PREFACE

The DIAMOND II study compares the potential performance of the manned and unmanned versions of the MOL(DORIAN) system from the standpoint of the total number of intelligence targets which might be photographed during a typical 30-day mission. In the manned system, the astronauts would provide a weather avoidance function by exercising the option of photographing pre-designated alternate targets when adverse weather was encountered at the pre-designated primary targets.

Where applicable, to insure realism in DIAMOND II results, NRO experience in the planning and operation of reconnaissance satellite systems was used to the maximum extent possible. The study concludes that a manned DORIAN system will successfully photograph approximately 18-20 percent more targets than an unmanned system when employed on identical intelligence-collection missions against average Sino-Soviet Bloc climatology.

The DIAMOND II effort would not have been possible without the assistance of the Defense Intelligence Agency, the Air Force Global Weather Center, the MOL System Project Office, Aerospace Corporation representatives, the SAF Director of Special Projects, and the National Photographic Interpretation Center. However, the interpretation and analysis of basic data, and the conclusions expressed should be viewed as representing those of the NRO Staff and not necessarily all agencies who provided inputs to the study.

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I. INTRODUCTION

This study compares the relative merit of the manned and unmanned versions of the MOL (DORIAN) System from the standpoint of the total number of intelligence targets which might be photographed during a 30-day mission when the astronaut provides a weather-avoidance function. By weather-avoidance is meant that the astronaut may select among pre-designated alternate targets for photography when adverse weather is encountered at the pre-designated primary targets.

Every effort was made to insure a maximum of realism in the study--the use of actual targets, existing weather and climatology, GAMBIT mission-planning software and operating experience (in view of the similar characteristics of the GAMBIT and DORIAN camera sub-systems), etc. Further, to reduce the effect of variables to the maximum degree, where possible, identical operating environments (orbit, target deck, weather, target selection technique, photographic requirements, etc) and technical characteristics were assumed for each manned/unmanned system comparison. Additionally, each variable "frozen" was examined carefully to insure that neither version of the MOL/DORIAN System was favored.

However, prior to attempting a comparison of the potential target coverages of the manned and unmanned systems, it was necessary to establish first that the astronauts can provide a weather avoidance function, and that weather patterns are such as to offer the opportunities to do so.

2. THE ASTRONAUT AND WEATHER AVOIDANCE

Certain aspects of the astronaut in a weather avoidance role were examined as a limited measure of the feasibility and practicality of this function. These were: weather patterns; weather relationships between primary and relatively-close (30-50 miles) alternate targets; the effect of oblique viewing angles on the ability of the astronaut to estimate target cloud-cover; and the time available for the astronaut to evaluate weather conditions at primary and alternate targets.

a. Weather Patterns:

Analyses of cloud patterns by the Global Weather Center and NRO Staff of index camera photographs, weather satellite mosaics, and KH-4 mosaics (see attachment 1 for examples), plus the observations of aerial weather observers all seemed to support the following general conclusions:

(1) Randomly spaced, similarly sized and shaped clouds are seldom found over areas even as small as 150 x 150 miles.

(2) Clouds tend to group together in clumps, rolls, bands, etc, even in scattered to broken conditions, and sizable clear areas are frequently encountered in almost total overcast conditions.

(3) Cloud cover amounts change radically between local areas (for example, 5-mile radius "local" circles with centers separated by 25 miles), even though a much larger overall area may be cloud-covered approximately the same percentage.

b. Primary-Alternate Target Weather Relationships:

The general conclusion drawn in a(3) above with regard to radical changes in cloud cover over adjacent local areas was further verified by GWC analyses of more than 132,000 frames of KH-4 photography. The technique employed by GWC was to sort the frames into different groups of a spread of weather conditions at nadir (i.e., clear; overcast; 1-9% cloud-cover, etc) and then analyze adjacent weather at 10 mile intervals out to the frame extremities. See Attachment 5 for graph-plots of the various conditions analyzed.

For example, the analysis of 17,000 frames which were completely cloud-covered at nadir (akin to a primary target) indicates that 30 miles away, the probability of a small area (akin to an alternate target) being clear is approximately 10%. Fifty miles from nadir, the probability of clear skies is approximately 14%.

As might be anticipated, the analysis indicates that under 60-100% cloud-cover conditions, adjacent areas tend to have reducing amounts of cloud cover out to 50-70 miles distance. Conversely, under 0-40% cloud-cover conditions, the adjacent areas tend to have increasing amounts of cloud cover out to 50-70 miles distance. See Attachment 7 for a plot of alternate target weather probabilities 30 miles away from the primary target (nadir).

c. Effect of Oblique Viewing Angles:

It is an accepted fact that ground observers consistently over-estimate the amount of cloud-cover because of the difficulty the mind has in estimating the total amount of scattered cloud elements seen against the sky hemisphere and because the observer sees the sides of clouds toward the horizon as well as the bottoms. This therefore was cause for some concern as to the ability of the astronaut to perform effectively in a weather avoidance role.

However, a point generally overlooked in considering the ground-observer's tendency to over-estimate cloud-cover, having been misled by seeing the sides of clouds as well as the bottoms, is that the observer for the most part is looking at very high obliquities. Most significant weather has cloud-bases less than 10,000 feet above the ground; thus, the ground observer, when scanning only a five-mile radius circle around his observation point is already viewing at obliquity angles of approximately 70° or more.

Both GWC and University of Michigan studies on cloud-free line of sight probabilities (based on sunshine-illuminated ground vs various cloud-cover conditions at various sun angles) indicate that the reduction in "seeability" is approximately four times as much between 45 and 70° obliquity for 50-90% cloud-cover as it is between 0 and 45°. According to the U of M study, the reduction in "seeability" between 0 and 45° obliquity ranges from about 5% at 50% cloud-cover conditions to about 30% at 90% cloud-cover conditions. Thus, the total reduction in viewing effectiveness is not significant up to, perhaps, 50-55° viewing angles.

d. Time Available for the Astronaut:

Attachment 2 depicts the time available for the astronauts to view the weather at the primary and alternate targets through their tracking scopes and select a target for photography. It appears that at least 15 seconds is available for this weather scan function.

e. Summary:

As a result of this brief review, it was generally concluded that significant weather differences between relatively close (30-40 miles) primary and alternate targets exist; that the astronauts would have little difficulty visually identifying the area of best weather through their tracking scopes; that the effect of obliquity on astronaut seeability would not be significant for the most part; and that the astronaut would have sufficient time to perform the task. It is believed that future ground simulator activities will prove out these conclusions.

3. APPROACH

The general approach to the comparison of manned and unmanned MOL (DORIAN) systems, with the astronauts providing a weather avoidance function in the manned vehicle, was as follows. First, the potential maximum number of targets which might be photographed by an unmanned system in a 30 day period (uninhibited by expendable limitations or system malfunctions--only limited by weather) were determined; then, the manned system potential was determined for an identical mission against the same primary targets plus up to three optional alternate targets (where available) for each primary target (with the astronaut providing a weather avoidance function).

More specifically, the following sequence of study events was followed:

a. A suitable MOL target deck was developed from current intelligence community thinking and the GAMBIT target deck.

b. GAMBIT software (modified to accommodate MOL (DORIAN) performance characteristics) was used to select a basic orbit for a 30 day mission.

c. Necessary assumptions (re control gas, power, drag make-up, system malfunctions, etc) were made to minimize the effects of variables.

d. GAMBIT software was used to select the maximum possible number of highest value primary targets for the unmanned system, limited only by system constraints (roll rates, time required to photograph, etc).

e. Up to three alternate targets (where available) for each of those primary targets were selected manually for the manned system, with a restriction imposed that alternate targets for a primary target could not be so located as to preclude the possibility of photographing the next designated primary target.

f. The number of photographic attempts which resulted in target photographs was then computed using several weather models, current weather, and climatology of the Sino-Soviet Bloc.

The sub-sections which follow discuss the above in more detail.

a. <u>Target Deck</u>:

Several versions of DORIAN target decks have been assembled by agencies for various studies and reasons. The deck used for this study was a combination of the latest GAMBIT/GAMBIT CUBED target deck (Mission 4027) and 361 DORIAN targets selected by the Defense Intelligence Agency (DIA). Since many DIA targets did not have COMOR assigned numbers, site shredout numbers of existing GAMBIT targets or suedo-COMOR numbers were assigned.

All Mapping and Charting and World City targets were deleted from the 4027 target deck. All lateral pair (search) targets and targets with diameters of more than 1.5 NM were also deleted. All 4027 targets with larger than zero diameters were reduced to zero to accommodate existing software and identified by a special code (1911). All DIA originated targets were assigned priority one and identified by a special code (361). All remaining targets were also identified by a special code (1156). Other than the DIA targets, all 4027 target priorities remained unchanged.

The MOL (DORIAN) target deck, as finally assembled, contained 3428 targets. Of these, 205 targets were external to the Sino-Soviet Bloc and are located in Algeria, Middle East, Cuba, Indonesia, Rhodesia, United Arab Republic, French Polynesia, Pakistan, Albania, France and Tibet.

The deck consists of the following number of targets in each COMOR category:

Category	PRIORITIES 1	2	3	4	5	6	7	8	9	Total
Missiles	176	8	3		10	7	8	619	131	962
Aircraft	36	1	1		2		11	467	187	705
Nuclear Energy	50	1	1		2	2	4	32	14	106
Naval Activity	44	1	2		1		1	42	19	110
Biol/Chem Warfare	19						1	21	10	51
Electronics	14				1	3	4	103	73	198
Military	7	1			3	5	4	902	297	1219
Urban Industrial	12							39	11	62
Unidentified Installations	3				2	2		6	2	15
Totals	361	12	7		21	19	33	2231	744	3428

b. <u>Orbit</u>:

The MOL (DORIAN) 30-day orbit was selected using the GAMBIT TOOLS (Target Orbit Optimization - Least Squares) computer program.

This program used the entire DIA-provided target deck (361 priority one targets) and determined that orbit which minimizes the sum of squares of the distance of each target to vehicle nadir. The limits of the inclination angle search were 80°-110° in one degree increments. The limits of the period search were 88-93 minutes in .25 minute increments. Two orbits with near equal scores were selected by the computer. Of these, the orbit more favorable to the spacecraft was selected for this study. The parameters of the selected orbit were:

Period	89.33 Min
Inclination Angle	96.01 Deg
Apogee	193.08 NM
Perigee	80.72 NM
Eccentricity	.016
Lat of Perigee	55.71 North latitude

The attached reduced EURASIA ASC map (Atch 3) depicts rev 3 through 11 of Day 1 and a representative rev for each successive day through day 9. It can be seen that the orbit provides 100% coverage of all targets North of 21° North latitude. The orbit coverage overlaps at the equator although a very small area between $5^{O}N$ and $21^{O}N$ exists during which targets are not available during the first nine days but become available during the first nineteen days.

The orbit was not permitted to decay nor was orbit adjust used. Drag was set equal to zero to simplify computations.

c. Assumptions:

Several assumptions were made and employed throughout the study:

a. This study would not concern itself with limitations or constraints imposed by vehicle consumable, i.e., batteries, control gas, power, film, etc. The effect of limiting consumables, of course, would greatly favor the manned system. Consumable-limited unmanned systems must operate against predicted weather.

b. That the vehicle would continue to provide maximum capability (i.e., no malfunctions) for the full 30-day mission. The desired orbit was assumed to have been achieved and maintained (via auxiliary propulsion) for the 30-day mission.

c. That the intelligence community photographic reconnaissance requirements as presented by the COMOR proposed use of GAMBIT CUBED were similar in nature to the photographic requirements which will be used for the DORIAN vehicle (for example: photograph 7A and 2C categories in mono; limited use of color film, etc).

d. That the weather for each target was relatively independent of all others, including the primary and alternate target within a selected group, and permitted probabilities to be summed in the classical fashion.

e. That each group selection of primary and alternate targets could not affect the preceding or following selected group of targets.

f. That if 100% clear skies existed for the full 30-day mission, the manned and unmanned systems would return with an identical photographic product. This assumed that all targets were selected on the ground, and that if the primary target were cloud-free, it was the most important and would be photographed by the manned system regardless of weather at the alternates.

g. That the unmanned system would point at selected targets without significant pointing errors.

d. Primary Target Selection:

Primary targets (identical for both the manned and unmanned systems) were selected using GAMBIT software (GRESOLVE), which is sufficiently flexible to accept various system parameters.

The specific parameters used for the MOL (DORIAN) system were as follows:

(1)	Camera Field of View	1.10 Deg
(2)	Time for camera operation	1 sec.
(3)	Maximum obliquity	± 40 degrees
(4)	Mirror flip time plus settle time	4.67 sec.
(5)	No automatic frame extension	
(6)	No ascending photography	
(7)	Sun angle cut off	0 degrees
(8)	Roll rate	6 deg/sec.
(9)	Roll settle time	3 sec.
(10)	Optimization of Target Selection	
(a)	Cosine of roll angle squared, i.e., zero degree roll optimum	
(b)	Infinite weight between priorities	
(c)	Stereo/mono weight 1 to .4	
(11)	Total stereo convergence angle	20°
(12)	Mono photography	
(a)	Forward	10°
(b)	Aft	10°
(c)	Vertical	0°

The GAMBIT software provides the optimum sequential series of photographic operations based on target availability, the orbit, target priorities, target obliquity, photographic mode desired vs vehicle capability (i.e., maximum obliquity, roll rates, stabilization time, camera operating time, etc). The sequential list of target operations computed thus represents the maximum vehicle capability.

In the Diamond Study concept, the unmanned system would photograph each designated primary target regardless of weather. The GAMBIT software identified 3988 camera operations as the maximum possible for the unmanned system during the 30-day period. Attachment 4 lists the number of camera operations against the target deck category/priority matrix.

