164-24-9
Copy 3 of 4

25X1

[redacted]

Post Office Box 6733
Fort Davis Station
Washington, D. C. 20020

25X1

Attention: [redacted] Contracting Officer

Subject: PROPERTY REPORT - FINAL

25X1

Reference: [redacted]

Gentlemen:

Attached are four copies of DD Form 543's pertaining to Task 03. We request approval to transfer accountability for this inventory to Task Order No. 02 of Contract [redacted] so that the items may be made available for use on Task 02.

25X1

Very truly yours,

25X1

[redacted]

Project Administrator

Attch.

Distribution:
- Contracting Officer (two copies of letter, four copies DD-543)
- Technical Representative (one copy of letter, one copy of DD-543)
- File

INVENTORY SCHEDULE B

[ ] TERMINATION [X] NON-TERMINATION

DATE: January 28, 1966

Form approved. Budget Bureau No. 22-R075

[ ] RAW MATERIALS (Other than metals) [X] PURCHASED PARTS [ ] FINISHED COMPONENTS [ ] FINISHED PRODUCT [ ] MISCELLANEOUS

PROPERTY CLASSIFICATION (See instructions on reverse): Commercial Value Over $300.00

PAGE NO. 1 NO. OF PAGES 1

THIS SCHEDULE APPLIES TO (Check one): [X] A PRIME CONTRACT WITH THE GOVERNMENT [ ] SUBCONTRACT(S) OR PURCHASE ORDER(S)

COMPANY [redacted]

STREET ADD[redacted]

CITY AND ST[redacted]

LOCATION O[redacted]

CONTRACTOR WHO SENT NOTICE OF TERMINATION

25X1

NAME [redacted]

ADDRESS

PRODUCT COVERED BY CONTRACT OR ORDER: Research and Development

25X1

[redacted] REFERENCE NO. 282

FOR USE OF CONTRACTING AGENCY ONLY a	ITEM NO.	DESCRIPTION — ITEM (If property has commercial value, furnish adequate commercial description (See instructions). Otherwise, furnish description sufficient to enable contracting officer or authorized contractor to determine appropriate disposition thereof. Where practicable, show manufacturer's name, address and catalog number. Where columns b1 and b2 are not applicable, write column b entry across the two columns.) b	GOVERNMENT PART OR DRAWING NO. AND REV. NO. b1	TYPE OF PACKING (Bulk, bbls, crates, etc.) b2	CONDITION (Use code) c	QUANTITY d	UNIT OF MEASURE d1	COST (For Finished product, show contract price instead of cost) UNIT e	COST TOTAL f	CONTRACTOR'S OFFER OR PROCEEDS OF SALE g	FOR USE OF CONTRACTING AGENCY ONLY
	1	Log Linear Photometer W/general purpose Photomultiplier Housing Model 700L [redacted]			E2	1	Ea		[redacted]		
	2	[redacted] Monochrometer w/visible region grating, collective lens [redacted]			E2	1	Ea				
		We are requesting permission to transfer this inventory as Government Furnished Equipment to Contract [redacted] Task 2.									

25X1

25X1

25X1

25X1

25X1

INVENTORY SCHEDULE CERTIFICATE

The undersigned, individually and as an authorized representative of the contractor, certifies that he has examined this Inventory Schedule, page numbers 1 to 1 inclusive, dated Jan. 28, 1966 and that in the exercise of his best judgment and to the best of his knowledge, based upon information believed by him to be reliable, said Schedule has been prepared in accordance with applicable instructions; that the inventory described therein is allocable to the designated contract and is located at the places specified; if the property reported therein is termination inventory, that the quantities are not in excess of the reasonable quantitative requirements of the terminated portion of the contract; that said Schedule does not include any items reasonably usable, without loss to the Contractor, on its other work; that the costs shown on such Schedules are in accordance with the Contractor's books of account; and that the prices shown in column g, representing the proceeds of authorized sale of the items covered thereby, are fair and reasonable.

The Contractor agrees to inform the Contracting Officer of any substantial change in the status of the inventory shown in this Schedule between the date hereof and the final disposition of such inventory.

Subject to any authorized prior disposition, title to the inventory listed in this Schedule is hereby tendered to the Government and is warranted to be free and clear of all liens and encumbrances.

