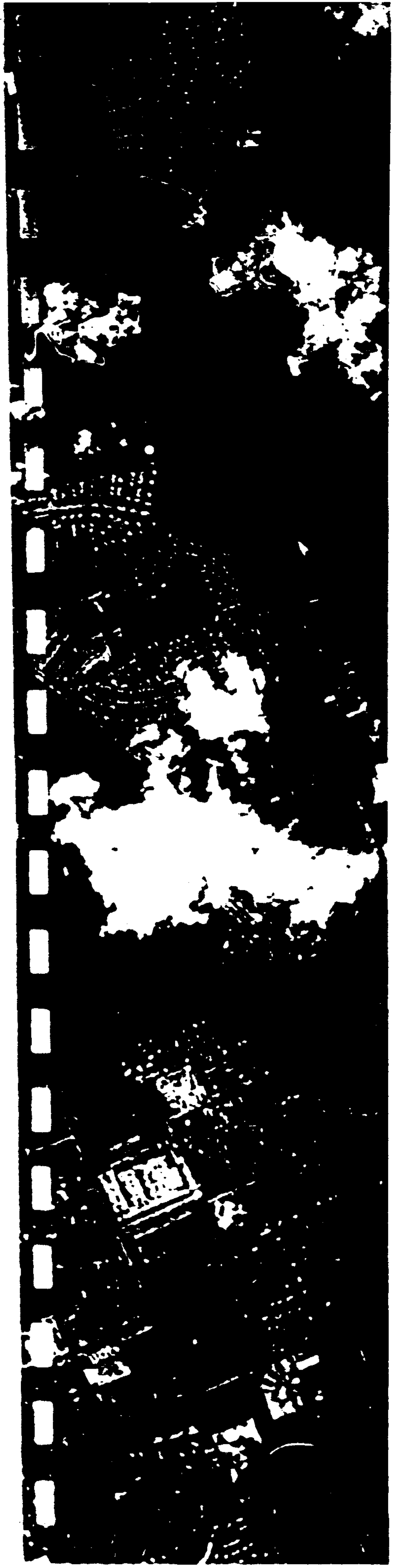

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EKIT REPORT NUMBER 14

INDEX ANALYSIS

1 SEPTEMBER 1967

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Itek

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1. SUMMARY

This EKIT test, unlike the majority of previous EKIT tests, did not involve the use of an aircraft as a system test bed. The analysis consisted of a study of 1 year's supply of previously flown satellite index film. The photography was made during the period of September 1965 (mission 1024) through November 1966 (mission 1037). The initial analysis was designed to determine the large area transmission density (LATD), or one type of average density over the entire frame, from seven areas that were covered repeatedly during this time period. The objective was to determine any trends in weather patterns that might be present over those areas. Admittedly it was a "stab in the dark" as far as a quantitative measure is concerned for it was not known what trends in the data would be like. The results were that no information was learned about weather patterns from these density readings. The data was also evaluated in several different ways and again, nothing was learned that was not already an obvious fact. For example, the LATD increases with increasing solar altitude and percentage cloud cover.

A visual evaluation of the index material was carried out to determine the relationship between general weather conditions and main camera performance. The main camera performance was determined by the relative comparison of the PIER evaluations. The index photography was assessed for the (1) percentage cloud cover, (2) percentage haze and fog, and (3) percentage clear weather. It was found that there was a correlation between the haze percent and the main camera performance. In evaluating future index material it is recommended that a stronger emphasis be placed on the haze and fog rather than cloud cover, especially when evaluating the performance of the main cameras.

The following list presents the conclusions of this report. These conclusions are discussed in greater detail in Section 3.