The 3988 camera operations also represent the maximum number possible for the manned system in view of the target priorities and relative weights imposed. Thus if 100 percent clear skies prevailed for the entire 30-day mission, the manned and unmanned systems would photograph precisely the same 3988 targets. However, in addition, up to three alternate targets (in case adverse weather prevailed at the primary target) were also selected for the manned system, with the proviso that no alternate target selected could be so located as to preclude the possibility of attempting photography of either the preceding or subsequent designated primary target. The selection of alternate targets is discussed in the next section.

e. Alternate Target Selection:

The "ground rules" for the selection of alternate targets essentially were as follows:

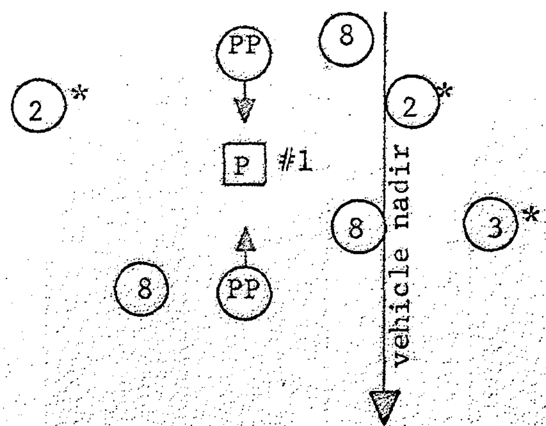
(1) Those targets selected by the target selection software (i.e., by the computer) were designated as the primary targets for the manned and unmanned systems.

(2) A photograph of any primary target or of any alternate target designated for that primary target could not interfere with the capability of the system to photograph any other primary target (or any of the alternate targets associated with it).

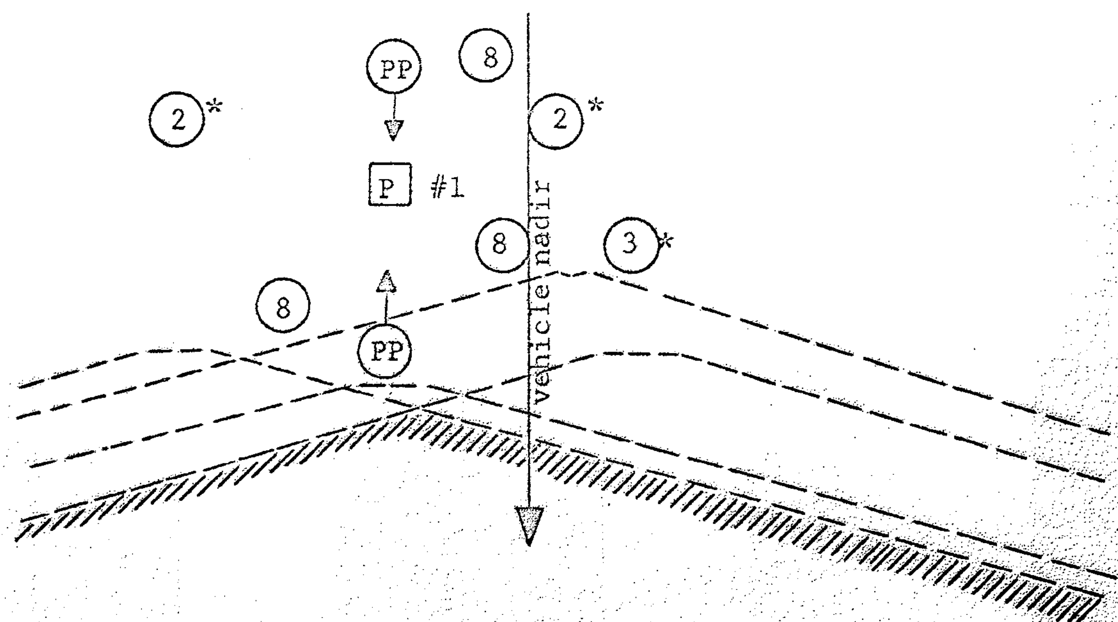
(3) The highest priority targets available were first contenders for alternate targets. The next consideration was the ability to obtain a stereo photograph. The third and last consideration was to obtain the minimum obliquity photograph.

The GAMBIT target select computer print-out was used to select the alternates (the print-out properly locates all accessible targets on either side of nadir for each pass over the area and indicates the primary target selection. A description of the process used in selecting alternate targets follows.

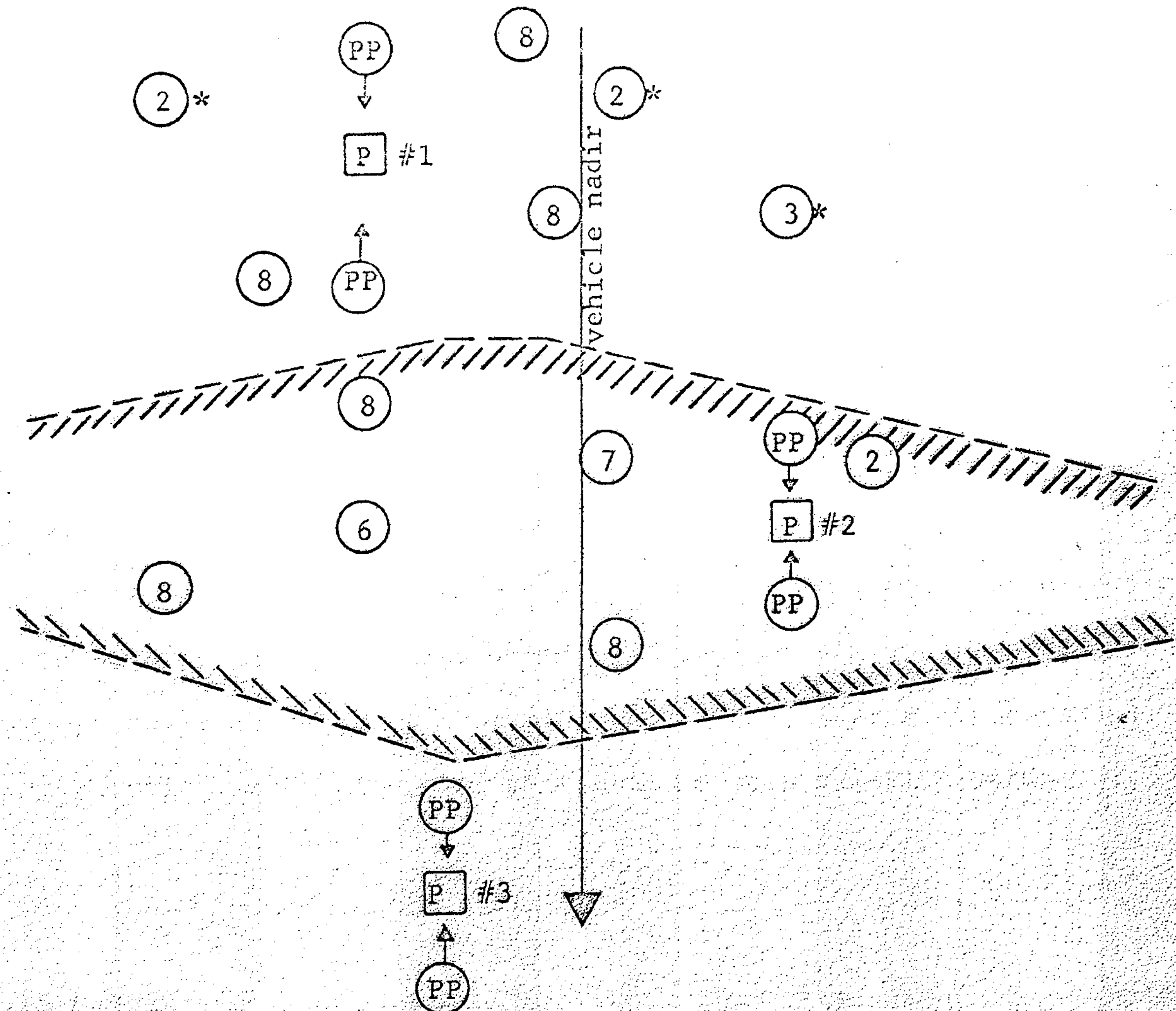
In the following graphic, the symbol [P] represents a designated primary target. The symbol (PP)→ indicates camera operation; two of these symbols on both sides of the symbol [P], with arrows pointing to the symbol [P], indicates stereo photography of that target. The circled numbers indicate possible alternate targets, with the encircled number indicating priority. As a starting point, assume a primary target and its alternates have been selected, with the selected alternates identified by an asterisk. The relative position of the primary and its alternates is depicted below



Now the same group of targets are displayed with dotted lines representing the maximum system roll capability (i.e., rate of mirror roll) to proceed to the next operation. The "worst case" from a non-interference standpoint is a combination of targets. The area below the cross-hatched line now represents the area which is "free" for the next primary target and its group of alternates.



The "free" area for the next primary target ($\boxed{\text{P}}$ #2) and its alternates now appears in the area bounded by the corss-hatched lines. Note the lower line is determined by the third primary in this sequence which must not be interfered with. In this example, the priority 2 , 6 , and 7 targets would be chosen as alternates 1, 2, 3 respectively, for primary target #2.



For the 3988 primary targets selected for the manned and unmanned systems, 1934 were found to have one alternate, 1316 of those 1934 had two alternates, and 985 of the 1934 had three alternates (Note: in many of the 985 primary targets which had three alternates selected, there actually were from 4-20 alternates available).

The obliquity summation for the primary and alternate targets is shown in the following table:

Roll Angle	Primary	Alt #1	Alt #2	Alt #3
0 - 10°	961	386	271	217
10 - 20°	910	462	333	244
20 - 30°	931	479	330	246
30 - 40°	1186	607	382	278
Totals	3988	1934	1316	985

Finally, the alternate targets averaged approximately 30 nautical miles from the primary targets. No particular effort was made to select alternates at a maximum distance from the primary; rather, the alternate selection criteria was based on priority, obliquity, and photographic mode relative values.

f. Probability Summation Methodology:

Earlier in this paper, it was pointed out that the unmanned system would attempt to photograph each of the 3988 primary targets selected for the 30-day mission. To determine the total number of targets actually photographed (cloud-free and/or partially cloud-covered), it was necessary to know the existing target weather at the time when photography was attempted. Depending on the source of target-weather verification (ground observers, weather satellites, forecasts, climatology, etc), a probability of "seeing" the target was assigned for each camera operation. Added together, these represented the total usable unmanned system "take" for any given weather situation or model.

To compare the potential manned system "take," the probability of each primary plus its alternate targets (where available) were summed to develop a probability for each camera operation. Where a primary target had no alternate, the manned system probability of "seeing" that target was the same as the unmanned system. Where an alternate (or alternates) target was available, the manned system probability of "seeing" that target was determined by applying the probability equation as follows:

$$P_t = 1-(1-P_p)\ (1-P_1)\ (1-P_2)\ (1-P_3)$$

P_t = Total probability of "seeing" (i.e, photographing) the target

P_p = Probability for primary target

P_1 = Probability for 1st alternate target

P_2 = Probability for 2d alternate target

P_3 = Probability for 3d alternate target

The summation of the manned system probabilities for each individual camera operation (primary target plus alternates where available) represented the total useable manned system "take" for a given weather situation or model and could be compared directly with the unmanned system.

The weather situations and models, plus probabilities of "seeing" the targets associated with each, are discussed in the section which follows.

4. WEATHER

Sino-Soviet Bloc weather has been observed by various means and recorded for many years. Correlating all sources of information and reducing this data to a readily available source is a time-consuming task. Nevertheless, recognizing that the potential results of the manned and unmanned systems would be quite sensitive to the weather encountered, the study therefore investigated a wide range of weather models and situations, as follows:

a. "Verified" (i.e., observed and recorded) weather for the period March 7 through April 5, 1960.

b. An average-climatology model based on the analysis of 132,000-plus frames of KH-4 photography.

c. An average-climatology model based on the analysis of 1159 frames of GAMBIT KH-7 photography.

d. An average-climatology model based on the analysis of the results of 3007 individual GAMBIT KH-7 camera operations.

e. "Verified" (i.e., observed by all available sources) weather in July and August 1966.

f. Climatology for several large target complexes which are known to have both much better and much worse weather than the overall Sino-Soviet Bloc average.

The above are discussed in some detail in the sub-sections which follow.

a. 1960 "Verified" Weather:

Actual cloud cover which was observed and recorded during the 30-day period from March 7 through April 5, 1960 was used. Because weather observing stations are seldom located at target sites, a method had to be devised to determine the actual cloud cover over the targets. The following technique was employed.

(1) Sino-Soviet Bloc

Actual weather reports nearest local noon have been plotted and hand analyzed by meteorologists to produce a four year (1957-60) series of daily cloud cover maps of the Sino-Soviet area. That series of 1461 daily maps represent the best possible source of cloud cover information for any day from Jan 1, 1957 through Dec 31, 1960 over any point in the Sino-Soviet area. Maps were analyzed in three categories with category 1 representing observations of 0 through 2/8, category 2 including 3/8 through 5/8, and category 3 including 6/8 through 8/8 cloud cover. The analyzed categories were then assigned to a system of almost 1500 grid points equally spaced (approximately 90 miles apart) throughout the Sino-Soviet area. That grid point cloud cover data was stored on magnetic tape for later use.

For this study, the latest available data (1960) was used since weather observations have improved somewhat in both quality and quantity in recent years. The data for March 7 through April 5, 1960 was then compared to data from the same periods of 1957, 1958, and 1959 to verify that 1960 was neither an abnormally good nor bad Spring weather period. It was not, so 1960 data may be considered as reasonably typical of Sino-Soviet cloud cover in the Spring.

After consultation with the GWC, grid point cloud cover categories 1, 2, and 3 were changed to representative percent clear sky values of 77, 57, and 12 respectively. A computer was then programmed to compare target locations to grid points and interpolate a percent clear sky for each target for each day of the mission.

(2) <u>For Areas External to Sino-Soviet Bloc (Indonesia, Middle East, etc)</u>

Actual weather observations and weather satellite photographs for the period March 7 through April 5, 1966 were manually examined to determine a daily noon percent clear sky figure for each target external to the Sino-Soviet Bloc.

