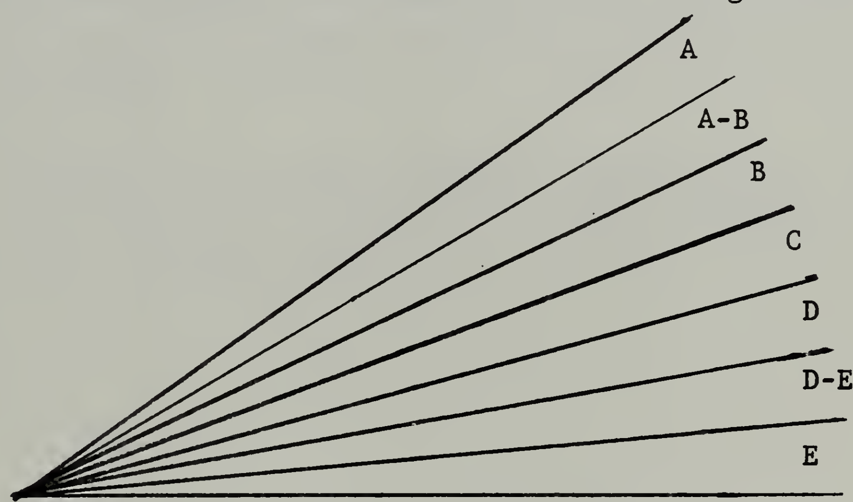
IV. CARRIER LIGHTING AIDS

A Cassegrain optical system designed for use in the PLAT system has been examined for suitability. A number of distortions were found. In addition the transmittance of the system was low because of the obscuration of the primary mirror by the secondary mirror.

A light box designed and constructed by NAEL (SI) for use in testing image tubes for the PLAT system was calibrated. Before calibration the dichroic filter in the unit was replaced with a filter of Corning type 5900 glass in order to obtain the desired color temperature.

Depth-of-Flash Indicator.

A tricolor glide-path indicator incorporating a depth-of-flash indication was received from the Naval Research Laboratory for evaluation. The presentation of the indicator is shown in the following sketch.



Beam A. Flashing Green. Intensity 2,000 candelas. Vertical beam spread 4°. Indicates "too-high" to the pilot.
Beam A-B. The transition zone between the steady and flashing light. About 0.5° photometrically, somewhat less visually. The "depth-of-flash" (relative intensities of steady and flashing light) is designed to indicate pilot's position within this beam.
Beam B. Steady Green. Intensity comparable to flashing green. Vertical spread 0.3°. Indicates "slightly above glide-path" to pilot.
Beam C. Steady Yellow. Intensity 11,000 candelas. Vertical spread 0.3°. Indicates "on glide-path."
Beam D. Steady Red. Intensity 4,000 candelas. Vertical spread 0.3°. Indicates "slightly below glide-path" to pilot.
Beam D-E. See A-B above.
Beam E. Flashing Red, Intensity 4,000 candelas. Vertical spread 4.5°. Indicates "too-low" to pilot.

Horizontal spread about 13°. The beam spreads are measured at the points of 50% of peak intensity. The lamps in the units were operated at 115 volts.

The beams are generated by two commercial $3\frac{1}{4}$ x 4-inch slide projectors mounted side-by-side. According to information received from NRL, the colors are produced by dyed Mylar films. Each projector has a 750-watt lamp. One projector incorporates a flat revolving shutter with a 25%-on duty cycle turning at 150 rpm.

The units were enclosed in a sheet metal housing for weather protection after being received at NBS. The electrical circuits of both projectors were modified to permit dimming the lamps by means of a continuously variable autotransformer.

Using the same principles, a prototype weatherproof model was fabricated at NBS. Two Westinghouse glide-slope indicators were modified to duplicate as far as possible the beam characteristics of the NRL model. Filters were made of glass conforming to the aviation colors (red, yellow and green) of MIL-C-25050.

Intensities achieved at 115-volt operation were as follows: green, 1200 candelas (8° flashing, 0.8° solid); yellow, 2400 candelas (.35°); and red, 600 candelas (8° flashing, 0.7° solid.) The horizontal spread was about 18°. The flash rate is 100 per minute.

V. MISCELLANEOUS TECHNICAL AND CONSULTIVE SERVICES

Review of Proposed Specifications.

The following proposed specifications were reviewed:

MIL-P-8944(ASG) General Specifications for Airport Lighting Control Panels.

MIL-P-2690A(USAF) Approach and Runway Lighting Control Panel, Type MA-1.

Draft of Proposed Specification on Airport Lighting, Constant-Current Regulators.

VI. MISCELLANEOUS

In addition proposals for a study of the lighting and marking of catenary power lines and for airborn fog simulation were evaluated. Draft reports "An Analysis of Runway Visual Range" and "Backscatter Signature Studies for Horizontal and Slant Range Visability" were reviewed. Conferences relating to the lighting and marking of heliports, the lighting and marking of helicopter carriers, and the improvement of optical landing systems for aircraft carriers were attended.

At the request of the Ship Installations Division, NASC, a group of photographs were taken from various viewpoints to illustrate the comparative projections of the type AN-L-9 light fixture (two inches) and the B-3 fixture (one inch.) The lights were mounted side-by-side with their edges flush with a plywood base to simulate a service installation.

