Cy # 1

11 January 1955

MEMORANDUM FOR: Director of Central Intelligence

SUBJECT: Photographic Equipment

1. Reference is made to the memorandum dated 5 November 1954 on the subject of "A Unique Opportunity for Comprehensive Intelligence" and particularly to the objectives stated and the general results which could be expected from established US photographic capabilities appropriately applied to accomplish these objectives.

2. The subjects of optical systems and photographic techniques has been under intensive study during the past several years by highly skilled specialists within the armed services, as well as by civilian organizations engaged in research and development and fabrication activities. As members of civilian organizations thus engaged, and as members of the USAF Scientific Advisory Board, Dr. James G. Baker and the undersigned have continuously reviewed the advances being made, the possible courses of further development, and the application of these to photo reconnaissance overflights.

3. In view of the objectives to be achieved by the project now under way, and due consideration being given to availability of equipment, operating capabilities, weight limitations, detailed information required and extreme flight conditions and altitudes, the photographic configurations outlined in Attachment A are recommended.

4. It is noted that the first configuration adapts standard equipment for use in early missions in order to assure meeting established schedules. However, the remaining arrangements and materials are being specifically designed for the vehicle and missions contemplated and do not duplicate other developments. They should greatly increase the intelligence value of the results over those obtainable from standard equipment or equipment under development for other purposes.

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Edwin H. Land

Encl.
Attachment A

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ATTACHMENT A

1. Configuration A.

This will consist of various combinations of more or less standard aerial photographic equipment, though selected and put into optimum condition. For example:

Combination 1. Standard Tri-Met arrangement in crabbing mount with sufficient film to last through the longest mission. Together with two K-36-type cameras, usually with 24-inch lenses, but taking also 12 and 36-inch lenses. Film capacity will accommodate almost complete coverage with the 12-inch, about half with the 24-inch and only about one-quarter with 36-inch lenses. The K-36's are intended mostly for oblique coverage on either side of the central 6-inch of the Tri-Met, but can be tilted as needed from near the vertical to near the horizon. All cycling will employ 60% overlap.

Combination 2. The Tri-Met is replaced by two 12-inch cameras in split vertical. The rest will be as above. Coverage will be almost complete with the 12-inch cameras. This combination is essentially a multi-station installation, with the longer focal lengths used obliquely. The mission is to cover 3600 miles at altitude.

2. Configuration B.

This will consist of a single 36-inch (later 48-inch) lens, giving 9x18 coverage on 18-inch wide film, with 60% overlap. The optical system is fed by a cube prism, cycled transversely to give nearly horizon to horizon coverage, though more restricted transverse coverage can also be programmed. The film spools will handle about 4000' of standard film, and perhaps 7000' of thin base film. With the latter (and 36-inch lens), the coverage can be up to 100% along the line of flight, if the lateral coverage is slightly limited. This system is intended for reconnaissance. If standard film is used, the coverage will be correspondingly limited.

This camera is intended to be the workhorse, combining large area coverage with intermediate scale.

There will also be a charting camera accompanying all flights not having a Tri-Met. Plans are not definitized as yet, but probably the charting camera will take the form of a Tri-Met on a single roll of film. $5\frac{1}{2}$-inch film will probably be used and the picture will be perhaps 9 inches along the roll from horizon to horizon. The oblique views will be taken with longer focal length lenses, say 6-inch lenses, and the vertical view with probably a 3-inch wide angle lens. The oblique views will be fed through fixed prisms. The shutters will be standard between-the-lens shutters operated simultaneously. The vertical pictures will have 60% overlap.

3. Configuration C.

This will consist of a 240-inch f/20 optical system feeding the same magazine arrangement as in Configuration B. However, the film spools will be somewhat smaller. This long focal length system is intended for large scale pictures of limited areas, and is pointed by servo, aligned with the pilot's perscope sweep. The pilot looks into his periscope, which has a transverse sweep, with either 25 or 50 degree field at any one glance. The camera is always pointing whatever is on the cross-wire of the periscope. The pilot pushes an exposure button whenever he sees something of interest and brings it to the cross-wire. The camera then takes a set of pictures around that area, either 2, or 4 or 8, with 60% overlap, according to the pilot's direction.