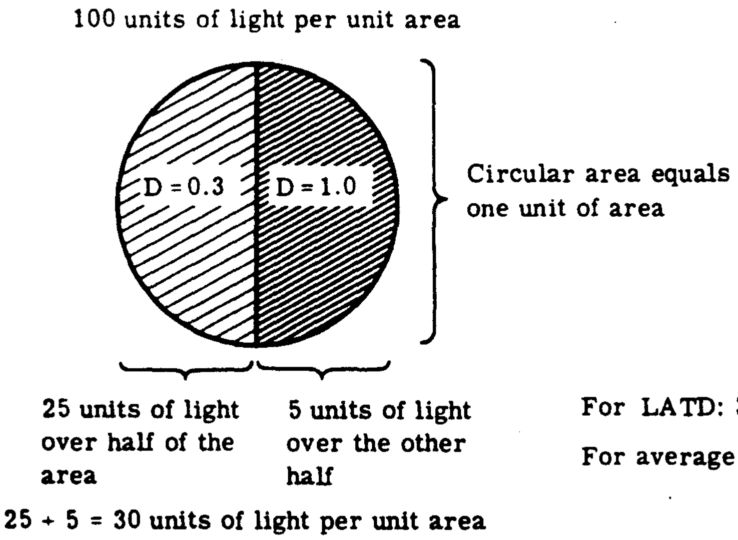
1. There seems to be no physical measurement (i.e., D_{min}, D_{max}, D_{avg}, and LATD) that relates to weather conditions.
2. Visual inspection of the photography seems to be a valuable tool in assessing weather conditions.
3. The percent clear (and/or percent haze) photography seems to be a much more meaningful criterion (vis-a-vis camera performance) than percent cloud cover.
4. In the KH-4B analysis program, visual analysis of the DISIC photography is recommended.

2. DENSITY AND CLOUD ANALYSIS

The initial work with the index material was concerned with a quantitative measure on the film that might be correlated with weather patterns that existed when the photography was made. The measurement chosen was large area transmission density (LATD) which is one type of average density. First, this concept will be explained with an elementary example and then extended to the photographic images at hand.

2.1 LARGE AREA TRANSMISSION DENSITY

LATD is a form of an average density, though it cannot be found by simply averaging density values from a piece of film. The number is more closely related to the density that the eye would see when looking at the film from a distance. The following example will illustrate the concept. Assume, for example, that a film had a circular area 1 inch in diameter. Half of the circle had a uniform density of 0.3 and the other half was 1.0. The average density, $\bar{D}$, is 0.65. This, however, is not the average density, as an integrating photometer, for example, would record. Fig. 2-1 illustrates the difference between LATD and $\bar{D}$. In this example, the circular aperture (of densities 0.3 and 1.0 on each half) is illuminated by 100 units of light per unit (the circle) area. Fifty of these units of light are therefore incident upon the left half of the aperture. Since the density is 0.3 (T = 50 percent), 25 of these units will pass through. On the right side there are also 50 units of light; however, since the density is 1.0 (T = 10 percent), only 5 of them will be transmitted.



For LATD: 30 percent transmittance, D = 0.477

For average density: $\bar{D} = \frac{0.3 + 1.0}{2} = 0.65$

Fig. 2-1 — Illustration of the difference between average density and large area transmission density

The sum total of all the light passing through the aperture is then 30 units. The transmittance is effectively 30 percent, which is equivalent to a density of 0.477. As can be seen, this is quite different from the $\bar{D}$ of 0.65. The LATD type of average density is more useful because it represents what would be recorded by a large aperture photometer and is closer to what the eye would see. The LATD measurement can be made very easily by using a photometer or densitometer that covers the large area of concern.

2.2 LATD MEASUREMENT OF SELECTED TARGETS

The objective of this test was to make LATD measurements of the index film of several selected targets throughout a year's time. The resulting density values were then to be correlated with a visual examination of the weather patterns for that photography. In order to obtain the density readings over the entire image format, an imaging telephotometer was used. Fig. 2-2 illustrates the geometry involved in making these measurements.