25X1

[redacted] TITLE: Specialist, Contract Acct'g. DATE: 1/28/66

25X1

[redacted] ...NG OFFICIAL TITLE: Specialist Contract Accounting

DD FORM 1 APR 57 543 Edition of 1 Jul 51, is obsolete.

DEPARTMENT OF DEFENSE

INVENTORY SCHEDULE B [ ] TERMINATION [X] NON TERMINATION

DATE: January 28, 1966

Form approved. Budget Bureau No. 22-R075

[ ] RAW MATERIALS (Other than metals) [X] PURCHASED PARTS [ ] FINISHED COMPONENTS [ ] FINISHED PRODUCT [ ] MISCELLANEOUS

PROPERTY CLASSIFICATION (See instructions on reverse): Commercial Value Under $300.00

PAGE NO. 1 NO. OF PAGES 1

THIS SCHEDULE APPLIES TO (Check one): [ ] A PRIME CONTRACT WITH THE GOVERNMENT [ ] SUBCONTRACT(S) OR PURCHASE ORDER(S)

CONTRACTOR WHO SENT NOTICE OF TERMINATION

NAME [redacted]

ADDRESS

COMPANY

STREET ADDRESS [redacted]

CITY AND STATE

LOCATION OF

25X1

25X1

PRODUCT COVERED BY CONTRACT OR ORDER: Research and Development

[redacted] REFERENCE NO. 282

FOR USE OF CONTRACTING AGENCY ONLY	ITEM NO.	DESCRIPTION: ITEM (If property has commercial value, furnish adequate commercial description (See instructions). Otherwise, furnish description sufficient to enable contracting officer or authorized contractor to determine appropriate disposition thereof. Where practicable, show manufacturer's name, address and catalog number. Where columns b1 and b2 are not applicable, write column b entry across the two columns.) b	GOVERNMENT PART OR DRAWING NO. AND REV. NO. b1	TYPE OF PACKING (Bulk, bbls, crates, etc.) b2	CONDITION (Use code) c	QUANTITY d	UNIT OF MEASURE d1	COST (For finished product, show contract price instead of cost): UNIT e	TOTAL f	CONTRACTOR'S OFFER OR PROCEEDS OF SALE g	FOR USE OF CONTRACTING AGENCY ONLY
	3	Multi Speed Gear Motor Model 6700 - TS [redacted]			E2	1	ea.		[redacted]		
		We are requesting permission to transfer this inventory as Government Furnished Equipment to Contract [redacted] Task 2.									

25X1

25X1

25X1

INVENTORY SCHEDULE CERTIFICATE

The undersigned, individually and as an authorized representative of the contractor, certifies that he has examined this Inventory Schedule, page numbers 1 to 1 inclusive, dated January 28, 1966 and that in the exercise of his best judgment and to the best of his knowledge, based upon information believed by him to be reliable, said Schedule has been prepared in accordance with applicable instructions; that the inventory described therein is allocable to the designated contract and is located at the places specified; if the property reported therein is termination inventory, that the quantities are not in excess of the reasonable quantitative requirements of the terminated portion of the contract; that said Schedule does not include any items reasonably usable, without loss to the Contractor, on its other work; that the costs shown on such Schedules are in accordance with the Contractor's books of account; and that the prices shown in column g, representing the proceeds of authorized sale of the items covered thereby, are fair and reasonable.

The Contractor agrees to inform the Contracting Officer of any substantial change in the status of the inventory shown in this Schedule between the date hereof and the final disposition of such inventory.

Subject to any authorized prior disposition, title to the inventory listed in this Schedule is hereby tendered to the Government and is warranted to be free and clear of all liens and encumbrances.

[redacted]

TITLE: Specialist, Contract Acc'tg. DATE: 1/28/66

25X1

25X1

[redacted]

TITLE: Specialist, Contract Accounting

DD FORM 1 AUG 57 543 Edition of 1 Jul 51, is obsolete.

File

144-79-12
Copy / of 3

FILE

3 May 1965

25X1

Dear Dick:

Attached is a draft copy of the report we discussed during our telephone conversation this morning. Each of the sections is written as a separate chapter which will be embodied in the final report. Please note that these sections are preliminary and continuing work may change some of the conclusions reached so far.

John's review of the scope and status of the job at this time is summarized below:

Purpose

The aim of this work has been to determine if it is feasible to build an automatic device to detect selected objects in aerial photographs. This includes an estimate of the engineering difficulties and tests of all the major parameters we considered important when the job was outlined. This program will include enough tests to allow a decision to be made on what the process can and cannot do in its present state of development.