The pilot either can be briefed on what to photograph from studies of the smaller scale photography earlier, or else can simply go hunting. He can pick out individual towns or cities, or cover a river bank for many miles, and so forth. The camera will show perhaps 20 times the return of what the pilot can glimpse in terms of resolution, and hence the instructions to the pilot should be in terms of gross detail, and prominent landscape features.

The 240-inch on the average should resolve objects of the order of a foot in size on the vertical, up to several feet 40 miles off the vertical, to several dozen feet at 100 miles off the vertical.

There will be certain ground equipment provided in addition to the usual processing. For example, a projector will be provided for the charting camera. Collimators will be provided for aid in checking focus in the field.

Special films will be used if haze is a serious problem, along with photo-electric iris or shutter control. All cameras will have IMC, and will be in damped, vibration-filtered mounts. Only the Tri-Met will have crabbing control. No camera will have tilt control. The airplane is supposed to fly within 1 degree of vertical in roll and pitch, and to maintain a true flight line with about the same degree of precision.

Cameras will be thermostated. The film will be heated and proper humidity obtained in the back focus space. Extreme attention will be given to keeping the windows clear. The highest possible resolution will always be sought for, and hopefully, better than 20 lines/mm. Fine-grained film will be used when illumination permits. Vignetting will be minimized. The lenses will generally be used at f/8 or slower, except where illumination requires maximum aperture.

On excellent photographic days it is anticipated that haze will not be serious over a band 100 miles wide. With the 36-inch Configuration B a useful strip up to 200 miles wide can be expected. With the spotting camera, some results might be available over a band 250 miles wide. However, vertical coverage will always be desirable for any camera, over important targets, or, the more nearly vertical, the better.

[redacted]

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January 14, 1955

Photoequipment

The following is a brief summary of equipment and planning. The Hycon perspective and lay-out drawings of January 13 should be referred to for more complete details.

For reasons discussed below we have planned for a total of 20 separate payloads made up from 8 kinds of payloads. The tentative designation and the distribution are as follows:

A-1a	A-1b	A-2a	A-2b	A-3a	A-3b	B	C
2	2	2	2	2	2	4	4

After considerable study and numerous revisions we have found that minimum weight and maximum logistical simplicity are obtainable if each payload has its own bottom with its own windows for the camera bay. Thus, we must have made up 20 separate bottoms of which there are 8 kinds.* The bottoms are to be designated with the same notation used above, such as A-1a, etc. Although it is possible to have but a single kind of bottom servicing all kinds of payloads, the plane would be carrying quite a lot of dead weight for the simpler missions, there would be much increased danger of window breakage and loss of pressurization, and finally, there would result a much increased cost in manufacture of the numerous windows and possible delays in procurement.

The "A" designation comprises payloads made up from standard equipment in accordance with everyone's desire to make use of cameras with proved reliability. "B" refers to the intermediate reconnaissance camera combining intermediate focal length with maximum coverage. "C" refers to the long focal length spotting camera to be used for limited coverage at maximum resolving power.

The quantities given above are derived from a concept of outfitting 3 widely separated and independent bases with adequate equipment to provide for the missions of pioneer search and mapping, intermediate reconnaissance and spotting of critical areas. Furthermore, at all times we must strive to obtain the maximum information return per mission, picking a few days with exceptionally clear air, and making use of these vigorously when they occur. For that reason each base ought to have at least two or at most four aircraft, having available the 5 payloads (A-1a, A-2a, A-3a, B and C, or the equivalent). Maintenance should be accomplished during the numerous photographically unfavorable days of which there will be many suitable

* (A 9th kind is probably needed. See below.)

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for check flights. Any one of the first four payloads covers a wide area, so that as many as four planes can be sent in simultaneously to photograph as many as 2 million square miles in 6 hours at altitude. Even "C" can be used right away for going after known critical targets, or for covering a small target area in great detail, or for following along rivers, roads or rail lines for associated industrial complexes. The various payloads are interchangeable among the 2 to 4 aircraft as needed, the change-over time amounting at most to several hours.

A-1a. Camera Bay #1 contains a rockable K-38 with 24-inch lens cone, making use of a modified A8-B magazine with 2000' of thin base film. Bay #2 contains both a split vertical pair of 12-inch cameras, and a single vertical 6-inch K-17. Bay #3 contains the side oblique 6-inch K-17's completing the Tri-Met installation.

A-1b. The same, except that the rockable K-38 has a 36-inch cone.