In view of the recognized inaccuracies in weather observers' estimates of cloud-cover (i.e., percent of clear sky), the so-called "verified" weather as used in this model must be adjusted accordingly. The NRO Staff has developed a technique for making these adjustments, and this is discussed in Section 5 (GAMBIT Experience).

b. KH-4 Weather Model:

The Global Weather Center has analyzed more than 132,000 frames of KH-4 photography in its continuing analyses of cloud cover and cloud patterns. The frames were correlated in terms of sky condition at nadir (six groupings: clear sky; 1-9% cloudy; 10-25% cloudy; 26-50% cloudy; 51-99% cloudy; and 100% cloudy--or overcast--at nadir); and then, sky conditions at 10 mile intervals, out from nadir in both directions to the extremities of the frames, were measured. Graphs of the GWC analyses of the six sky conditions at nadir are included as attachment 5 to this study.

In view of the large number of samples (from many missions) in each category, plus the fact that the six categories cover all conditions from clear skies to complete overcast conditions, it may be assumed that these analyses also are representative of average climatology conditions in the Sino-Soviet Bloc.

Therefore, assuming that the results of any additional frame analyses would not change radically those already plotted (i.e., that the plots do represent climatology), the percent of total time that each of the six weather categories are encountered can be determined by summing the areas of identical weather conditions on each graph. For example, for overcast conditions, add the area percent of each graph covered by 100% cloudy conditions and divide by six. (Follow the same procedure for the other five categories). These computations are plotted as a bar graph and included as Attachment 6 to this study.

Using the bar-graph (Atch 6), a manual distribution was made in smaller percentile groups to graph a smooth curve sky condition. That KH-4-derived sky condition climatology distribution is included as Attachment 7 to this study.

The KH-4 Sky Condition Distribution represents the percent of time various sky conditions will be encountered and also indicates the probability of photographing a relatively small target in those conditions. For example, in the grouping of

20-29 percent clear sky, the graph indicates that these conditions will be encountered approximately 3½% of the time, and in that condition, the probability of photographing a target is 25%; similarly, overcast conditions will be encountered 16% of the time, with photographic probability, of course, being zero.

If the entire graph is integrated for probability of achieving photography (i.e., 16% overcast times zero probability; plus 10½% of 1-9% clear sky conditions times .05 probability; plus 6% of 10-19% clear sky conditions times .15 probability; and so on through each grouping), it indicates that photography of all or part of targets (depends on size of target) will be achieved 55-plus percent of the time. This compares favorably with long-term GAMBIT experience (54.1%) which generally reflects average climatology (see Section 5).

Additionally, the KH-4 graphs can also be used to determine the clear sky probability of adjacent (or alternate) targets. Since, the alternates selected for this study averaged 30 miles distance for the primary, that probability has been plotted and is included as Attachment 8 to this study.

c. KH-7 Weather Model Based on Frame Analysis:

Representatives of SAFSP and the MOL System Project Office assembled a weather distribution model based on analysis of 1159 separate frames (each approximately 10 x 20 miles) of KH-7 photography from three 1965/1966 missions. These frames were sorted into completely overcast, cloud-free, and ten other groupings from 1-99% cloud-free conditions. A plot of this analysis is included as Attachment 9 to this study.

This sky condition distribution model can be used in the same manner as that derived from the KH-4 frame analysis (i.e., 26% of the time, overcast conditions are encountered and probability of photography is zero; 11 percent of the time, 1-9% clear sky conditions are encountered, with a photographic probability of .05, etc). When integrated over the entire graph, it indicates that photography of all or part of a target (depending on diameter) can be expected approximately 50 percent of the time. This is approximately 10 percent less than GAMBIT experience (see Section 5).

d. <u>KH-7 Weather Model Based on Operational Results:</u>

Another weather distribution model was developed based on the actual results of 3007 separate camera operations (from seven different missions), plus the sorting of individual frames into appropriate cloud-cover percentage categories.

The GAMBIT experience (see Section 5) and individual frame cloud-cover counts were manually sorted into a "best-fit" distribution of sky condition distribution. A graph of this model is included as Attachment 10.

This sky condition distribution model can be used in the same manner as that derived from the KH-4 frame analysis (i.e., for any percentile grouping of sky cover, those conditions will be encountered that percent of the time, and the probability of photographing a target--at least partial coverage, depending on target diameter--will be the mid-point of the percentile grouping). When integrated across the entire graph, the results, of course, match GAMBIT experience (photography of at least a part of the intended target approximately 54% of the time).

e. 1966 "Verified" Weather:

During July and August 1966, on a day-to-day schedule which did not interfere with normal GWC activities, the GRESOLVE-selected primary targets plus manually-selected alternate targets for a total single day's operations were sent to GWC for determination of "verified" (observed) weather on a target-by-target basis. In other words, GWC was requested to provide the "verified" weather that specific day in the Sino-Soviet Bloc for the list of targets provided them.

The results of G experience, in terms of probability of obtaining a photograph of a target under a given sky-cover "verified" condition (see Section 5), were then applied to each target in the same manner used for the 1960 "verified" weather.

f. <u>Climatology for Large Target Complexes</u>:

Climatological values of cloud amounts observed at two locations in the USSR were used to compare probable manned and unmanned system results in a typically poor-weather area and a typically good-weather area. The Moscow area is fairly representative of USSR weather west of the Ural Mountains (worse than average); Kakterin (near Sary Shagan) is fairly representative of the semi-arid, south central good weather area of the USSR. Sky condition weather distribution models for these two areas are included as Attachments 11 and 12.

Both GAMBIT probability experience and KH-4 alternate weather probability were combined to estimate the probable results of manned and unmanned systems against these areas.

*   *   *   *

(Manned and unmanned system probable photographic results under the weather conditions described in this section are contained in Section 6 of this study.)

5. GAMBIT EXPERIENCE

The NRO Staff requires a capability to estimate the GAMBIT probability of having photographed a given target on a given day (as a basis for planning subsequent days' operations in the same area on the same mission) as well as the probability of photographing a target or targets against average or seasonal climatology (as a basis for scheduling a mission or series of missions). As indicated previously in this study, recognizing the inaccuracies in observer-verified weather, a technique has been developed based on a large sample of actual results which accurately compensates for these inaccuracies.

3007 camera operations, from seven GAMBIT missions, against 3007 primary targets (the aiming points) were analyzed in terms of "verified" (i.e., observed) weather vs NPIC reports of actual results. The 3007 camera operations were distributed (i.e., percent of total vs percentile groupings of "verified" clear-sky conditions ranging from overcast to clear) as graphically indicated in Attachment 13.

Next, the NPIC-reported results of the 3007 camera operations against the 3007 primary targets were tabulated and plotted against "verified" weather (in terms of probability of photographing a target in each "verified" percentage of clear-sky grouping). This graph is included as Attachment 14. Note that Attachment 14 is plotted in terms of probability of photographing a complete target cloud-free, a target partially cloud-free with scattered clouds covering a portion of the target, and a target partially cloud-free with heavy broken clouds covering a portion of the target.

The coverage of partial targets is largely a function of target diameter (i.e., if all targets were "point" size, there would be no "partials") vs cloud size and spacing. Since the average MOL (DORIAN) targets will be somewhat smaller than GAMBIT targets in diameter, the MOL can be expected to have a higher ratio of "completes" vs "partials" than the GAMBIT; however, the overall ratio of targets (partials plus completes) vs total attempts should be about the same.

The GAMBIT results plotted on Attachment 14 can be used as follows. For example, in the observed 60-69 percent clear-sky grouping, 64 percent of all GAMBIT attempts under these conditions can be expected to result in cloud-free photographs of complete targets (this, of course, does not necessarily mean that the entire frame is cloud-free), eleven percent can be expected to result in photographic coverage of partial targets with scattered clouds involved, and four percent can be expected to result in photographic coverage of partial targets in the presence of and interfered with by heavy broken clouds.

When integrated across the entire graph, Attachment 14 indicates that 54.1% of all GAMBIT attempts result in at least partial photographic coverage of targets (41.8% resulting in cloud-free coverage of complete targets, plus 6.9% targets partially covered by scattered clouds, plus 5.4% targets partially covered by heavy clouds and haze).

Additionally, the frames which resulted in complete targets being photographed cloud-free (41.8% of total) were checked for overall frame cloud conditions. 64% of the 41.8% frames were cloud free (26.8% of total GAMBIT attempts, this correlates quite closely with the KH-7 frame count. See Section 4c). Further, of the 1410 camera operations (45.9% of 3007) which resulted in no target readout at all, approximately 56% of the frames (or 25.7 percent of total attempts) were completely overcast; in the remainder of the 1410 frames, some ground could be seen but the targets were completely cloud-covered.... The data contained in this paragraph was used in determining the sky-condition distribution weather model (Attachment 10) based on KH-7 results; however, only Attachments 13 and 14 were used in determining manned and unmanned system results using "verified" (i.e., observed) cloud cover conditions.

6. MANNED & UNMANNED SYSTEM RESULTS

The results of the calculations of probable numbers of targets successfully photographed by the manned and unmanned systems, when operated against the six weather models described in Section 4, are described in the following sub-sections.

a. Against "Verified" 1960 Weather:

As indicated in Section 4, the primary targets (selected by the GRESOLVE software) and alternate targets (selected manually, where available) for each day of the 30-day mission were sent to the GWC for identification of the March 6-April 5 1960 "verified" (observed) weather. When appropriate, the weather for individual targets was computer-derived by GWC by integrating between appropriate grid points. Thus, a unique observed cloud-cover (conversely, clear sky) amount was provided for each primary and alternate target.

Since 1960 observed weather was reported in only three major categories, two large groups of camera operations were identified in the less-than-twenty percent clear sky and more-than-seventy percent clear sky categories. Using GAMBIT operational experience (Attachment 13), the 2120 camera operations in the $<$20% clear sky category were redistributed into appropriate percentile groups of 0%, 1-9%, and 10-19% clear sky. Likewise, the 947 camera operations in the > 70% clear sky category were redistributed into appropriate percentile groupings of 70-79%, 80-89%, 90-99%, and 100% clear sky.

Then, using GAMBIT-experience probability (Atch 14) derived from actual operations against "verified" weather, the probable number of targets photographed was calculated for the manned and unmanned systems (See Section 3 for technique). The calculations indicate that the unmanned system would provide photographic coverage of 2019 targets, and the manned system coverage of 2533 targets (an improvement of 25.2 percent in favor of the manned system). The tabulations are included as Attachment 15 to this study.

GAMBIT experience also indicates that approximately 20 percent of the total targets successfully photographed by both the manned and unmanned systems would be partially covered by clouds. However, since the MOL (DORIAN) targets will have a smaller average diameter than past and present GAMBIT targets, the percentage of partial-target photographic coverage should be less than 20 percent for both the manned and unmanned MOL (DORIAN) systems.

It was noted that the 1960 "verified" weather produced about seven percent less total target photographs for the unmanned system than GAMBIT experience indicates should be obtained.

b. Against the KH-4-Derived Weather Model:

Next, the 3988 camera operations were distributed against the sky-condition climatology model derived from KH-4 photography (See Section 4 and Attachment 7). Since this weather model depicts the actual percentage of time each cloud-cover percentile grouping will be encountered, the probability of target photography is the mid-point of each percentile grouping (for example: the probability of photographing all targets encountered in the 20-29 percentile grouping is 25%, etc). Alternates for the manned system were distributed in each percentile grouping in accord with the distribution of the GRESOLVE and manual selections. The probability of photographing primary and alternate target combinations was obtained by summing the primary probability and the KH-4-derived alternate weather probability (See Section 3 and Attachments 7 and 8).

The computations made as described in Section 3 indicated that the unmanned system would provide photographic coverage of 2209 targets, and the manned system 2585 targets (an increase of

17.1 percent in favor of the manned system). The tabulations are included as Attachment 16 to this study.

As noted previously, GAMBIT experience indicates that approximately 20 percent of the total targets successfully photographed by the manned and unmanned systems would be partially obscured by clouds. However, since the MOL (DORIAN) targets have a smaller average diameter than past and present GAMBIT targets, the percentage of partially-obscured targets should be less than 20 percent.

Against this weather model, the unmanned system provided about one percent more targets than would have been expected on the basis of current GAMBIT experience.

c. KH-7-Derived Weather Model (Individual Frame Cloud-Count):

Next, the 3988 manned and unmanned system camera operations were measured against a sky-condition weather distribution model derived from sorting 1179 individual KH-7 frames of photography (See Section 4 and Attachment 9) into appropriate percentile groupings. The 3988 primary camera operations were distributed as indicated by the frequency of occurrence for each percentile grouping.

Using this weather model, the mid-point of each percentile grouping is the probability of primary target photography for that grouping (i.e., in the 20-29 percentile grouping, the probability of photographing each primary target encountered in those conditions is 25 percent). The probability of photographing alternate targets was obtained from the appropriate KH-4-derived alternate target weather probability (Attachment 8).

Computations made as described in Section 3 indicate that the unmanned system would provide photographic coverage of 2023 targets, and the manned system coverage of 2365 targets (an improvement of 17 percent in favor of the manned system). Tabulations are included as Attachment 17 to this study.

As noted previously, something less than 20 percent of the total targets successfully photographed by both the manned and unmanned systems would be partially obscured by clouds.

d. KH-7-Derived Weather Model (NPIC Results plus Frame Cloud-Count):

Next, the 3988 manned and unmanned system camera operations were measured against a sky-condition weather distribution model based on the results of 3007 individual KH-7 camera operations against verified weather (See Section 4 and Attachment 10). The

3988 primary camera operations were distributed into each percentile grouping as indicated by the appropriate frequency of occurrence. The probability of photographing each primary target is then the mid-point of each percentile grouping. Appropriate probabilities for alternate targets were obtained from the KH-4-derived alternate weather probability (See Attachment 8).

Computations made as described in Section 3 indicated that the unmanned system would provide photographic coverage of 2153 targets, and the manned system coverage of 2592 targets (an improvement of 20.4 percent, in favor of the manned system). Tabulations are included as Attachment 18 to this study.

As indicated in each previous sub-section, something less than 20 percent of the total targets successfully photographed by the manned and unmanned systems would be partially obscured by clouds.

e. "Verified" 1966 Weather:

The primary and alternate targets (selected by GRESOLVE and manually) for the first 15 days' operations were sent to GWC during July and August 1966 for identification of the actual Sino-Soviet "verified" (i.e., observed) weather for each target for successive days. Thus, each primary and alternate target was assigned a unique individual "verified" weather. The probability of photographing each primary and alternate target was obtained from GAMBIT experience operating against "verified" weather (Attachment 14).