Two Main Programs

The major part of the testing is being done on simulated aerial photographs made in our laboratory. It was felt that this was the only way to clearly separate the complicated effects of the many picture variables. The subjects were the best small models of military vehicles we could find. These were all sandblasted to give them a dull, dusty finish which makes them very difficult to photograph. It was felt that this treatment compared to the worst sort of dustiness we could expect on real vehicles. The backgrounds for these pictures were purposely made as "noisy" as possible by using fine and coarse sand, dark-colored sawdust and other materials. At the time the pictures were taken, we believed these backgrounds compared to the worst natural backgrounds that would ever be encountered. The photographs were processed to what we believe is a normal contrast for aerial film. About half the testing on this program has been completed and reported.

The second part of the testing will use actual aerial photographs and, so far as practical, we will try to find the degree of correlation between the actual and simulated cases.

Equipment Used

In order to speed the work and also to learn the effects of equipment scale, part of the work has been done with a small optical processor which covers a one-inch square format and has near-perfect optics, and the remainder of the work has been done with a large system having a 4 x 5 inch format and somewhat less perfect optics. As had been predicted, the small instrument shows its best sensitivity for objects that appear about 1 mm long on the film and the large instrument works best with the objects about five times this large.

Other Tests To Be Made

The final tests will be of the proposed automatic readout consisting of a modified image orthicon chain in which the detection signals are taken from the video scan. At that time we will determine signal-to-noise ratios. At the present time, measurements of signal-to-noise ratios are made using a special fiber-optics microscope which can be positioned to read the intensity of an extremely weak spot as small as 6 microns in diameter and also the adjacent noise.

Theoretical Investigations

There are also six questions of theory which are being studied. Reports on three of these have been completed. In some cases, the experiments and theory cover the same ground. For example, the use of Photoplastic film to make instantaneous spatial filters presents an interesting problem in that there is no density to block the intense zero order and the image is recorded as phase variation instead of amplitude. Both theory and test indicated that the use of a phase-modulating medium such as Photoplastic film makes no difference in the operation of the process.

* * * * *

Sincerely,

25X1

Attch.
Draft Copy "Automatic Image Recognition"
J. M. Holeman, April 26, 1965

Approved For Release 2005/05/02 : CIA-RDP78B04770A002300020002-4

 25X1

The study program now completed has shown that an automatic image recognition system is technically feasible. Basically, there are no limiting technical problems, but there are several subsystems techniques that should be perfected before an automatic system is designed. The investigations which should precede the equipment design are:

1. Develop a system for providing the best technique for image search in scale and rotation. The presently completed study determined the tolerances on scale, rotation and alignment of the filter with respect to the input image and the optical axis of the system. These measurements were carefully made under optimum conditions and are not necessarily the best methods for achieving these recognition parameters. We propose to investigate several means of achieving image-to-filter rotation. Specifically, we will consider methods of rotating the input plane with the problems of a liquid gate as well as a large roll of film. We will consider the use of a prism to rotate the image and finally we will investigate the problems of filter rotation. Scale changing studies will cover the range of scale possible and the equipment design problems which are involved in making scale change.
2. The use of a liquid gate appears to add little to the recognition process as studied under the controlled conditions of our experiments. We know from the theory of the process that its use is mandatory under certain conditions. It is our proposal, therefore, that the liquid gate be developed into a more

operational unit and that its effectiveness be studied when poor quality imagery is used in the system. This work will also consider the problems of rotating a liquid gate, in case this is necessary, and how a roll of film is effectively "pulled through" the gate.

3. Spatial filters are currently made in a very precise manner and in such a way as to rule out the production of a filter in a rapid manner, even though a recording material exists that will record a filter image instantaneously. It is desirable in certain applications to make the filter from an object found in an aerial film. We propose to develop the necessary technique to produce a filter under these conditions.

4. The study just completed has demonstrated TV readout of recognition signals. The video signal contains redundant information and, in general, additional work is necessary to process this signal so that exact target information is the output.

5. Only one roll of aerial film was of good enough quality to provide the imagery required for this process. The duplicate negatives were poor. It is desirable to work with a substantial number of aerial films to learn what quality specifications must be expected of the film for automatic recognition. In addition, it is desirable to test the recognition system with actual aerial films for the various parameters tested under the controlled model photography.