A-2a. Camera Bay #1 contains the rockable K-38 with 24-inch lens cone again, but the mount now is changed to go with another rockable K-38 with 24-inch lens cone in Bay #2. The forward K-38 is for the right-looking obliques, and the center K-38 for the left-looking obliques. Bay #3 now contains the split vertical 12-inch pair. Bay #4 contains a small charting camera to be described below.

A-2b. The same, except that the two K-38's are equipped with 36-inch lens cones.

A-3a. Camera Bays #1 and 2 still contain the rockable K-38's. Bay #3 now has a fixed vertical K-38. Bay #4 has the charting camera.

A-3b. The same, except that the 3 K-38's are equipped with 36-inch cones.

B. This is an entirely new camera where intermediate focal length and extreme coverage are combined. The optical system is light for what it accomplishes. The maximum film load of 9000' per spool, or 18000' altogether, accounts for more than 60% of the weight of the payload, including windows. Hence, the maximum information return per pound has been realized. By the same token, the payload can only be made lighter by decreasing the film supply, but for extreme altitude missions, or later retake missions of smaller areas, a reduced film supply will be satisfactory. Some further attention might be given to use of still thinner film, say of 2 mil base thickness, to take away another 75 lbs. B makes use of a 36-inch lens. Space is provided for substitution later of a 48-inch lens, if found desirable. The format is essentially 18x18, but is covered by two 9x18's, photographed simultaneously. The 18x18 permits slower cycling and twice the stereo base line. The use of 9-inch film is better all around, particularly with thin base film. The two spools are contra-winding to maintain the c.g. accurately without further mechanical parts.

The transverse coverage in B is provided by means of a rockable 45-degree mirror that assumes anyone of 7 transverse positions in turn and then resets. The windows are small and discrete at these 7 positions. Because of weight restrictions we have discarded the heavy double dove prism, and instead must put up with having the field rotate on the 18x18 format, and with a reversed image. Both can be overcome in later laboratory printing without loss of information. B is accompanied by the charting camera with its total coverage. Further study of programming technique will probably reduce the film weight.

C. This is also an entirely new camera. The problem has been to get the longest possible focal length in round numbers into the camera compartment given us, the maximum format size, and the maximum number of pictures. The result has been a 200-inch lens of f/16 speed covering an 18x18 format, and film spools accommodating up to 4000 pictures. From altitude each picture will cover approximately one square mile and show a resolution at least as good as one foot on the ground, which corresponds to about 3 seconds of arc. We are gunning for 1 second, however, The camera has a side-sweeping quartz mirror giving access to transverse coverage from horizon to horizon. The pilot is to select the interesting areas through a periscope having two degrees of freedom. Thus, he can look ahead and sweep from side to side to pick out suitable targets up to a minute ahead of time. When he centers the area on his cross-wires and pushes a button, he programs the camera to take the picture when the area crosses the transverse line. Thus, the pilot can stay comfortably ahead of picture time by an arbitrary number of seconds, and not worry about more than simple "shooting".

C can be programmed to take a number of pictures in a burst, or continuously. One might simply fly along a river and take high resolution pictures of both river banks for hundreds of miles. The same holds true for roads and rail lines. The pilot simply can keep the river on his cross-wires, more or less, when he flies.

C is also accompanied by the charting camera that will help determine later just where the large pictures were taken.

Reference to the summaries of equipments given in the Hycon report indicates the magnitude of the camera and optical work to be accomplished. Although A is always comprised of standard equipment, we plan to make many modifications to lighten the systems, improve reliability, increase film capacity, image quality,* and to perfect hundreds of windows and filters. The large windows for C must be exceptionally precise, allowing no optical deviations greater than a fraction of a second of arc, and slightly wedged to eliminate image twinning due to pressurization. The other windows are fairly easily made to optical standards but there are several hundred of them. The shutter problem must be given considerable attention owing to the large numbers of exposures. A full mission may bring back as many as 6,000 pictures or a 4-plane sortie may bring back as many as 20,000 pictures in sixhours.

* Lenses and filters will be matched and calibrated. Lenses will be set at f/8, adjusted and figured for optimum performance. Magazine platens will be curved as needed.

Even one plane in six hours can bring back the equivalent of our present annual take in peripheral photography all in 6 hours, not to mention location. Hence, the equipment must be 100% reliable.