Computations made as described in Section 3 indicated the unmanned system would provide photographic coverage of 1120 targets on a 15-day mission, and the manned system coverage of 1367 targets (an improvement of 22 percent in favor of the manned system). Tabulations are included as Attachment 19 to this study.

As indicated in each previous sub-section, something less than 20 percent of the total targets successfully photographed by the manned and unmanned systems would be partially obscured by clouds.

f. Climatology at Two Selected Targets:

As described in Section 4 (Weather) climatology for the Moscow and Kakterin (near Sary Shagan and Tyura Tam) areas was used as representative of typically "worse-than" and "better-than" climatology areas.

(1) Moscow Target Complex:

Against the Moscow target complex area, the manned and unmanned system missions achieved six good photographic passes on the 30-day mission. Using the target deck described in Section 3 of this study, plus the GRESOLVE selection of primary targets and manual selection of alternate targets, the six orbits through the Moscow area totaled 24 camera operations against primary targets. No alternates were found for two primary target operations; one alternate was identified for two other primary targets; two alternates were found for two other primary targets; and three or more alternates were available for the remaining 18 primary target operations.

The frequency of occurrence of each category of observed Moscow area weather is depicted in Attachment 11. The probability of photographing the primary target was obtained from GAMBIT actual operating experience against observed weather (Attachment 14). The appropriate alternate target weather probability for each percentile grouping was obtained from the KH-4-derived alternate weather probability (Attachment 8).

Results were computed for one year's operations (six successful 30-day missions for both the manned and unmanned systems). The computations indicated that the unmanned system would provide photographic coverage of 58 individual targets, and the manned system coverage of 85 targets (an increase of approximately 45 percent in favor of the manned system). Tabulations are included as Attachment 20 to this study.

It should be noted that the Moscow area has both worse-than-average weather and a more favorable distribution of alternates than the average primary. Both of these factors bias the results upward in favor of the manned system.

(2) Kakterin Target Complex:

The same approach was taken for the Kakterin area as was done for the Moscow area. During the 30-day mission, the manned and unmanned systems had seven good photographic passes against Sary Shagan and Tyura Tam.

The frequency of occurrence for each sky condition percentile grouping is indicated in Attachment 12. The probability of photographing each primary target was obtained from GAMBIT experience operating against "verified" weather (Attachment 14). The probability of photographing each alternate target was obtained from the KH-4-derived alternate weather probability (Attachment 8).

Target distribution at Sary Shagan and Tyura Tam indicated that 51% of the primary targets would have no alternates, 9% would have one alternate, 7% would have two alternates, and 33% would have three alternates (roughly comparable to the average distribution of alternates vs primary targets).

The results computed for one year's operation (i.e., six successful 30-day missions) indicated that the unmanned system would provide photographic coverage of 160 targets, and the manned system coverage of 183 targets (an increase of 15 percent in favor of the manned system). Tabulations are included as Attachment 21 to this study.

It should be noted that the Kakterin area climatology averages about 10-15 percent better weather than the overall Sino-Soviet Bloc.

*   *   *   *

7. SUMMARY/CONCLUSIONS

The results of this analysis indicate that the manned system, with the astronaut performing a weather avoidance role, will successfully photograph significantly more intelligence targets than will the unmanned system on a comparable mission. (By weather avoidance is meant that the astronaut may select among pre-designated alternate targets for photography when adverse weather is encountered at the pre-designated primary targets.)

The capability of the astronaut to perform as a weather "scout" was briefly investigated. It was concluded that the astronauts would have little difficulty visually identifying areas of best weather since significant weather differences between relatively close (30-40 miles) primary and alternate targets does exist, that the effect of obliquity of viewing angle when the astronaut scanned weather was not serious, and that the astronauts would have sufficient time to perform the task.

A representative target deck, based on the current GAMBIT/GAMBIT-CUBED target deck and current intelligence community thinking, was used as a basic tool for the manned/unmanned system comparisons. The availability of alternate targets did not particularly favor the manned system (since 51% of the primary targets had no alternates available, 16% had but one alternate available, 8% had two alternates, and 25% had three or more alternate targets--obviously, a distribution of one alternate for each primary target would have been considerably more favorable to the manned system); however, the locations of targets are believed to be representative of the situation which will exist when the MOL (DORIAN) system becomes operational.

To insure a realistic study and reasonably accurate projections of targets photographed, maximum advantage was taken of NRO operating experience with reconnaissance satellites--particularly GAMBIT experience operating against forecast and observed weather, GAMBIT software, etc (in view of the similar characteristics of the GAMBIT and DORIAN camera sub-systems).

Recognizing the sensitivity of the manned/unmanned system comparison to the weather information employed (it was obvious, at the outset, that the manned system--given the option of photographing alternate targets--would appear in a more favorable light in adverse weather situations), a wide variety of weather models and data were utilized, with results as follows:

a. Operating on simulated, identical 30-day missions against observed March 7-April 5, 1960 weather, the unmanned system would have successfully photographed 2019 primary targets, and the manned system 2533 primary plus alternate targets (an increase of approximately 25% in favor of the manned system). It should be noted, however, that the total targets photographed by the unmanned system are about 7% less than present GAMBIT experience indicates is the proper total. It may be concluded, therefore, that either the March 1960 period was worse-than-average climatology or else the observers overestimated cloud-cover moreso in 1960 than in 1966. Whatever the cause, this in-effect worse-than-average climatology undoubtedly biased the results somewhat in favor of the manned system.

b. Operating on simulated, identical 30-day missions against a weather model derived from the analyses of more than 132,000 frames of KH-4 photography, the unmanned system would have successfully photographed 2209 targets, and the manned system 2585 primary and alternate targets (an increase of approximately 17 percent in favor of the manned system). It is believed that this weather model is fairly representative of Sino-Soviet Bloc climatology, although it may be biased a very limited degree in favor of better-than-average weather conditions. If so, then the manned increase is slightly less than would ensue in average climatology conditions.

c. Operating on simulated, identical 30-day missions against a weather model derived from a cloud-cover count and sorting of 1179 frames of KH-7 photography (from three separate 1965/66 missions), the unmanned system would have successfully photographed 2023 primary targets, and the manned system 2365 primary and alternate targets (an increase of approximately 17 percent in favor of the manned system). Despite the similarity of the percentage increase between this comparison and that for the preceding KH-4-derived weather model, this answer is not considered valid since results obtained from this model diverge radically in some respects with actual GAMBIT results and experience.

d. Operating on simulated, identical 30-day missions against a weather model derived from the results of 3007 separate GAMBIT operations against primary targets, the unmanned system would have successfully photographed 2153 primary targets, and the manned system 2592 primary and alternate targets (an increase of approximately 20 percent in favor of the manned system). This weather model is believed to be reasonably representative of average Sino-Soviet Bloc climatology, although recent GAMBIT target selection techniques may have biased the model a slight amount toward better-than-average climatology. If so, then the manned system increase is slightly less than it would be under average conditions.

e. Operating on simulated, identical 15-day missions against actual "verified" (i.e., observed) July and August 1966 Sino-Soviet weather for each primary and alternate target, the unmanned system would have successfully photographed 1120 primary targets, and the manned system 1367 primary and alternate targets (an increase of approximately 22 percent in favor of the manned system). Since the July and August days used for this analysis were selected at random, the results are believed to be reasonably typical of the increase one might expect from the manned system (using alternate targets).

f. Operating on simulated, identical missions against the Moscow area target complex (an area known to have considerably worse-than-average climatology), the manned system would have successfully photographed 45 percent more targets than the unmanned system. Similarly, operating on simulated, identical missions against the Sary Shagan and Tyura Tam area target complexes, the manned system would have successfully photographed approximately 15 percent more targets than the unmanned system.

However, to place the Moscow area analysis in a proper context, it must be understood that the Moscow area had a higher proportion of available alternate targets than did the average Diamond primary target. Had the distribution of alternate targets been similar to the overall average, the manned system would have shown an increase of about 28 percent in the Moscow area, which is more representative of the relative improvement in worse-than-average climatology conditions.

The DIAMOND II study leads to the following general conclusions:

a. On identical missions against average Sino-Soviet weather, the manned system (with the astronaut providing a weather avoidance function and having the option of photographing pre-designated alternate targets) can be expected to successfully photograph about 18-20 percent more targets than the unmanned system.

b. Operating against large target complexes, with numerous primary/multi-alternate target combinations available, under average weather conditions, the manned system successful photographic results can be expected to exceed the unmanned system by considerably more than 18-20 percent.

c. When overall Bloc weather is worse than average, the manned system results will exceed the unmanned system by more than 18-20 percent; conversely, when overall Bloc weather is better than average, the manned system results will exceed the unmanned system by less than 18-20 percent.