6. It has been demonstrated that the various diffraction orders in the spatial filter have different effects in the recognition process. If a filter were made where all orders were recorded with equal densities, then the realization of a "super-filter" might be achieved. We propose to develop the technique and test the theory of the production of a super-filter.

10 August 1965

Technical Specifications

The project shall basically consist of laboratory experimentation to answer the following questions:

(1) Determine how obscure a target can be, in contrast as well as obscuration, and still be recognized.

(2) Determine experimentally how much information a photograph can contain before the hologram or spatial filter fails to recognize the desired target.

(3) Determine what effect shadows have in the image recognition process.

(4) Determine experimentally the tolerance between the scale of the target in the photograph and the scale of the target for which the spatial filter was made.

(5) Determine experimentally the tolerances of target perspective.

(6) Determine the effects of image packing density.

(7) Determine the tolerances or limits of target orientation.

(8) Determine the effects of multiple, identical targets in the same field of view.

(9) Determine how many different types of targets can be made into one multiple spatial filter.

(10) How seriously does the insertion of glass plates affect the optical performance.

(11) Investigate the use of liquid gates with photographic films.

(12) Determine how seriously vibration affects the optical system performance.

(13) Determine the feasibility of photoplastic film as a recording medium.

(14) Determine how accurately the filter must be located and aligned for best recognition.

(15) Study the various means for reducing the amplitude of the reference beam of the two-beam interferometer used to produce spatial filters.

(16) Determine the relative merits of phase and amplitude filters.

(17) Determine what the expected resolution limits of the hologram system are.

(18) Determine what the system time constants are for a scale and orientation search for a target.

(19) Analytically determine the optimum modulation transfer function of a recognition system.

(20) Determine the effects of signal-to-noise ratio on the read-out system.

(21) Investigate the feasibility and complexity of real-time filter generation.

(22) Make a system evaluation which will made use of the various pieces of data gathered from the aforementioned studies.

Automatic Image Recognition by Coherent Optical Techniques

Summary Technical Status

Section A - Theory

The main problem considered here was to find if there were any theoretical limitations to the recognition process in handling large amounts of highly detailed information or recognizing objects of any degree of complexity. This was broken into 4 problems:

A - 1 Maximum Information Content of a Photograph or Filter

Calculation shows that the upper limit of detail in the negative which the process can handle is 2000 lines per millimeter. At the present time there are few lenses or emulsions which will realize as much as 200 lines per millimeter, and therefore the process is not a limiting factor in any photograph we can make.

There is no problem in attaining the necessary information content in the filter. The two technical difficulties are resolution and dynamic range. The resolution of the filter material has to be adequate to record the interference lines produced by the two-beam process. This is usually in the range of 120 lines per millimeter and is easily recorded on high resolution materials. Unfortunately, these materials have a short dynamic range which makes it necessary to adjust the exposure fairly exactly to obtain the desired selectivity in the filter, but this is not a limitation on information content.

A - 2 Minimum Size of Detectable Objects

As the size of an object in a negative decreases the amount of light which it passes decreases in proportion to its area. At some size the object will pass so little light that even after it is concentrated into a recognition spot this energy will not be appreciably higher than the surrounding noise level and the object cannot be detected. Theory shows that for aerial negatives having an average "noise" this minimum size is .3 mm or .012 inch. For fine-grained films the minimum size would be even less, and for noise-free subjects such as printed copy the minimum size is much less.

A - 3 Modulation Transfer Function of the Optical System

The problem was to find if the recognition process imposed impossible requirements on the optics. The requirements placed on each of the optical elements in the recognition system and the filter making subsystem were analyzed separately. Theory and experiment both show that there is no practical difficulty in realizing a transfer function that is high enough for any practical application. The only serious problem is keeping the lenses and other optical parts clean during the life of the system.

A - 4 Obtainable Signal-to-Noise Ratios

Aerial photographs contain objects containing all sorts of detail as well as grain which together create the optical equivalent of noise. The SNR can be calculated only in closed form for specified signal shapes and for certain spectral densities or noise. Making logical assumptions for the area of the object, film graininess and other variables, it is possible to calculate a SNR of about 15 db. Translated into optical terms this is adequate for detection and appears to agree with experimental findings.