Considerable attention will be given to vibration elimination and to control of the low frequency oscillations. We plan to develop a triggering device that makes exposures during selected moments of minimum angular rate of the airplane. The larger cameras are in isolated mounts more or less on a c.g. principle, and have IMC. C will contain quartz mirrors in invar mount to stabilize focus thermally. Very close attention must be given to thermostating the cameras, providing proper environmental conditions for the film, and keeping windows clean and free of moisture. The periscope design and linkages with the camera must be done with extreme care, and provision must be made to allow the pilot to see essential instruments while using his periscope. In addition there will be a good deal of ground equipment needed, including maintenance facilities, spare parts, film storage, some processing units, etc. Also, we plan to have test devices made up for checking the vibration and resolution performance of the various installations. It will be necessary to construct collimators for focusing cameras in the field. Hycon plans to train tech representatives for field service and to equip GFE vans with everything needed. When all this is accomplished, we shall have a most extraordinary means for gathering information, and in particular for obtaining the most information per hour at altitude. It will take only a few missions on perfect days to return more information than we have ever managed to collect photographically from earlier efforts, range excepted, and this information will all be up-to-date. Weather observations should begin even right away in order to determine what the frequency distribution seasonally is of "perfect" days where there is minimum haze. It should be emphasized that minimizing atmospheric haze by selection of observing times is much more important than further increase in quality of optics, and that a few perfect hours in the air are more important than dozens of days where haze is present. In the overall planning, expert weather analysis and weather information gathering should be given as much attention as the aircraft and camera effort, or the data reduction effort.

Charting camera. This is a small panoramic system making use of 1000' of 70 mm film. Each picture is a sweep from horizon to horizon transverse to the line of flight. The successive pictures have 60% overlap. The film supply will provide continuous coverage for up to 4000 miles. The pictures will be useful for recording navigational and weather conditions, as well as helping tremendously in the plotting of the thousands of larger scale pictures. The charting camera will be indispensable with C for locating the critical areas photographed somewhat at random by the pilot in flight. This a brand new development. The camera will be very useful later to the Air Force in low altitude coverage, being small and light, and providing complete coverage. For this latter reason, attention ought to be given to fast cycling rate, or at least designing the camera in such a way that fast cycling can later be incorporated.

Part of the optical development will include laboratory copying systems for projection printing and preparation of master negatives from which contact printing can be done. Two systems in this country operated full time can accommodate all of the work in the field, and hence should be located in the main processing center.

We believe that we have as good a team as can be found in the country for carrying through this large photographic program on a crash basis. Already by this date we have completed the basic plans and are ready to start detailing of many parts. The design of the optics for C is well along, 11 days of electronic computing already have been put in, with about 5 more to go. Materials will shortly be ordered for windows and mirrors. More effort will soon be required in the problem of the thin film base and special emulsions, and particularly on the elimination of vibration from the pictures. Now that the basic plans are in hand, we know what the task is for isolation of the inertial mass, damping, and exposure control, and can go into this problem in the greatest detail. We are targeting for 60 lines/mm on the special lenses, including the 36-inch f/8 modified standard lens, and at least for 25 lines at f/8 with the standard lenses. This is to be compared with an average of 10 lines/mm in the usual course of events in previous practice. Furthermore, we shall know why we cannot do better, from vibration analysis, contrast studies, and film properties.

We should like to emphasize that the developments referred to above are very desirable ones for the Air Force and can be taken over readily. These developments in some cases are years ahead of the present R & D program. Conversely, the above systems are the outgrowth of many years of experience gathered from Air Force sponsorship of basic R & D programs, and are therefore implicitly Air Force products. This is particularly true of the electronic computing of optical systems, where for several years the Air Force has backed fundamental research with the Perkin-Elmer Corporation. The development of the complicated optical system in C would have taken years in Germany by the older methods, and many months here by design methods using desk calculators, but now is about to be accomplished in 16 full working days with our IBM computers (the CPC), which in a year or two might be reduced to only a few hours. Already, the design results obtained would provide quite satisfactory pictures, but we seek extreme quality.