* * * *

ATCH 1-1

~~TOP SECRET~~ RUFF

ATCH 1-2

ATCH 1-3

ATCH 1-4


~~TOP SECRET~~ RUFF
MISSION 9009
PASS 7 [redacted]
PART 2 OF 7
~~TOP SECRET~~ RUFF

ATCH 1-5


MISSION 9009 PART 1 OF 6
PASS 5
~~TOP SECRET~~ RUFF
JOINS 2 OF 6
~~TOP SECRET~~ RUFF

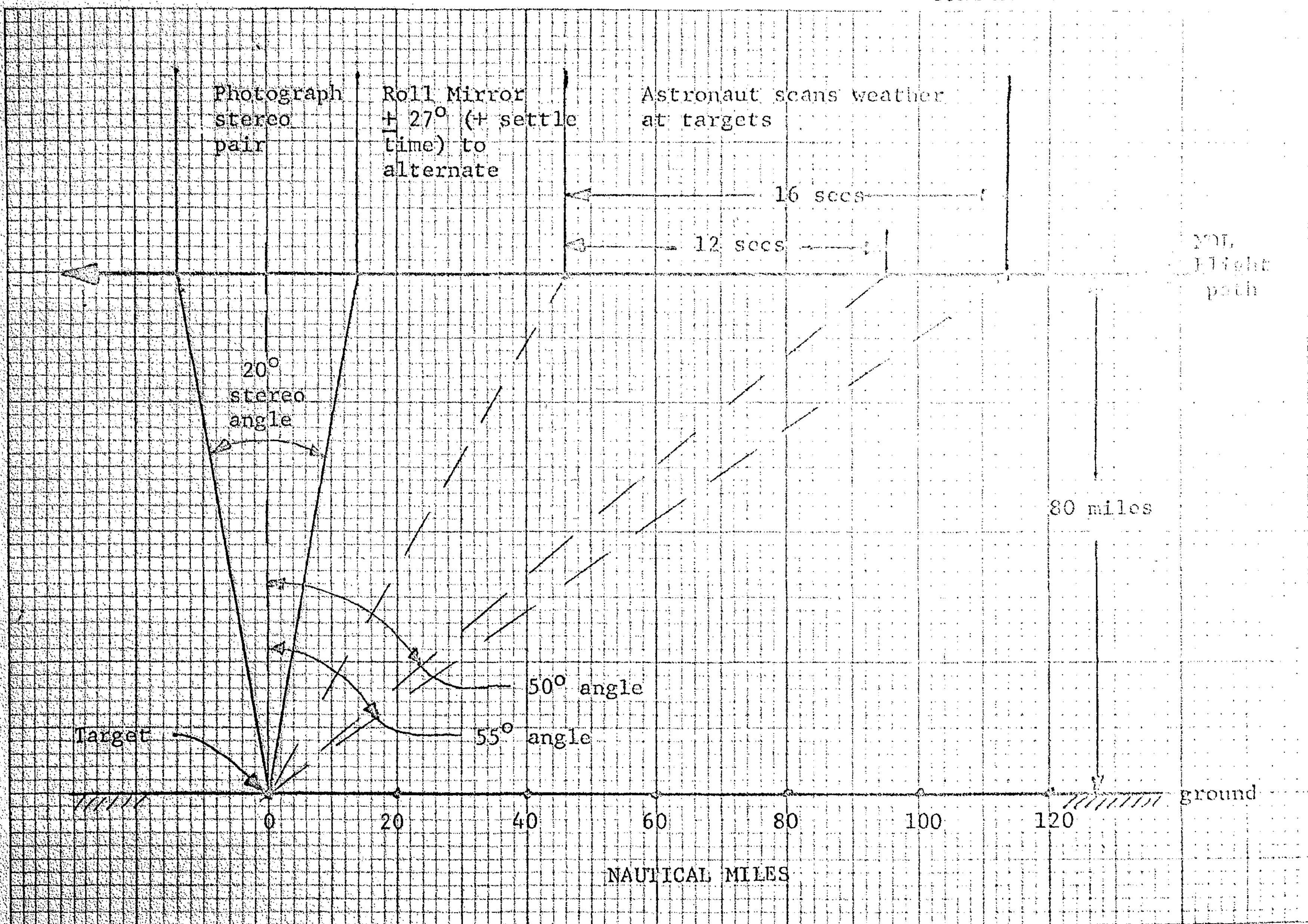
ATCH-1-6

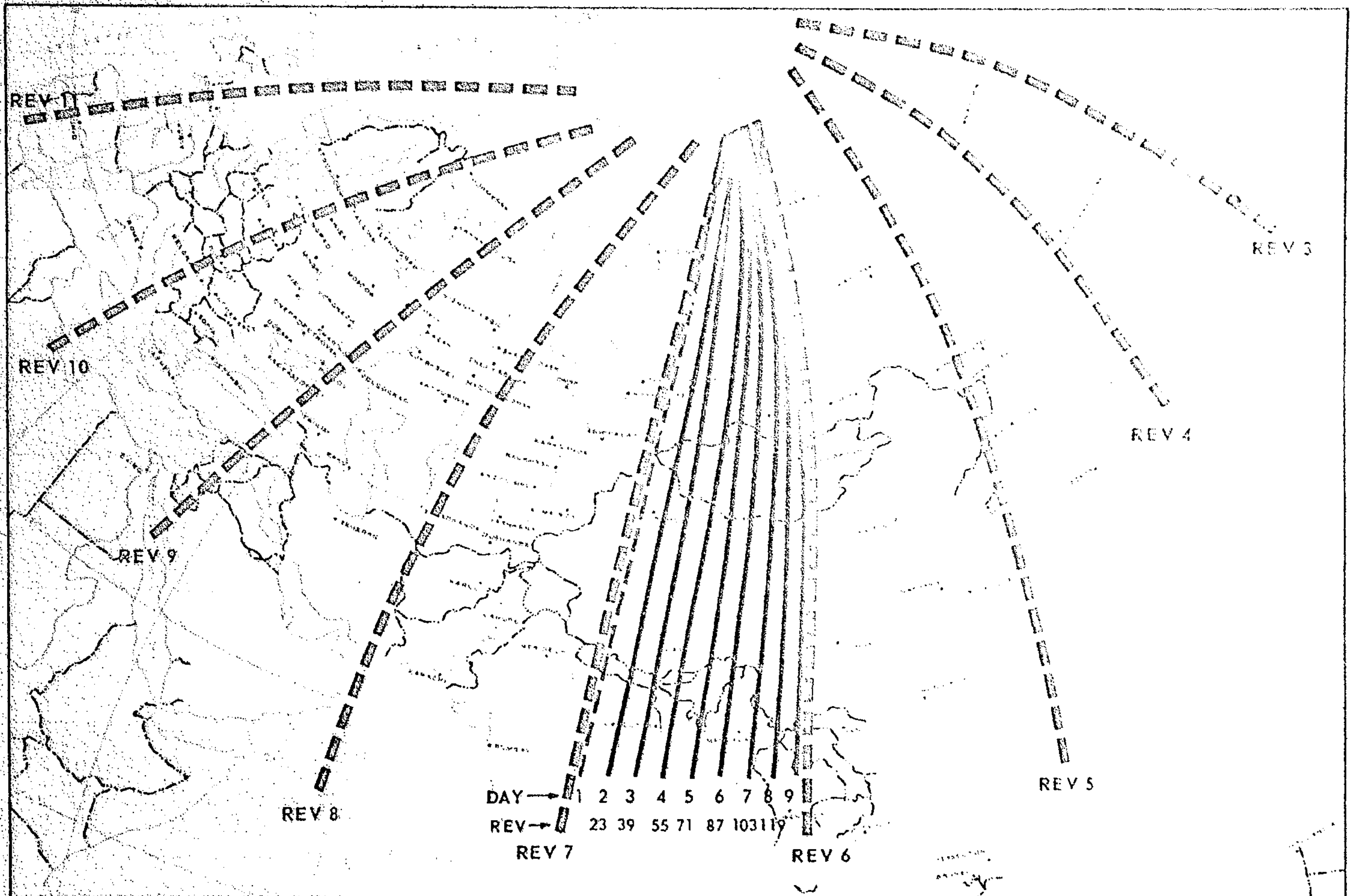

~~TOP SECRET~~ RUFF
MISSION 9009
PASS 4
PART 2 OF 8
JOINS 3 OF 8
~~TOP SECRET~~ RUFF

ATCH 1-7

~~TOP SECRET~~ RUFF

ATCH 1-8


Photograph stereo pair
Roll Mirror ± 27° (+ settle time) to alternate
Astronaut scans weather at targets
16 secs
12 secs
MOL flight path
20° stereo angle
80 miles
50° angle
55° angle
Target
ground
0
20
40
60
80
100
120
NAUTICAL MILES



DIAMOND ORBITAL TRACES

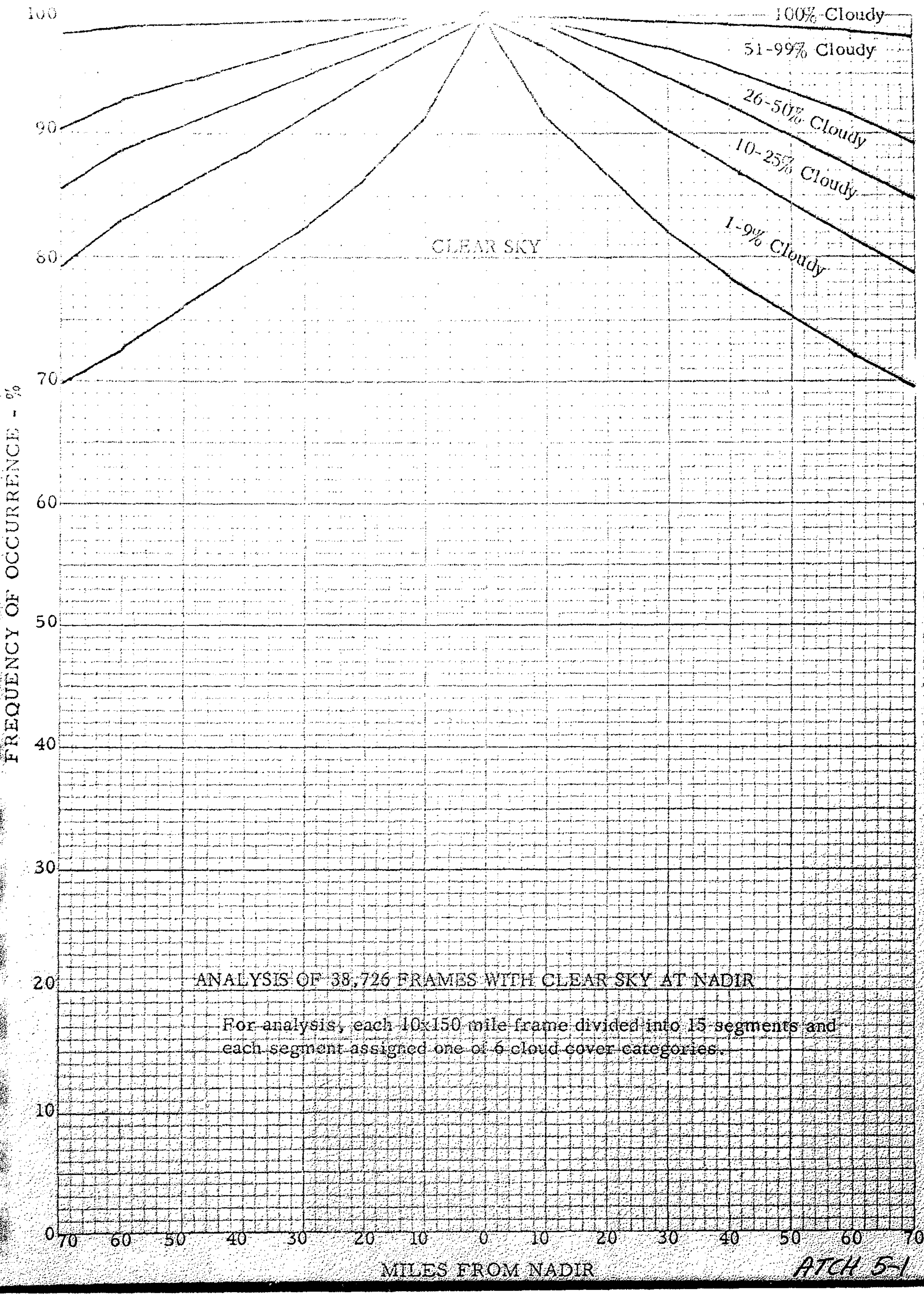
ALL PASSES DAY ONE &
PASS SEVEN DAYS TWO THRU NINE

ATCH 3

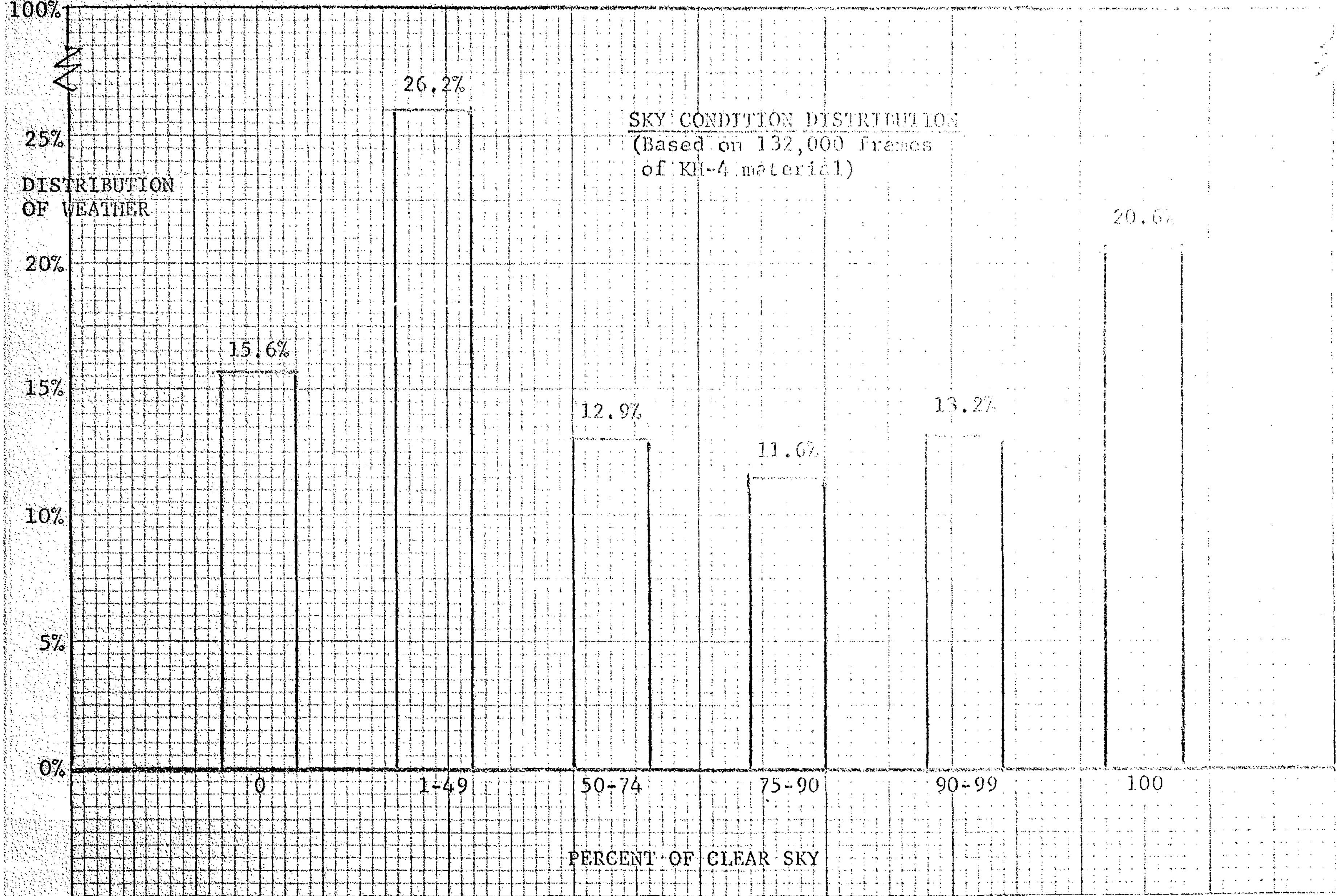
Camera Operations vs Priority & Category Matrix

Category	Priorities 1	2	3	4	5	6	7	8	9	Total
1A	106							45	2	153
1B	20				6		13	58	5	102
1C	58						2	7		67
1D	96						6	9		111
1E								1		1
1G	73							4		77
1H	18	1					1	2		22
1I	4					6	7	53	7	77
1J					3	3		6		12
1K	9					12		2		23
1L			1					2		3
2A	52							27	52	131
2B	16	2			1			6	1	26
2C	55		5		1		22	517	263	863
2G	7									7
3A	30							1		31
3B	39					4		23	9	75
3C	37		2		3			1	1	44
3E							8	6	5	19
4A	56							27	11	94
4B	36									36
4C	19							22	19	60
5A	6								2	8
5B	24							2		26
5C	26							5	1	32
5D	9									9
6A	31					1		32	22	86
6B							5	299	297	601
7A	18	4			11	22	15	718	228	1016
7B	6									6
8A	18							19	18	55
8B	17							12	1	30
8C									26	26
9A	6				3	3		3	1	16
Totals	929	7	8		28	51	79	1915	971	3988