300-Foot Photometric Range.

The electrical work on the new 300-foot photometric range at Gaithersburg has been completed, and the range is now fully operational. A new control console has been designed and installed. This console houses the equipment used in reading the voltage and current of the standard and test circuits, plus housing the recording instruments necessary for reading the output of the photoelectric detector. Instllation of adjustable baffles located at approximately forty-foot intervals on the length of the range has been completed. Black curtains have been installed in the immediate area of the goniometer to provide additional shielding when required for low level photometry.

1200-Foot Outdoor Photometric Range.

Work has been started on the 1200-foot outdoor photometric range. The goniometer used on the Washington outdoor photometric range has been rebuilt

and installed in the new range. It was necessary to lower the overall height of the goniometer by approximately twelve inches because of the low overhead clearance at the new location.

Discussions have been prepared for the following papers of the 1966 IES National Technical Conference:

"Circuits and Applications for Emergency Lighting Using Fluorescent Lamps" by J. H. Campbell and Q . D. Dobras.

"Halogen Cycle Lamps for Existing Lighting and Optical Control Systems" by R. L. Paugh and M. L. Stone.

"Ground Illumination Using Airborne Electrical Lamp Sources" by J. L. Burkarth.

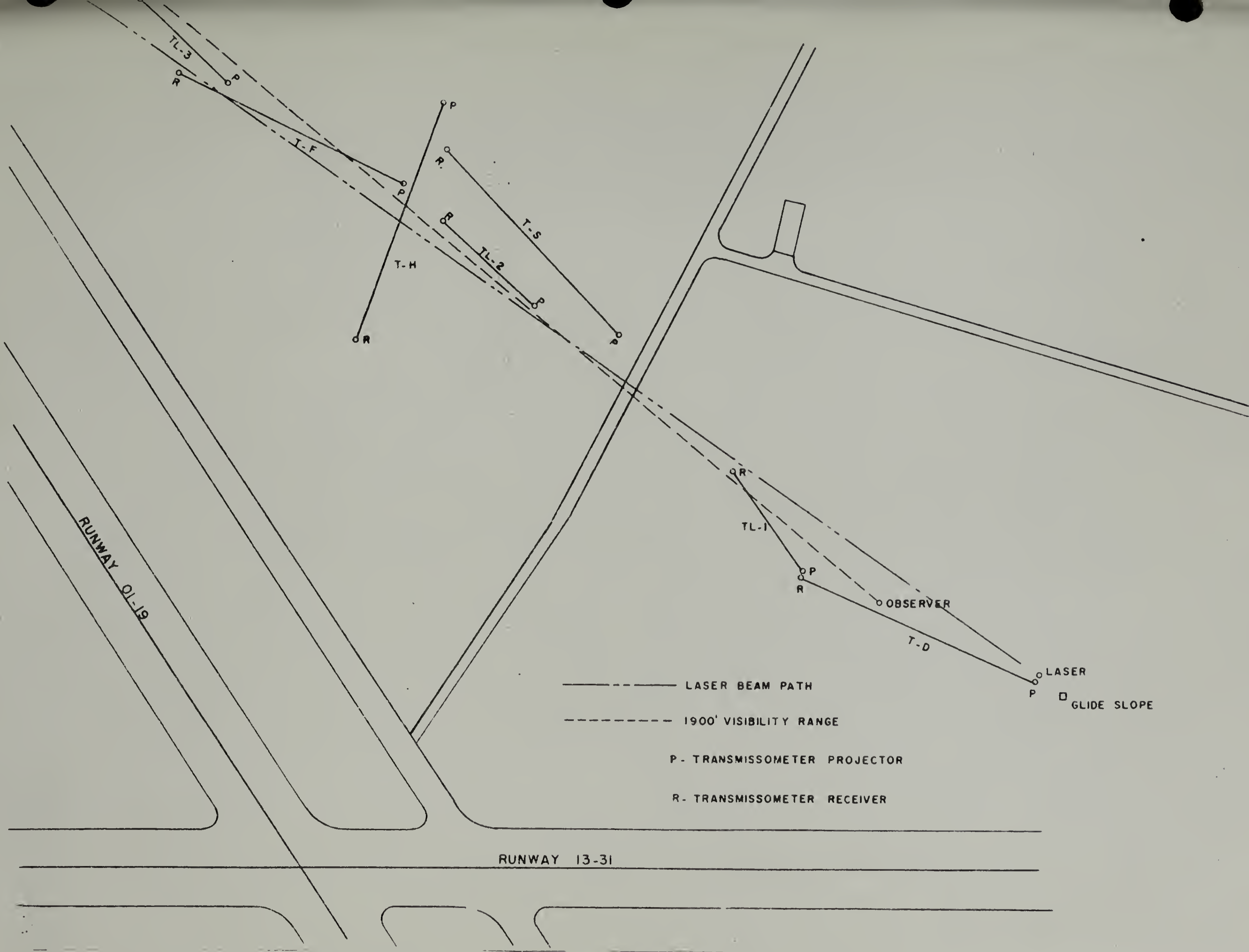


Figure 1. Installation layout for the laser tests at Arcata, California

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