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CENTRAL INTELLIGENCE AGENCY
WASHINGTON, D.C. 20505

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Attachment to
[redacted]
Copy
27 May 1969

MEMORANDUM FOR: [redacted] NRO Staff

SUBJECT : National Bureau of Standards
Proposal on Optical Testing

Attached is an analysis of the National Bureau of Standards' "Proposal to Establish Modern Methods of Optical Image Evaluation." This analysis was done of the revised proposal which we received from NBS subsequent to the receipt of the original proposal that was provided by you. I trust that you will find this analysis satisfactory and that it will assist the NRO in assessing the desirability of proceeding with their proposed program.

[redacted]
Director of Special Projects
DD/S&T

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13 May 1969

MEMORANDUM FOR: [redacted] NRO Staff

THROUGH : Director of Special Projects

SUBJECT : National Bureau of Standards Proposal on Optical Testing

REFERENCE : Proposal to Establish Modern Methods of Optical Image Evaluation, R. E. Swing and C. S. McCamy, National Bureau of Standards, March 1969

I have reviewed the above referenced proposal and feel several comments are in order. While I would recommend that this proposal should be of interest to the total NRP, it is not clear how such a proposal should be funded because of its all-encompassing nature.

1.0 BASICS OF PROPOSAL

The fundamental aspect of their proposal is to work out the procedures necessary to allow evaluation of optical performance and optical systems on the basis of statistical optics. While statistical optics is an extremely complicated field, the concept is rather straightforward. Recent approaches to system analysis have been based on the transfer function (MTF) concept. That is, it has been assumed that if the MTF of each component of a system (e.g., camera, film, printer, duping film, viewing equipment) could be defined, then the final product is simply the multiplication of the component transfer functions. This is true only for totally incoherent cases. The problem really is that MTF is not a fundamental measure of an optical system or component, but only a calculated artifact. The problem is further complicated by the fact that with reconnaissance systems there are components which do not operate incoherently. In fact, probably the only component of a reconnaissance system which operates incoherently is the camera. All other stages (i.e. printing and viewing)

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operate at some degree of coherence. What one desires to evaluate, therefore, is really the pupil function and not the MTF, the former being the more fundamental measure of quality. The basic aspect of their proposal, therefore, is

> "to investigate the outstanding problems relating to the measurement and application of pupil functions to image analysis. These investigations include development of techniques for measurement of the partial coherence in real illumination systems, the inclusion of photographic aspects of image formation within the context of statistical optics, establishment of physical and documentary standards for calibrating optical testing systems, and the development of computer programs for image analysis, utilizing the pupil function and the description of the partical coherence of the object."

A dramatic display of the Bureau's interest in this program is evidenced by their cost proposal. They request $98,000 which is solely for equipment needed to carry the program out. All labor, computer time, etc., will be provided by NBS at no cost.

2.0 SPECIFICS OF PROPOSAL

In specific terms, NBS proposes to perform the following tasks:

A. Develop an optical testing system consisting of a wavefront shearing interferometer, interferogram scanner and necessary computer programs.

B. Develop computer techniques for multi-lens system evaluation in terms of statistical optics. Develop techniques for employing pupil functions to determine system response and their application to problems of image formation. Study how to represent, in a suitable manner, a mutual coherence input for non-trivial cases.

C. Develop improved standards for optical testing-system calibration. This will include a study of the possibility of modifying the evaluation criteria of MIL-STD-150A.

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D. Study the limits of validity of MTF multiplication.

E. Study how film can be handled in the statistical optics concept.

F. Measure and analytically characterize, where possible, the mutual coherence distribution normally encountered in operating equipment such as rear projection viewers, high resolution printers and microdensitometers.

3.0 JUSTIFICATION FOR PROCEEDING

The reasons why it is in the best interest of the NRP to proceed with this program fall into two main areas; namely, camera-optics testing and total system optimization.

3.1 Camera-Optics Testing

The application of this concept to optical testing is both clear and not new. For example, the pupil function is being measured by [redacted] on [redacted] by use of a laser interferometer. The desirability for this program in the case of lens testing, then, is not to introduce a new concept, but rather to introduce both a better approach and for standardization.

Both Itek and [redacted] can measure pupil functions. They use, however, Twyman-Green interferometers which use lasers as the light source. Twyman-Green interferometers must be used with monochromatic light, and the laser is the easiest approach. The problem, however, is that one would really like to test pupil function with "white light" to get an accurate estimate of how the lens is going to perform under the illumination conditions of operational use. One wavelength band does not give you that kind of information. The interferometer (Shearing) proposed by NBS can be used with wide spectrum of energy, and hence would be a more accurate measure of lens performance than the technique currently employed.

The second aspect of the problem is standardization. At the present time, each camera manufacturer measures

lens performance with his own techniques. This leads to (1) an inability to easily compare systems because performance is measured differently, and (2) a proliferation of expenses for each program to establish their own extensive testing capability. The point is, I believe, that the Government should have a new standard (replacing MIL-STD-150A) that can be used in all NRP programs. Such a standard would provide a common measuring technique and, hence, a common understanding of performance levels.

Further, since the NBS-proposed interferometer is literally cheap and portable, it might be possible in the future to significantly reduce those costs associated with optical test equipment by making all contractors use a GFE interferometer(s) system.

3.2 Total System Optimization

As you well know, we have all been concerned with losses in duplication, etc. As the resolution of the systems continue to improve, the requirement for the duping/viewing equipment becomes more severe. It certainly seems ridiculous to spend millions on acquisition and then lose 30% in duplication. One of the difficulties in sorting out what improvements to make in duplication/exploitation equipment is the inability to accurately characterize the "information transfer" from ON to PI. The more specific problem is to characterize the information transfer of printers, viewers, microscopes. The statistical optics approach holds the most promise for solving this problem from a fundamental point of view.

4.0 SUMMARY

In summary, I recommend that the NRO proceed with this proposal. Who should actually handle the project, however, is not clear. While any one program could probably justify this effort, having a single program fund it is probably not desirable because of the all-encompassing nature of the effort.

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In all probability, a separate contract is in order. I am sure if you decided to proceed with this proposal that OSP would be happy to handle the contracting and monitoring functions.

[redacted]
Staff Scientist
H/OSP

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