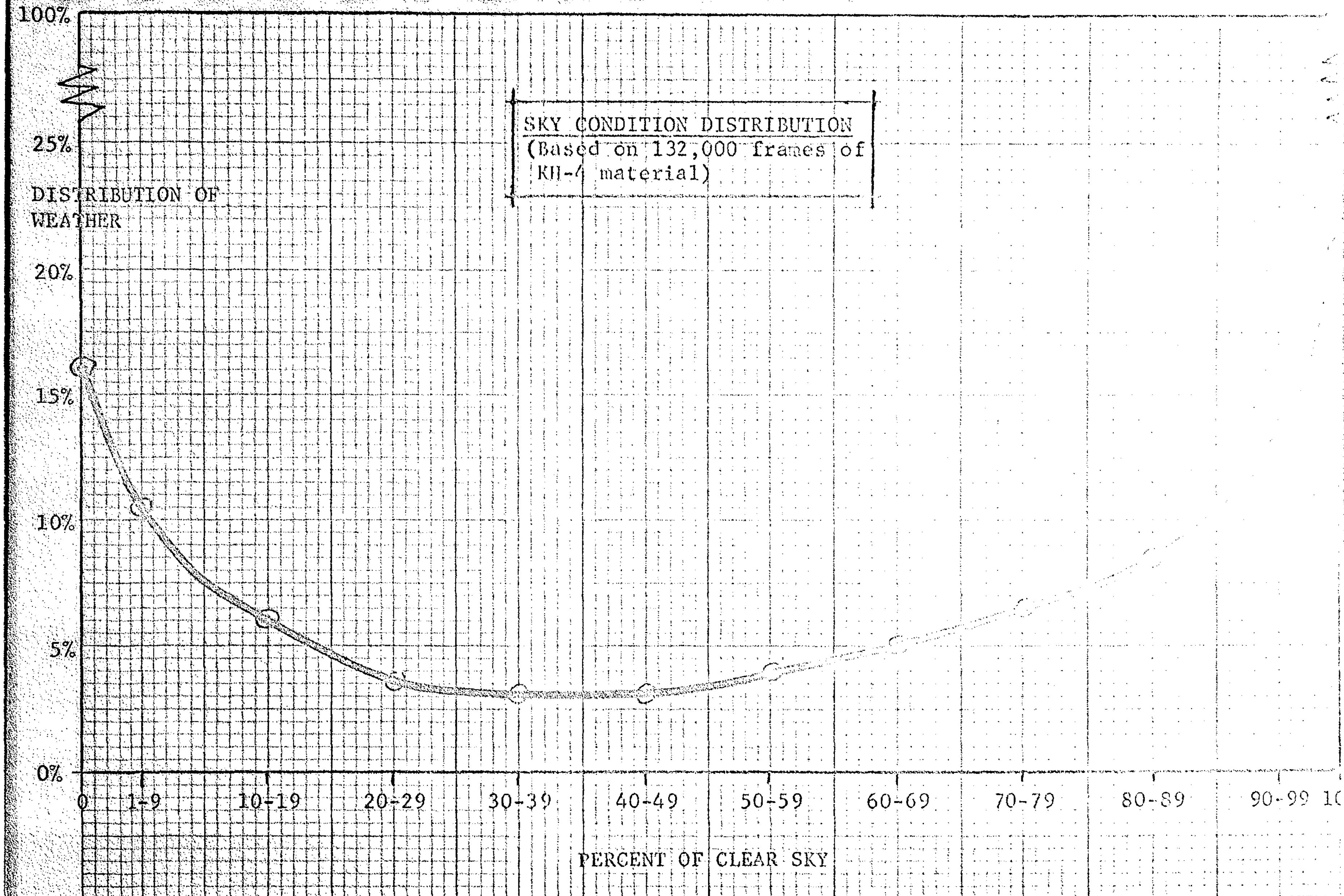
ATCH 4


100% Cloudy
51-99% Cloudy
26-50% Cloudy
10-25% Cloudy
1-9% Cloudy
CLEAR SKY
FREQUENCY OF OCCURRENCE - %
100
90
80
70
60
50
40
30
20
10
0
70 60 50 40 30 20 10 0 10 20 30 40 50 60 70
MILES FROM NADIR
ANALYSIS OF 38,726 FRAMES WITH CLEAR SKY AT NADIR
For analysis, each 10x150 mile frame divided into 15 segments and each segment assigned one of 6 cloud cover categories.

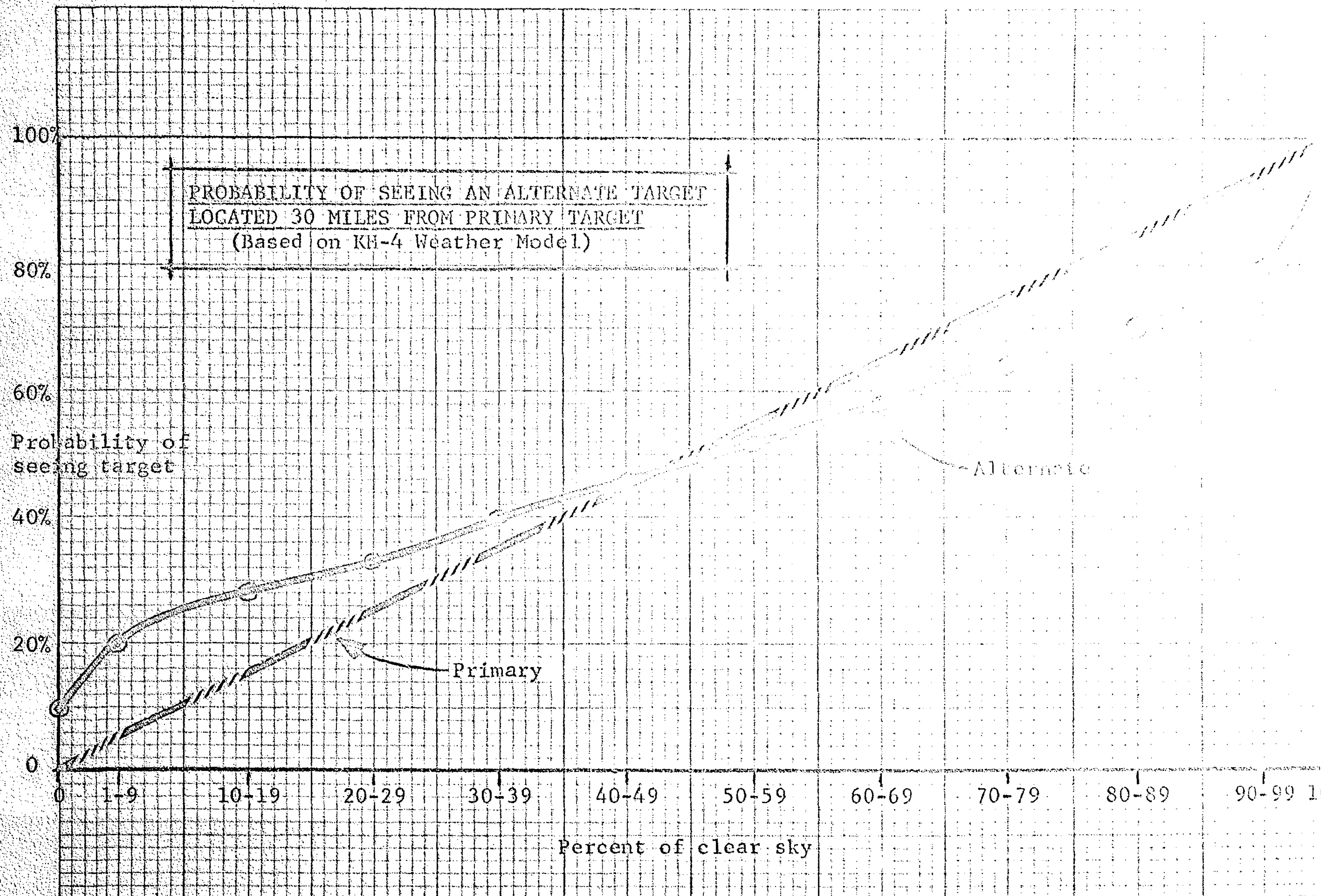
ATCH 5-1


SKY CONDITION DISTRIBUTION
(Based on 132,000 frames of KH-4 material)
DISTRIBUTION OF WEATHER
100%
25%
20%
15%
10%
5%
0%
15.6%
26.2%
12.9%
11.6%
13.2%
20.6%
0
1-49
50-74
75-90
90-99
100
PERCENT OF CLEAR SKY

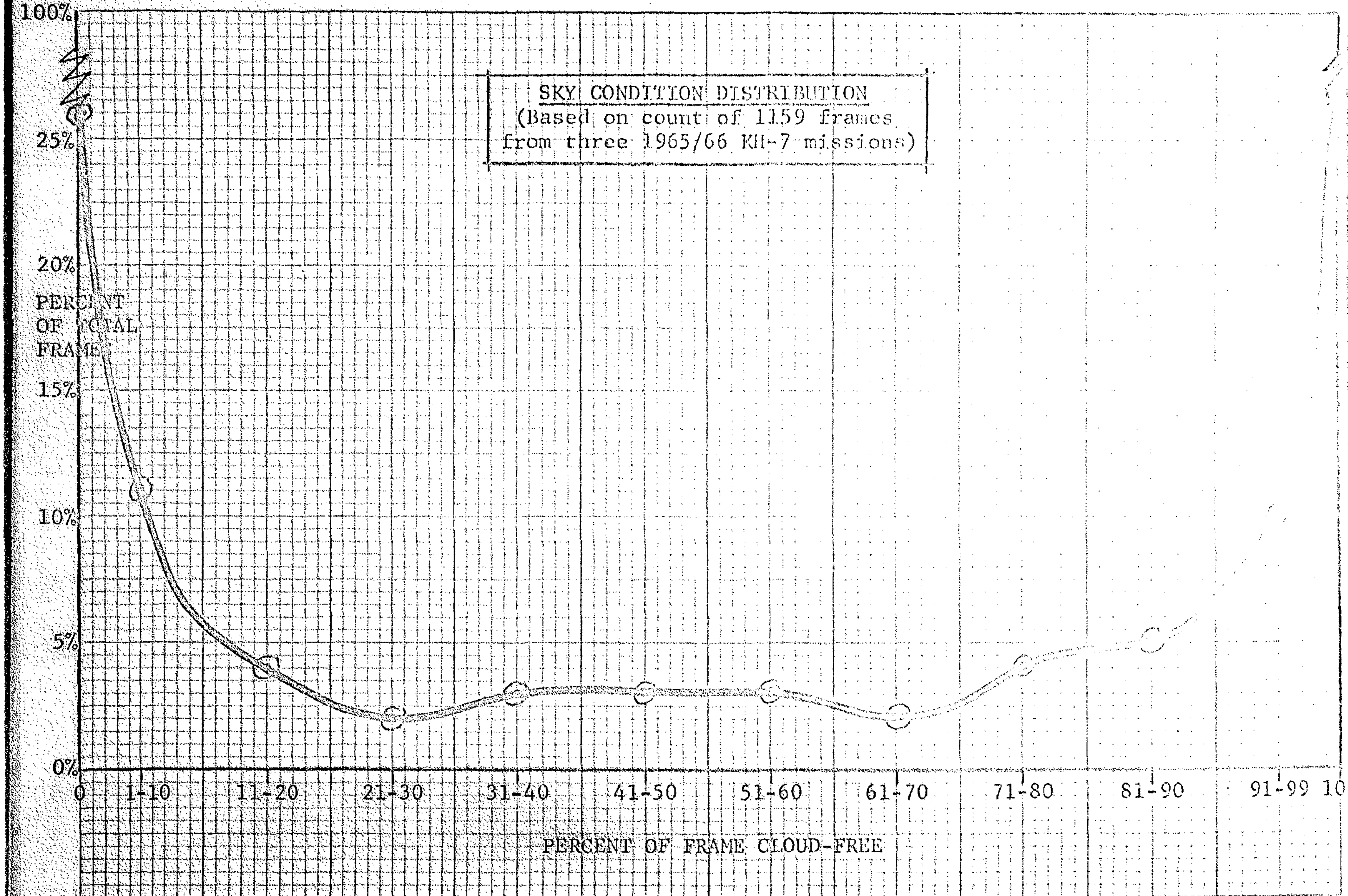
ATCH 6


SKY CONDITION DISTRIBUTION
(Based on 132,000 frames of
KH-4 material)
DISTRIBUTION OF
WEATHER
100%
25%
20%
15%
10%
5%
0%
0
1-9
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80-89
90-99
PERCENT OF CLEAR SKY

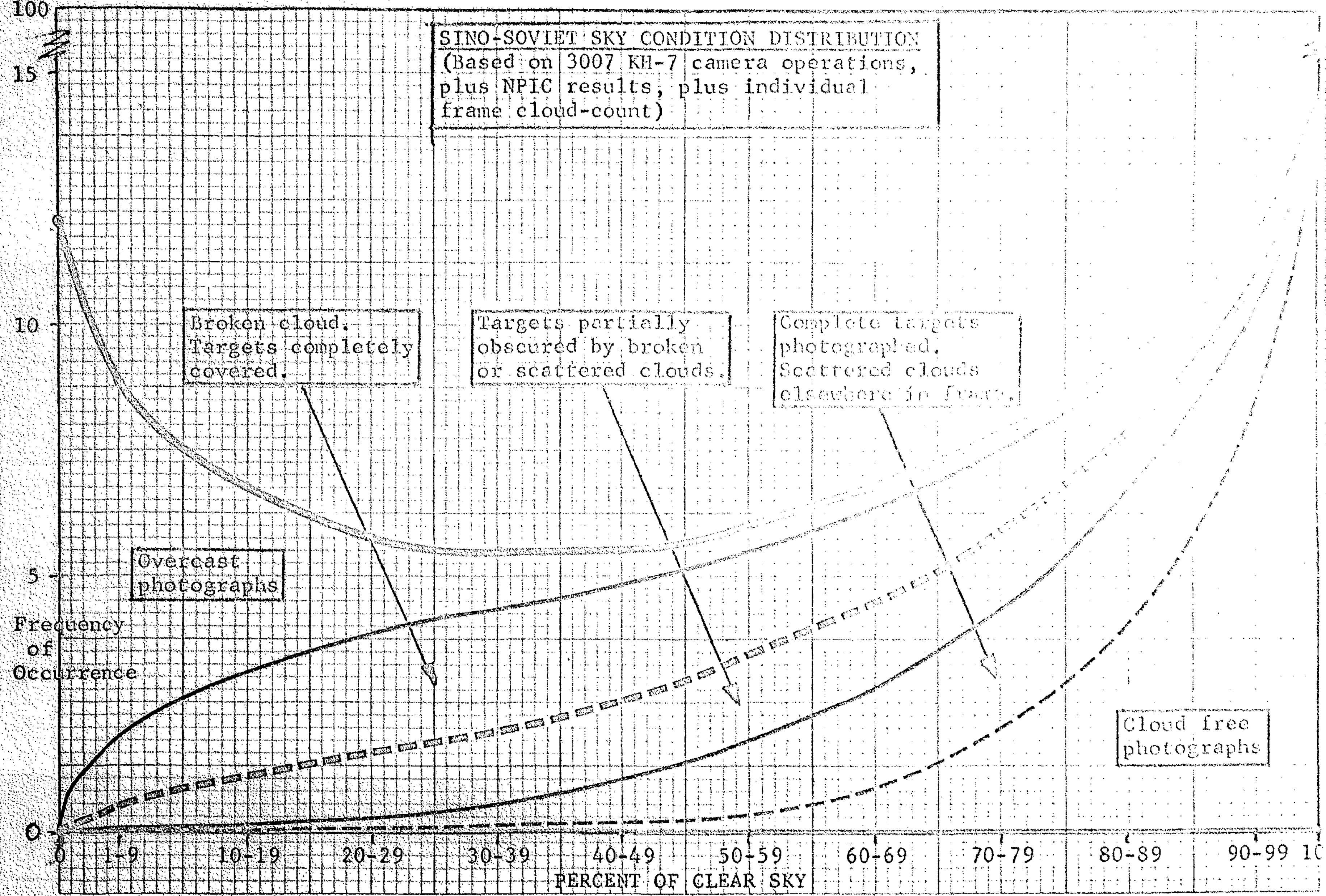
ATCH 7


PROBABILITY OF SEEING AN ALTERNATE TARGET
LOCATED 30 MILES FROM PRIMARY TARGET
(Based on KH-4 Weather Model)
100%
80%
60%
40%
20%
0
Probability of
seeing target
Primary
Alternate
0
1-9
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80-89
90-99
Percent of clear sky