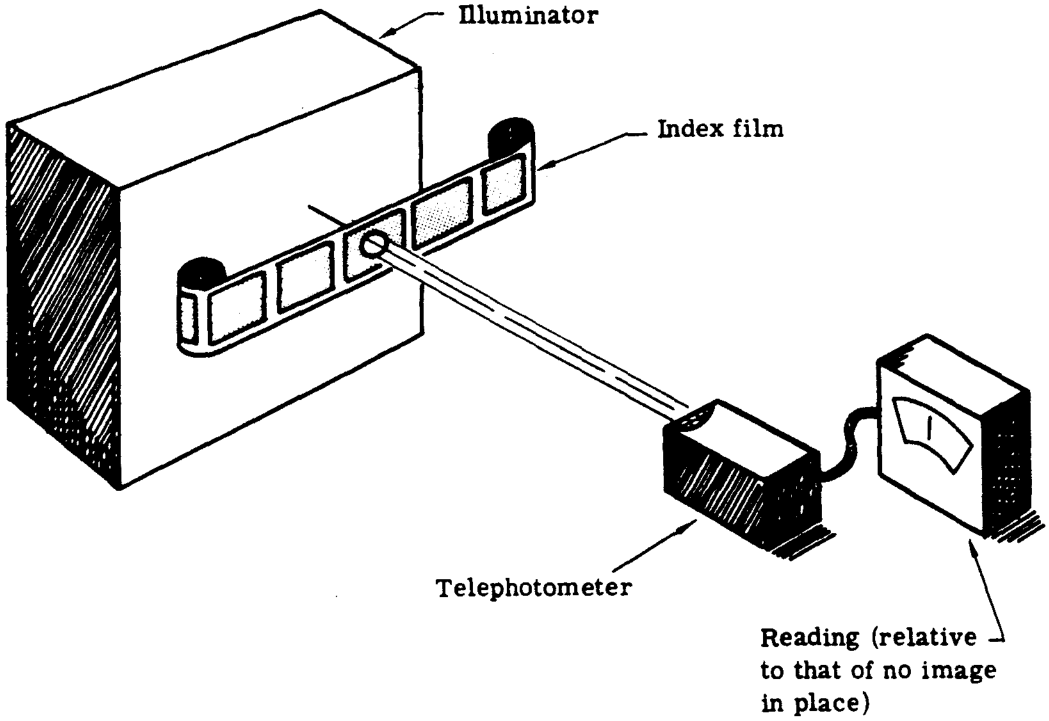


Fig. 2-2 — Laboratory setup for determining LATD of the index film

The telephotometer is first used to measure the brightness of the illuminator; this then becomes the standard. The negatives were then rolled in front of the illuminator and a reading taken, with the telephotometer imaging the majority of the frame. The log of the ratio of these two readings then became the LATD for that particular frame.

Seven areas that were covered many times throughout the year were chosen from the material available, as shown in Table 2-1.

In addition to reading the LATD, each of these frames was also evaluated for percentage cloud cover. The data were plotted in various forms, i.e., density versus solar altitude, versus time, versus percent cloud cover, and versus location. The data was so scattered on all of these plots that only the two following conclusions could be drawn:

1. LATD increases with increasing solar altitude.
2. LATD increases with increasing cloud cover.

Table 2-1 — Areas Chosen for LATD Measurements

	Area of Prime Interest	Area Type	Latitude
1	Polvostrov Tay Myr	Tundra region	75° N
2	Gobi Desert	Desert area	42° N
3	Kashmir	Himalaya Mountains	30° N
4	Moscow	City and suburbs	55° N
5	Amur River Region	Country farm	50° N
6	Tyuratam	Desert and missile site	45° N
7	Hanoi	Populated area	22° N

Both conclusions are, of course, well known facts, and verification did not contribute significantly to our knowledge. Fig. 2-3 illustrates some of the data as a plot of LATD versus solar altitude at two levels of cloud cover. There has been no distinction made in this plot as to target type; all seven areas were used that had data available at these percentage cloud levels. Note that the variation in data points is quite wide. When considering only one target area, though, the pattern becomes more obvious. One of the more interesting areas used was Tyuratam. Mission no. 1033 had an orbit such that this area was covered once each day for 11 days. Fig. 2-4 illustrates this data. Note that trend of decreasing density as the 11-day period passed. Actually what had happened was that the orbital characteristics required for this coverage caused each day's coverage to be later in the day. A plot of these density values and the other ones from Tyuratam at various times during the year are shown in Fig. 2-5. Here again is the trend of increasing LATD with solar alitutde.

2.3 CLOUD ANALYSIS

The ultimate goal of the density analysis was to be able to describe the effects, in general, of weather on the main panoramic photography. Since this quantitative approach was not successful, a subjective analysis was undertaken. Each frame of the index photography from one of the buckets (therefore, a 50 percent sampling for the year) was evaluated for:

1. Percent clouds
2. Percent hazy and/or foggy
3. Percent clear

Note that this is sampling all areas of the world that were covered in the first bucket, not just the seven areas selected for the initial work. The results for an entire bucket were averaged to give just three percentage values for each mission. The results are plotted in Fig. 2-6. From this graph it can be seen that the summer months—May, June, and July—had the highest percentage of cloud cover. In addition, the three lowest points occur in October and September, although they are only a small percentage below the average cloud cover.

