Research and Development
Project Approval Request

1. Identification

25X1A

This project concerns the development of a device for field measurements of optical system performance. Its internal designation is "Sine Wave Testing Equipment." The project will come under the Technical Development Program of the P&DS, NPIC, at a total estimated cost of [redacted] It was not originally included in NPIC's 1964 financial plan because the state-of-technology at that time did not evidence practical feasibility. Funds are not available without deferring other projects scheduled for this fiscal year.

2. Objectives

The primary objective of this program is to provide the technical monitors with a portable device of high precision for ascertaining the modulation transfer characteristics of the optical system under development, in the field. It will also serve to aid in aligning and calibrating equipment being installed and operated at NPIC. Its function is to test optical systems in situ, particularly where they cannot be evaluated on precision testing equipment because of their size, weight, or configuration. The equipment would also prove useful in testing optical systems in the laboratory, or laboratory equipment used in substantive investigations, where space and weight did not permit routine bench-testing.

3. Background

In the development of complex optical viewing equipment, field evaluation by the technical monitors is vital. This not only provides checks on contractor performance, but serves to point out design and fabrication flaws in the early stages, before a redesign or retro-fit becomes prohibitive.

The present technique of field evaluation is based on the use of USAF test targets. These furnish only the resolution limit at a given target contrast, and in no way provide a true test of the capabilities over the entire system range. The recommended analytical technique is that of Modulation Transfer, until recently only realizable under laboratory conditions.

The quality of the photographic material being exploited at NPIC continues to improve with each mission, as the film/camera combination with which it is obtained is more critically exposed and adjusted. The importance of viewing such material with minimal loss of information through optical degredation is obvious. Any optical system through which the material is passed will naturally degrade the image, and it is incumbent on those responsible for equipment development to insure the maximum possible information transfer through the system.

For many years, the measure of information transfer (or system performance) has been the resolution limit, or resolving power; the smallest detail in the scene observable with optimum magnification. In more precise terms, it is the practical frequency limit, or cut-off, on the modulation transfer curve. While resolving power suffices for assessment of the extremity of the performance curve, and is the basis for Mil-Std-150A, it cannot predict or evaluate performance at any other spatial frequency. It is like describing an automobile's performance by specifying the engine horsepower; an important parameter certainly, but not the whole story.

The three-bar target, whether high or low contrast, is not an adequate measure of the response of an optical system to continuous-tone photography, although recent developments at the [redacted] 25X1 25X1 25X1A [redacted] have shown a degree of subjective correlation with low-contrast targets. The use of sine-wave analysis is perferred for two reasons: 1) it is itself a continuous-tone object and therefore more representative of what the system will ultimately process, and 2) an optical system only affects the amplitude and phase of such objects and permits an assessment of the change in modulation. A bar-target, of the USAF type, has its shape changed by the system, and is suitable only for measurements which consider the complete extinction of modulation. Citing resolution in terms of a just-resolved target group also requires a specification of the contrast of the test target. These targets are only made in a few contrasts, usually referred to as "high". "medium", and "low", and hardly quantitative. A system's modulation transfer characteristics are independent of contrast, are reproducible regardless of the test objects, and conclusions based on them are therefore under less constraint.

It has not been until recently that the advantages of describing system response in terms of modulation transfer were made apparent.

This probably received an impetus from the increased capability of optical systems and photographic emulsions which could handle and record higher spatial frequencies and finer details than those a decade ago. Methods of implementing MTF measurements have not been reduced to standard practice, however, and this is currently manifested in the total lack of simple, off-the-shelf equipment and techniques for determining the MTF of optical systems.

The current proposal is concerned with supplying such an instrument. A preliminary test instrument, based on principles the contractor is proposing to extend, has already been constructed by him and shown to be feasible. It does not have a spatial frequency capability high enough for the intended purposes and therefore must undergo another stage of development. This will incorporate several newly-evolved measuring and analytical techniques which will make this development more than just a change in scale factor; increased accuracy and precision are promised. The necessity for compactness and portability necessitates additional design studies.

4. Technical Specifications

A two-phase program has been proposed. The first phase is an investigation and study of the basic parameters, as well as mechanical and optical design considerations. This phase terminates with an instrument design and a breadboarded feasibility demonstration. No prototype instrument will be considered, since the contractor feels he will have provided sufficient basis for a final design on a production instrument. The second phase, the costing of which is not included in this PAR, will furnish as many instruments as required, on a fixed-price contract.

The contractor proposes, paradoxically enough, to utilize 3-bar USAF-type targets in the measurement of MTF. The unit will be provided with a variable contrast control to determine the frequency at which contrast becomes extinct. This thus incorporates the most useful feature of bar-targets -- it forms the basis for yes/no judgements within fairly close limits. The frequency/contrast data are then converted, through a computer program, into the response which would be obtained were a sine-wave actually used, and thence to MTF. For field measurements, it will be possible to make manual computations of less precision but of approximately equal validity, through nomographs. The contractor has supplied a detailed analysis of his technique and indicates the precision of measurement, allowable errors in contrast adjustment, problems of phase error, and the mathematical basis for the techniques of modulation transfer measurement.

He proposes to investigate the influence of target imperfections as well as improvements in measurement techniques. He will design and fabricate the necessary optics and optical elements, and construct a breadboard to confirm the final design and measuring procedures. Following the necessary theoretical studies and experimental verifications, a basic design for the production instrument will be developed.

Based on the design of the equipment already developed, it is estimated that the testing device will weigh less than five pounds and be contained in a volume of approximately 0.125 ft^3. Its transfer function will be unity over the range of operation, the upper frequency limit of which is estimated to be 520 lines/mm. As newer, higher-frequency targets are received, they will be capable of insertion into this device. It will operate with a self-contained light source which is removable for inserting the test unit into the object plane of a projection system.

5. Contractor and Financial Arrangements

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This development program will be placed with [redacted] on the basis of its CPFF proposal on a [redacted] level of effort. This covers the first phase, which will last nine (9) months. The subsequent second phase will be negotiated on a fixed price basis. The contractor estimates for budgetary purposes that the cost of each instrument will be approximately [redacted] 25X1
They will be supplied at a fixed price, the exact cost being determined at the end of phase I. Delivery of the first model will be 3 months from the date of award.

25X1A [redacted] was chosen for this program not only because of their known competence in the field of optics, but because of the extent to which they have already developed the equipment under their own initiative and funding. Having already proved the basic instrumental feasibility makes the proposed development program less of a risk.

6. Coordination

Discussion with Air Force and Navy people concerned with the development of optical instumentation have revealed no similar effort in the intelligence community.

7. Security

The program is to be negotiated on an [redacted] CONFIDENTIAL basis. 25X1