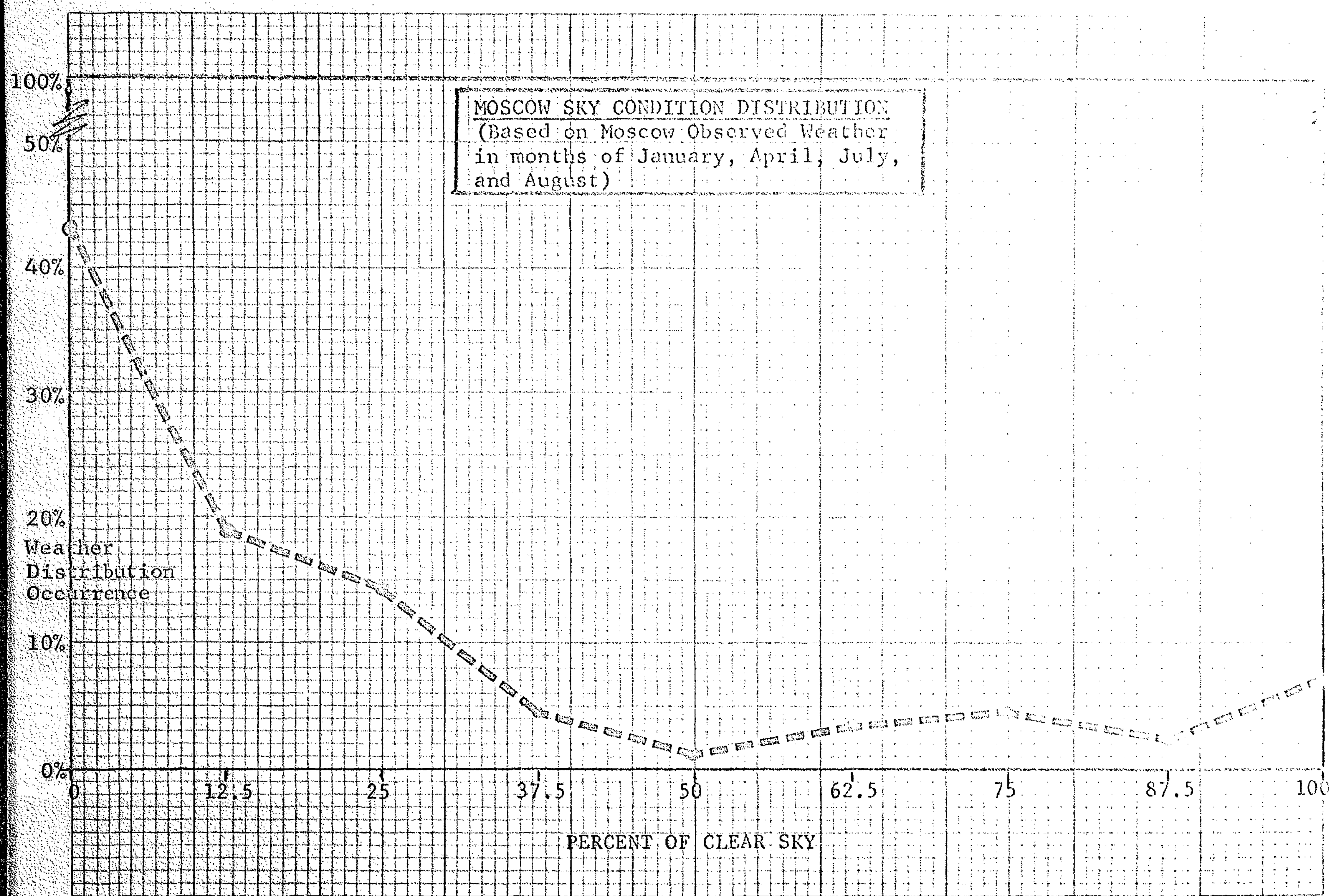
ATCH 8


SKY CONDITION DISTRIBUTION
(Based on count of 1159 frames
from three 1965/66 KH-7 missions)
100%
25%
20%
PERCENT
OF TOTAL
FRAMES
15%
10%
5%
0%
0
1-10
11-20
21-30
31-40
41-50
51-60
61-70
71-80
81-90
91-99
10
PERCENT OF FRAME CLOUD-FREE

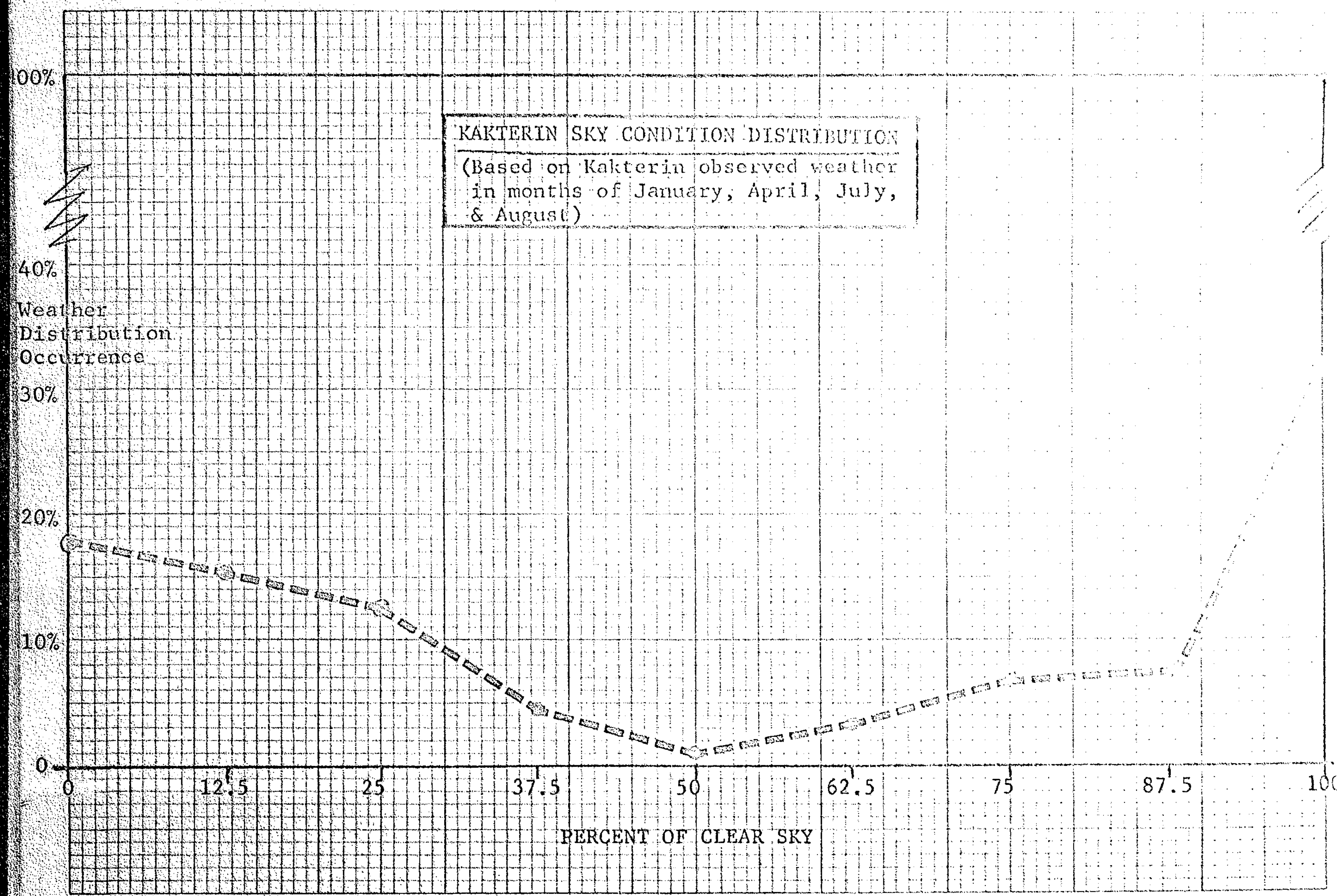
ATCH 9


SINO-SOVIET SKY CONDITION DISTRIBUTION
(Based on 3007 KH-7 camera operations, plus NPIC results, plus individual frame cloud-count)
Broken cloud. Targets completely covered.
Targets partially obscured by broken or scattered clouds.
Complete targets photographed. Scattered clouds elsewhere in frame.
Overcast photographs
Cloud free photographs
Frequency of Occurrence
100
15
10
5
0
0
1-9
10-19
20-29
30-39
40-49
50-59
60-69
70-79
80-89
90-99
PERCENT OF CLEAR SKY

ATCH 10

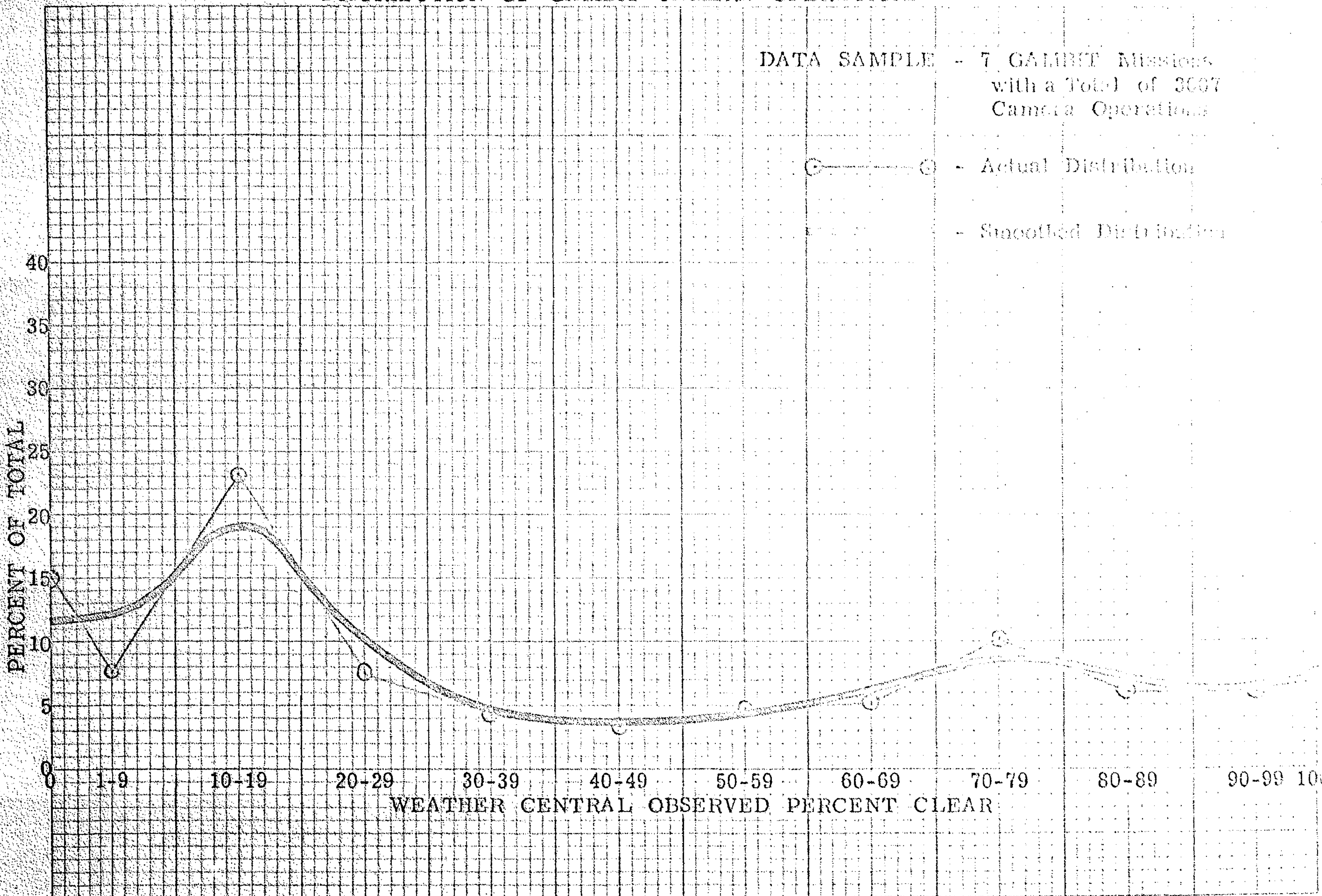

MOSCOW SKY CONDITION DISTRIBUTION
(Based on Moscow Observed Weather in months of January, April, July, and August)
100%
50%
40%
30%
20%
Weather Distribution Occurrence
10%
0%
0
12.5
25
37.5
50
62.5
75
87.5
100
PERCENT OF CLEAR SKY

ATCH 11


KAKTERIN SKY CONDITION DISTRIBUTION
(Based on Kakterin observed weather in months of January, April, July, & August)
100%
40%
Weather Distribution Occurrence
30%
20%
10%
0
0
12.5
25
37.5
50
62.5
75
87.5
100
PERCENT OF CLEAR SKY