Recent work indicates that the use of high contrast emulsions with finer grain will help overcome resolution and contrast losses caused by haze. We fully expect to use the new technique in B and C, where the optical systems are designed to have almost no vignetting. For B where wide angle coverage is involved, we can only increase gamma slightly above previous practice, and hence can employ ordinary exposure control. For C with its narrow angle coverage, we can use quite high gammas, but must have a photoelectrically operated shutter. Such a shutter is planned as part of the program.

On scheduling it seems easily possible to meet the aircraft scheduling with the A configurations. We expect also that the first B and C units will be ready before the end of the year in time for field use with the first several airplanes as needed and for tests. The A units are given priority, however, in order to be 100% sure that we have reliable payloads at hand.

Weight Restrictions:

We have followed a policy in planning that it is easier to take out a camera to reduce weight than it is to add one later for a more effective use of the mission at somewhat reduced altitude. Therefore, it is not surprising that our present weight figures add up to something more than the 550 lbs. allowed for the reduced altitude maximum weight, and substantially more than the 450 lbs. for extreme altitude. Furthermore, since so much planning has gone into fitting the space allowed us with logistically acceptable and practicable configurations, we have not really had the time to begin cutting weight. For one thing our film capacities are at maximum values in footage and weight, and later missions over territory already covered will, in general, use less film. For example, one B mission per year may be all that is required over a given flight line, and other uses of B in the interval will be for much smaller film supplies.

Before long we shall have much more carefully prepared weight figures on the various configurations, with additional columns to show weight figures for partially stripped configurations, and reduced film supply. Thereafter, judgment in the field will be all that is required to meet altitude performance where weight is a factor. For example, in A-1a the K-38 can be eliminated in about ten minutes of working time, and the resulting payload comes down to less than 400 lbs. In an extreme case, only the charting camera might be taken along, reducing the payload to 40 lbs. or so.

We have agreed to and will certainly follow the 450-lb. limit placed on the payload for maximum altitude, and will therefore list the partially stripped configurations that will meet this requirement. Similarly, we expect to give maximum attention to meeting the 550-lb. limit for full payload. Perhaps we have given a wrong impression of our good intentions in meeting weight requirements by describing mostly the maximum payloads, but it is the latter that has occupied our attention because of systems planning. It is hoped that this description will clarify matters.

For most mapping runs, it is recommended that we use the thicker base film on the new low shrinkage base manufactured by Eastman, instead of trying to do mapping with thin base film. The 600' spools with standard film thickness are already adequate to cover the entire mission, and the extra weight will not be serious for the advantages gained.

We might have planned for a lighter A-1 configuration if we used only one 6-inch K-17 with 1000' thin film magazine, in a rockable mount for the equivalent of a Tri-Met installation. However, we might lose precision in so doing, and certainly lose simultaneity on which mapping precision depends, and would have to use the thin base film. We feel we have made the better choice in spite of the weight problem.

As a final comment, we probably should get a ninth kind of bottom for C, consisting of a single horizontal large window for maximum spotting precision for near vertical photography. Missions sent out to obtain technical intelligence over very restricted areas ought to obtain the very best optical results, and the split window in our C system above is not at all desirable. We have used the split pair of windows to provide maximum resolution for the longest range side looks, and the vertical results through the V will still be very good. However, if we are really looking for details in terms of inches on ground objects such as missiles, aircraft, etc., we should have the single horizontal window that allows a plus or minus ten degree transverse sweep with full aperture and perfect optics. The decision as to getting the ninth bottom ought to be made soon as a request from the planning group, since already the aircraft people feel hardpressed by our requirements.

Prepared by JGB

Addendum:

Maximum payload return.

A-1a	5,250	pictures	
A-1b	"	"	
A-2a	6,000	"	
A-2b	"	"	
A-3a	4,750	"	
A-3b	"	"	
B	7,000	"	(all 18x18)
C	5,000	"	(all 18x18)

Distribution:
- #1 - JGB
- 2 - HIM
- 3 - AA
- 4 - EHL 4
- 5 - RSP
- 6 - EM
- 7 - RB
- 8 - OR

TOP SECRET

December 13, 1954

25X1

TENTATIVE PLANNING FOR PHOTO EQUIPMENT

1. Configuration A.

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It should be anticipated that the pilot may have to stay in clear areas where the weather front has been inaccurately predicted. He ought to be able to spot bad weather 100 miles ahead and redirect his flight to stay in the clear. Hence, alternate target areas should be assigned.

More detailed descriptions will be available several weeks from now.

J. G. Baker