A - 5 Relative Merits of Phase (PPR) and Amplitude (Photographic) Filters

So far as theory is concerned, there is little difference between the two kinds of filters. Ideally, the matched filter should consist of two parts, the signal-passing portion and the noise-rejection portion. It is possible to calculate that the signal-passing portion is identical in operation for a filter made by either the photoplastic or photographic process. It has not been possible to calculate the effect of noise-rejection portion, but this is rarely used anyway.

The conclusion to be drawn from the five theoretical studies is that the processes is capable of much more than we need, the real problems are materials and technique.

Section B - Equipment

Several practical operating problems were considered:

B - 1 Effect of Glass Plates

It is sometimes convenient to use object transparencies or spatial filters on glass photographic plates, will irregularities in the glass be a problem? For small areas, such as one-inch square spatial filters, the errors found in most glass photographic plates have little effect on the recognition system. Over large areas commercial photographic plates contain surface irregularities that result in wavefront deformations which reduce the S/N ratio and cause a loss of detection. This difficulty can be eliminated by placing the film or plates in a liquid gate or by making the transparencies on microflat glass.

B - 2 Effect of Vibration

The 20-foot optical bench was vibrated in a rather severe manner and the recognition system operated throughout the tests with no change in adjustments necessary afterwards. Vibration does not appear to be a problem if the system is properly designed.

B - 3 Reducing the Amplitude of the Reference Beam

Several means of beam attenuation appear equally satisfactory if the attenuators are placed at the focal point of the second lens. Satisfactory attenuation was obtained with a series of gelatin filters, a circular wedge and two crossed polarizers mounted on flat glass plates.

B - 4 Liquid Gates

For film we have tested, equally good results were obtained with or without liquid gates.

In review, none of the equipment problems appear serious and simple solutions were found for the four studied.

Section C - Automation

If the system is ever to be used economically it must be automated to perform the search and recognition mechanically. There are many problems to automation and only the following were studied:

C - 1 Accuracy of Filter Alignment

If spatial filters are to be changed mechanically we must know the tolerance on their location. Small errors of alignment, less than .001 inch had negligible effect. For average size objects, an error of ± .002 inch reduced the recognition signal to 80 percent of its normal value. These values are within the tolerance of automatic equipment.

C - 2 Orientation Tolerance

A rotation error of one-half degree between the image and filter results in negligible signal loss. A two-degree angle error reduces the signal to 80 percent of its normal value.

C - 3 Scale Tolerance

The curve of magnification error between the object and spatial filter as a function of signal intensity has a practically flat plateau at zero error and essentially linear slopes. A size difference of 2 percent results in little loss of signal. Another way of describing the magnification or scale tolerance is that the signal drops to 80 percent of maximum when the magnification is varied ± 3 percent and falls to 50 percent with a change in size of ± 6 percent. For variations of less than 1 percent the loss of signal strength is negligible.

C - 4 Time Constant for a Scale and Orientation Search

This is based on the time to perform the scale (magnification) and orientation (rotation) search of the photograph and indicates the time to process one negative. Using the rotational and scale tolerances derived earlier, it appears that the search time for a typical aerial negative is about two minutes including the time to change transparencies.

C - 5 Use of Photoplastic Film for Filters

The signal-to-noise ratio of the recognition signal is equal for equivalent silver and PPR spatial filters. The red-sensitive PPR material has low transmission for red light and the signal is attenuated by this absorption. The processing time as well as alignment of the finished filter is much faster for the PPR. The PPR (red-sensitive) requires less exposure time than a satisfactory silver material and it is reusable.

C - 6 Real-Time Filter Generation

We redefined "real-time" to mean a short time rather than instantaneous. The total elapsed time to make a silver-bearing filter on Kodak 649 material was 2 minutes exposure plus one-hour processing. The total elapsed time to make a PPR filter of the same subject was 10 seconds exposure plus 20 seconds charging time and a fraction of a second development time. The film could be precharged reducing the time to practically the exposure time.

C - 7 Television Readout of Recognition Signals

A mechanical readout is essential and a television type system appears most suitable. This work not yet completed.

In review, answers or at least partial answers have been found to several of the problems of automating the system and adapting it to operate in real time. Considerably more work on automation remains to be done, but no serious problems have been uncovered.

Section D - Problems of the Photograph

This section was concerned with problems such as how well low-contrast and camouflaged targets could be detected, also how well a filter made from a vertical photograph would detect an oblique image of the same object.