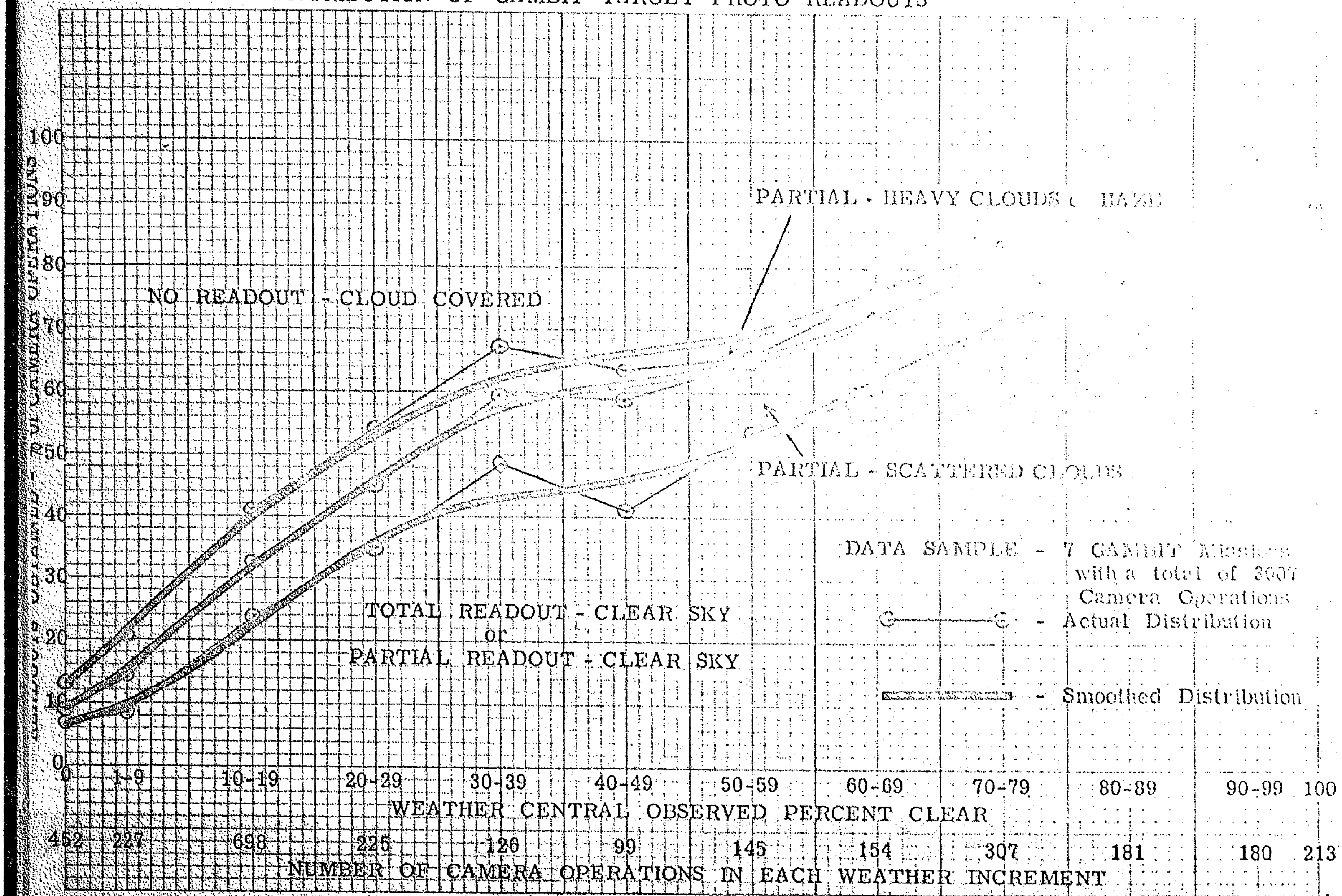
ATCH 12

DISTRIBUTION OF GAMBIT CAMERA OPERATIONS



ATCH 13

DISTRIBUTION OF GAMBIT TARGET PHOTO READOUTS



ATCH 14

UNMANNED SYSTEM

(Based on 1960 "Verified" Weather)

Percent of Clear Sky	Number of camera Operations	Primary/Alternate Target Distribution				Percent Probability of seeing Primary	Percent Probability of seeing Alternate	Probable Targets Photographed
		Without Alternates	With one Alternate	With two Alternates	With three Alternates			
0	702	NA	NA	NA	NA	.13	NA	91
1-9	348					.21		73
10-19	1070					.41		439
20-29	195					.53		103
30-39	158					.62		98
40-49	52					.66		34
50-59	255					.68		173
60-69	261					.76		194
70-79	322					.83		267
80-89	193					.85		164
90-99	192					.87		167
100	240					.90		216
	3988							2019

MANNED SYSTEM

(Based on 1960 "Verified" Weather)

Percent of Clear Sky	Number of camera Operations	Primary/Alternate Target Distribution				Percent Probability of seeing Primary	Percent Probability of seeing Alternate	Probable Targets Photo-graphed
		Without Alternates	With one Alternate	With two Alternates	With three Alternates			
0	702	344	112	56	190	13	~13	174
1-9	348	171	56	28	93	21	~21	128
10-19	1070	524	171	85	290	41	~41	646
20-29	195	111	29	14	41	53	~53	134
30-39	158	90	24	11	33	62	~62	118
40-49	52	30	7	4	11	66	~66	41
50-59	255	145	38	18	54	68	~68	202
60-69	261	148	39	19	55	76	~76	221
70-79	322	171	45	32	74	83	~83	290
80-89	193	102	27	19	45	85	~85	176
90-99	192	102	27	19	44	87	~87	177
100	240	127	34	24	55	90	~90	226
	3988							2533

ATCH 15-2

UNMANNED SYSTEM

(Based on KH-4 Weather Model)

Percent of Clear Sky	Number of camera Operations	Primary/Alternate Target Distribution				Percent Probability of seeing Primary	Percent Probability of seeing Alternate	Probable Targets Photographed
		Without Alternates	With one Alternate	With two Alternates	With three Alternates			
0	638	NA	NA	NA	NA	0	NA	0
1-9	419					5		21
10-19	240					15		36
20-29	148					25		37
30-39	120					35		42
40-49	128					45		58
50-59	152					55		83
60-69	199					65		129
70-79	259					75		194
80-89	339					85		288
90-99	508					95		482
100	838					100		838
	3988							2209

MANNED SYSTEM

(Based on KH-4 Weather Model)

Percent of Clear Sky	Number of camera Operations	Primary/Alternate Target Distribution				Percent Probability of seeing Primary	Percent Probability of seeing Alternate[illegible]	Probable Targets Photo[illegible]
		Without Alternates	With one Alternate	With two Alternates	With three Alternates			
0	638	313	102	51	172	0	10	67
1-9	419	205	67	34	113	5	20	1[illegible]
10-19	240	118	38	19	65	15	23	89
20-29	148	84	23	10	31	25	33	64
30-39	120	68	18	8	26	35	40	6[illegible]
40-49	128	72	19	9	28	45	46	89
50-59	152	87	23	10	32	55	52	105
60-69	199	114	29	14	42	65	58	154
70-79	259	137	36	26	60	75	64	221
80-89	339	180	47	34	78	85	70	309
90-99	518	270	71	50	119	95	80	493
100	838	838	NA	NA	NA	100	NA	838
	3988							2585

UNMANNED SYSTEM

(Based on KH-7 Frame Cloud-Count)

Percent of Clear Sky	Number of camera Operations	Primary/Alternate Target Distribution				Percent Probability of seeing Primary	Percent Probability of seeing Alternate	Probable Targets Photographed
		Without Alternates	With one Alternate	With two Alternates	With three Alternates			
0	1037	NA	NA	NA	NA	0	NA	0
1-9	439					5		22
10-19	159					15		24
20-29	80					25		20
30-39	120					35		42
40-49	120					45		54
50-59	120					55		66
60-69	80					65		52
70-79	159					75		119
80-89	199					85		169
90-99	399					95		379
100	1076					100		1076
	3988							2023

MANNED SYSTEM

(Based on KH-7 Frame Cloud-Count)

Percent of Clear Sky	Number of camera Operations	Primary/Alternate Target Distribution				Percent Probability of seeing Primary	Percent Probability of seeing Alternate	Probable Targets Photographed
		Without Alternates	With one Alternate	With two Alternates	With three Alternates			
0	1037	509	165	83	280	0	10	109
1-9	439	215	71	35	118	5	20	104
10-19	159	78	25	13	43	15	28	58
20-29	80	45	12	6	17	25	33	36
30-39	120	68	18	8	26	35	40	63
40-49	120	68	18	8	26	45	46	74
50-59	120	68	18	8	26	55	52	83
60-69	80	45	12	6	17	65	58	60
70-79	159	84	22	16	37	75	64	135
80-89	199	105	28	20	46	85	70	180
90-99	399	211	56	40	92	95	80	387
100	1076	NA	NA	NA	NA	100	NA	1076
	3988							2365

UNMANNED SYSTEM

(Based on KH-7 Results-Derived Weather)

Percent of Clear Sky	Number of camera Operations	Primary/Alternate Target Distribution				Percent Probability of seeing Primary	Percent Probability of seeing Alternate	Probable Targets Photographed
		Without Alternates	With one Alternate	With two Alternates	With three Alternates			
0	478	NA	NA	NA	NA	0	NA	0
1-9	349					5		17
10-19	269					15		40
20-29	249					25		62
30-39	219					35		77
40-49	219					45		99
50-59	239					55		131
60-69	269					65		175
70-79	299					75		224
80-89	370					85		314
90-99	458					95		436
100	578					100		578
	3988							2153

MANNED SYSTEM

(Based on KH-7 Results-Derived Weather)

Percent of Clear Sky	Number of camera Operations	Primary/Alternate Target Distribution				Percent Probability of seeing Primary	Percent Probability of seeing Alternate	Probable Targets Photographed
		Without Alternates	With one Alternate	With two Alternates	With three Alternates			
0	478	244	76	38	120	0	10	47
1-9	349	178	56	28	87	5	20	79
10-19	269	137	44	22	67	15	28	95
20-29	249	127	40	20	62	25	33	113
30-39	219	112	35	18	55	35	40	121
40-49	219	112	35	18	55	45	46	140
50-59	239	122	38	19	60	55	52	170
60-69	269	137	44	22	67	65	58	212
70-79	299	153	48	24	75	75	64	255
80-89	370	188	59	30	92	85	70	337
90-99	458	234	73	37	115	95	80	444
100	578	NA	NA	NA	NA	100	NA	578
	3988							2592

UNMANNED SYSTEM

(Against July/Aug 1966 Observed Weather)*

Percent of Clear Sky	Number of camera Operations	Primary/Alternate Target Distribution: Without Alternates	With one Alternate	With two Alternates	With three Alternates	Percent Probability of seeing Primary	Percent Probability of seeing Alternate	Probable Targets Photographed
0	210	NA	NA	NA	NA	13	NA	27
1-9	102					22		22
10-19	466					38		177
20-29	218					51		111
30-39	70					61		42
40-49	83					65		54
50-59	117					68		80
60-69	126					76		96
70-79	184					83		153
80-89	143					85		121
90-99	88					86		76
100	179					90		161
	1986							1120

* 15-day mission

MANNED SYSTEM

(Against July/Aug 1966 Observed Weather)*

Percent of Clear Sky	Number of camera Operations	Primary/Alternate Target Distribution				Percent Probability of seeing Primary	Summed % Prob. Range of seeing Prim or Alt	Probable Targets Photographed
		Without Alternates	With one Alternate	With two Alternates	With three Alternates			
0	210	100	39	26	45	13	24-40	58
1-9	102	53	20	10	19	22	31-26	35
10-19	466	261	68	38	98	38	40-90	252
20-29	218	117	32	9	60	51	54-83	142
30-39	70	34	12	5	19	61	69-94	55
40-49	83	43	11	7	22	65	63-83	65
50-59	117	60	12	7	38	68	69-94	97
60-69	126	55	17	9	45	76	88-99	112
70-79	184	65	30	24	65	83	97-99	170
80-89	143	70	24	8	41	85	97-99	132
90-99	88	42	15	2	29	86	97-99	82
100	179	103	30	18	28	90	97-99	167
	1986							1367

* 15-day mission

UNMANNED SYSTEM

(Against Moscow Area Climatology)

Percent of Clear Sky	Number of camera Operations	Primary/Alternate Target Distribution				Percent Probability of seeing Primary	Percent Probability of seeing Alternate	Probable Targets Photographed
		Without Alternates	With one Alternate	With two Alternates	With three Alternates			
0	62	NA	NA	NA	NA	13	NA	8
12½	26					38		10
25	20					56		11
37½	6					64		4
50	3					67		2
62½	4					73		3
75	7					83		6
87½	4					87		3
100	12					91		11
	144							58

MANNED SYSTEM

(Against Moscow Area Climatology)

Percent of Clear Sky	Number of camera Operations	Primary/Alternate Target Distribution: Without Alternates	With one Alternate	With two Alternates	With three Alternates	Percent Probability of seeing Primary	Percent Probability of seeing Alternates	Probable Targets Photographed
0	62	5	5	5	47	13	10	20
12½	26	3	3	3	15	38	26	16
25	20	2	2	2	14	56	33	16
37½	6	1	1	1	3	64	42	5
50	3	1	0	0	2	67	49	2
62½	4	1	1	0	2	73	56	3
75	7	1	1	1	4	83	64	7
87½	4	1	1	0	2	87	72	4
100	12	2	2	1	7	91	90	12
	144							85

UNMANNED SYSTEM

(Against Kakterin Area Climatology)

Percent of Clear Sky	Number of camera Operations	Primary/Alternate Target Distribution: Without Alternates	With one Alternate	With two Alternates	With three Alternates	Percent Probability of seeing Primary	Percent Probability of seeing Alternate	Probable Targets Photographed
0	42	NA	NA	NA	NA	13	NA	5
12½	39					38		14
25	33					56		18
37½	11					64		7
50	7					67		5
62½	9					73		7
75	15					8		12
87½	20					87		17
100	82					91		75
	258							160

MANNED SYSTEM

(Against Kakterin Area Climatology)

Percent of Clear Sky	Number of camera Operations	Primary/Alternate Target Distribution				Percent Probability of seeing Primary	Percent Probability of seeing Alternate	Probable Targets Photographed
		Without Alternates	With one Alternate	With two Alternates	With three Alternates			
0	42	21	4	3	14	13	10	10
12½	39	19	4	3	13	38	26	21
25	33	17	3	2	11	56	33	22
37½	11	6	1	1	3	64	42	8
50	7	4	1	0	2	67	49	5
62½	9	5	1	0	3	73	56	7
75	15	8	1	1	5	83	64	13
87½	20	10	2	2	6	87	72	19
100	82	41	8	6	27	91	90	78
	258							183