D - 1 Effect of Target Size

The optimum signal-to-noise ratio for aerial photographs was obtained with objects close to 5 mm size using our 20-foot bench, as predicted by the "f-400 rule". Objects much smaller than 2 mm gave poor recognition on this bench, but when processed on another instrument with shorter focal length lenses gave good recognition. The entire transparency could not be covered at one time on the smaller instrument.

D - 2 Effect of Multiple Identical Targets

Multiple, identical targets in the same photograph can result in loss of detection signal for some of these targets. If vehicles are oriented at certain small angles to each other resulting in phase interference in the most important parts of the diffraction pattern, then one or more of these vehicles will produce a weak signal. Close-packed vehicles lose part of their outline and the inner vehicles show some loss of detection. In none of the cases tested did the relative signal strength fall below 47 percent of that of a single vehicle.

D - 3 Multiple-Object Filter

For simple objects such as characters on a noise-free background, 20 or 30 can be used in one filter, certainly as many as 10. For more complex objects such as vehicles on a noisy background, the present limit appears to be three or four. The signal-to-noise ratio decreases as the number of objects in the filter increases. The number of false-alarms for similar objects increases as the number of objects in the filter increases. The magnification and orientation tolerances are tightened slightly as the number of objects increases. The use of a filter containing four objects should reduce the search time to nearly one-quarter that of using four separate filters.

D - 4 Effect of Shadows

Small, sharp shadows around a vehicle outline it, increasing the contrast with its surroundings and improving recognition. In general, recognition is better in photographs taken on sunny days than cloudy days when there are no shadows. On the other hand, a low sun will produce long distorting shadows which will reduce the recognition. We have no good numerical results on this effect at present.

D - 5 Effect of Target Aspect

This has not been completed, but the results indicate that variation in aspect angle up to 20 degrees is not serious for the recognition of vehicles.

D - 6 Target Obscuration - Effect of Low-Contrast

With negatives showing no scratches or flaws, images of objects at extremely low-contrast are located at the same signal-to-noise ratio as obtained in normal contrast negatives. Good recognition was obtained for images that had a density difference from the background of 0.15 or less. The intensity of the recognition signal is less in low-contrast pictures, but the noise also is smaller. Scratches and defects become more serious as the contrast of the negative is reduced. If the contrast is low due to camouflage, then the signal will be weak and the noise normal. Recognition under these conditions could be difficult.

D - 7 Dazzle Camouflage

Dazzle camouflage produces strong diffraction noise. If the average frequency of this noise is close to that of the chief spatial frequency of the target, then the target may be obscured by noise and be undetectable by this process. The presence of confusing background actually reduces the intensity of the recognition signals. This is not understood at present.

D - 8 Overlap or Partial Concealment

Good recognition was obtained when up to 60 percent of the target was obscured. Some recognition was obtained for targets 80 percent obscured. These recognitions are possible only when the target has average or high contrast and the background is the same. Low-contrast targets with noisy camouflage becomes more difficult.

D - 9 System Evaluation

This term is intended to include all of the factors in this section and the problems of design and automation. As seen in this section, it is possible to have objects too small to detect in a particular equipment and some kinds of camouflage are effective in confusing the instrument. On the other hand, the process has shown good performance on low-contrast and partially hidden objects. There is every indication at present that the process should find any object a human operator would normally find. An exception to this is deliberate camouflage which may alert a human operator to look for additional clues. Human beings have intelligence to cope with all sorts of difficult situations when necessary and the recognition process has no intelligence.

The present evaluation is that the recognition process appears adequate to handle many search and detection problems.

992385

Grain noise reduction by using hologram techniques on multiple exposures of same scene. [redacted] 25X1

<u>Goodness Scale</u>: (theoretical) ([redacted] report) 25X1

quality should increase by $\sqrt{n}$ → (number of exposures)

if $n = 2$, info bits (quality) should increase by a factor of 1.4 but would be undetectable to the eye;

if $n = 4$, info bits should increase by a factor of 2.0 & be barely detectable to the eye;

if $n = 9$, info bits should increase by a factor of 3.0 & be detectable to the eye

if $n = 25$, quality should increase by a factor of 5.0 with twice the amount of detectable detail as a single exposure

25X1

[redacted] approach is to utilize the fact that all parts of a hologram of a scene contain much of the information of the entire scene. By hologram masking techniques, it should be possible to 'average out' the noise of a scene but retain the strength of the signal (eg increase S/N ratio)