In order to obtain an estimate of the relative qualities of the main panoramic photography, the photographic interim evaluation reports (PIER) were studied.

The PIER reports assessed the quality of the missions in terms of atmospheric conditions and general quality in comparison with previous missions. Table 2-2 gives the results (graphically shown in Fig. 2-6) along with some of the PIER evaluation general comments.

Ten of these missions have been rated as "best," "good," and "poor" based on the PIER comments. Several interesting observations can be made from this table. First, one of the missions rated as the best (no. 1035, September 1966) had the highest percentage of clear weather. The PIER report also indicated that the atmosphere was good. Mission no. 1033 (June 1966) is reported by the PIER comments as having quite bad haze; the index analysis indicated that this mission had the worst percentage (33 percent) of haze.

Mission no. 1031 (April 1966) is also reported to have encountered poor atmospheric conditions; the index analysis indicated that this mission had 30 percent haze.

2.4 CONCLUSIONS

It is concluded from the index density analysis study that an LATD measure of the index material is not a useful quantitative measure of the material as far as weather patterns are concerned.

Instead a subjective evaluation is recommended for any weather analysis to be performed. The subjective analysis of the percentages of clouds, haze, and clear weather correlate well with the PIER evaluations and is in all probability the most effective evaluation technique.

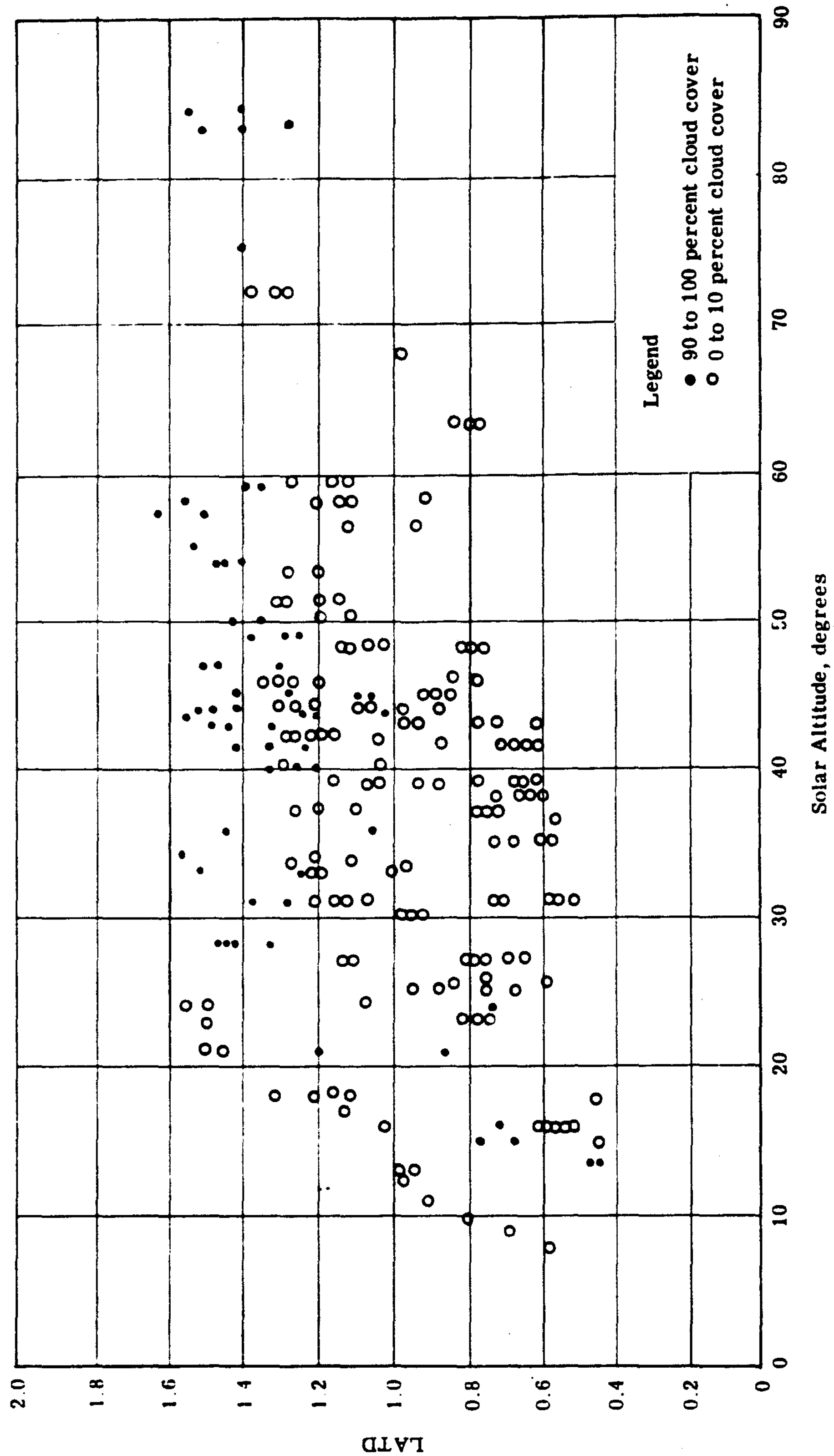


Fig. 2-3 — LATD versus solar altitude at two levels of cloud cover

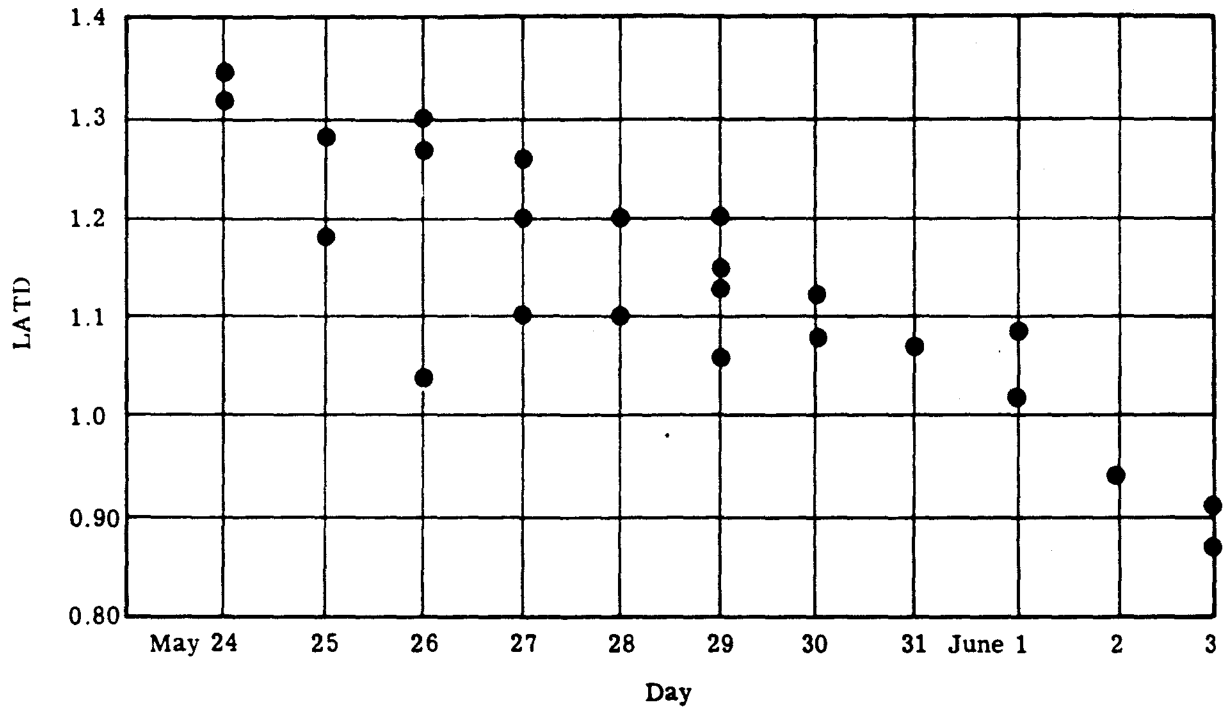


Fig. 2-4 — LATD at each day of the 11-day Tyuratam coverage of mission no. 1033

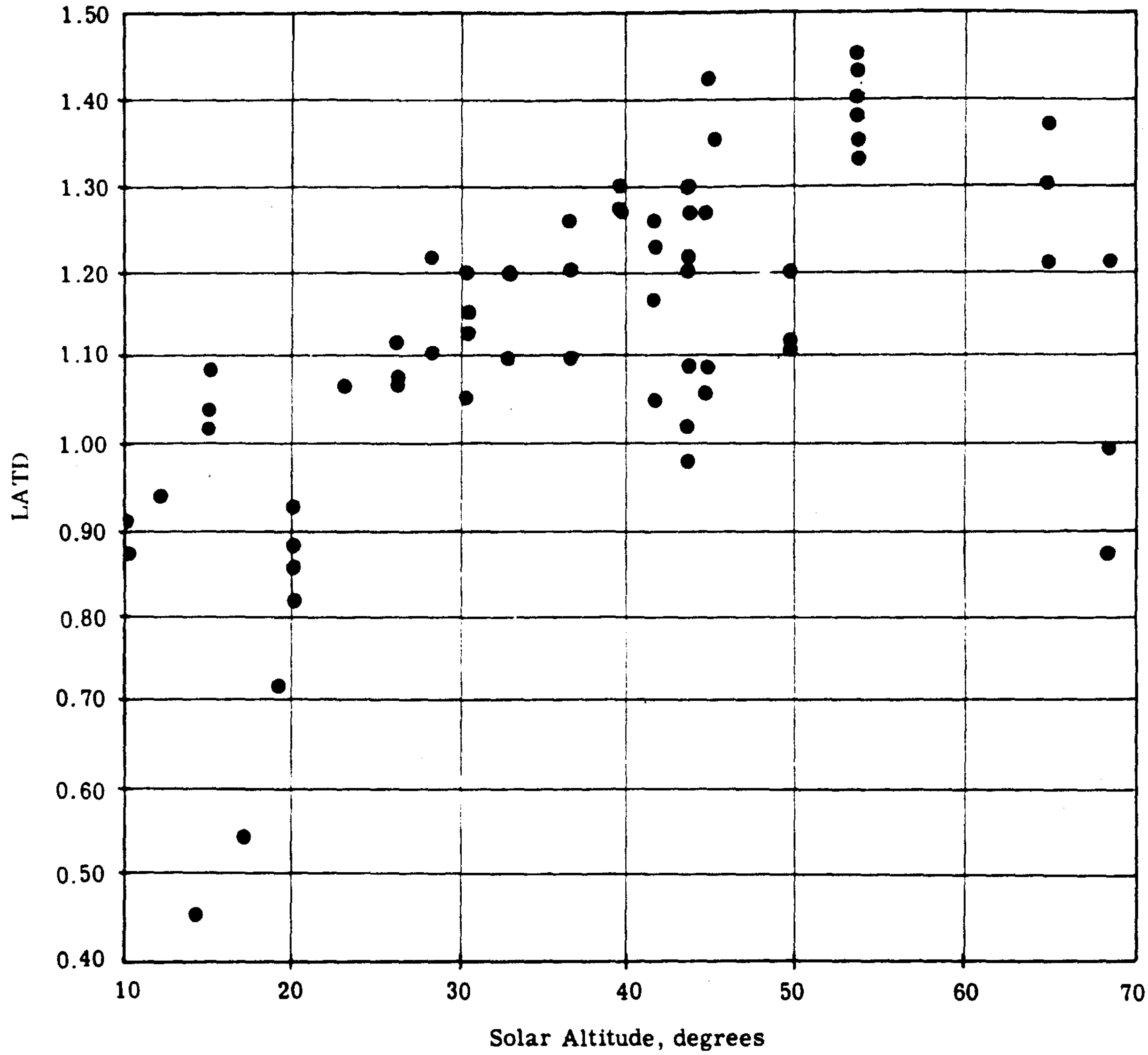


Fig. 2-5 — LATD (measurements from the index material) versus solar altitude for Tyuratam from September 1965 to November 1966

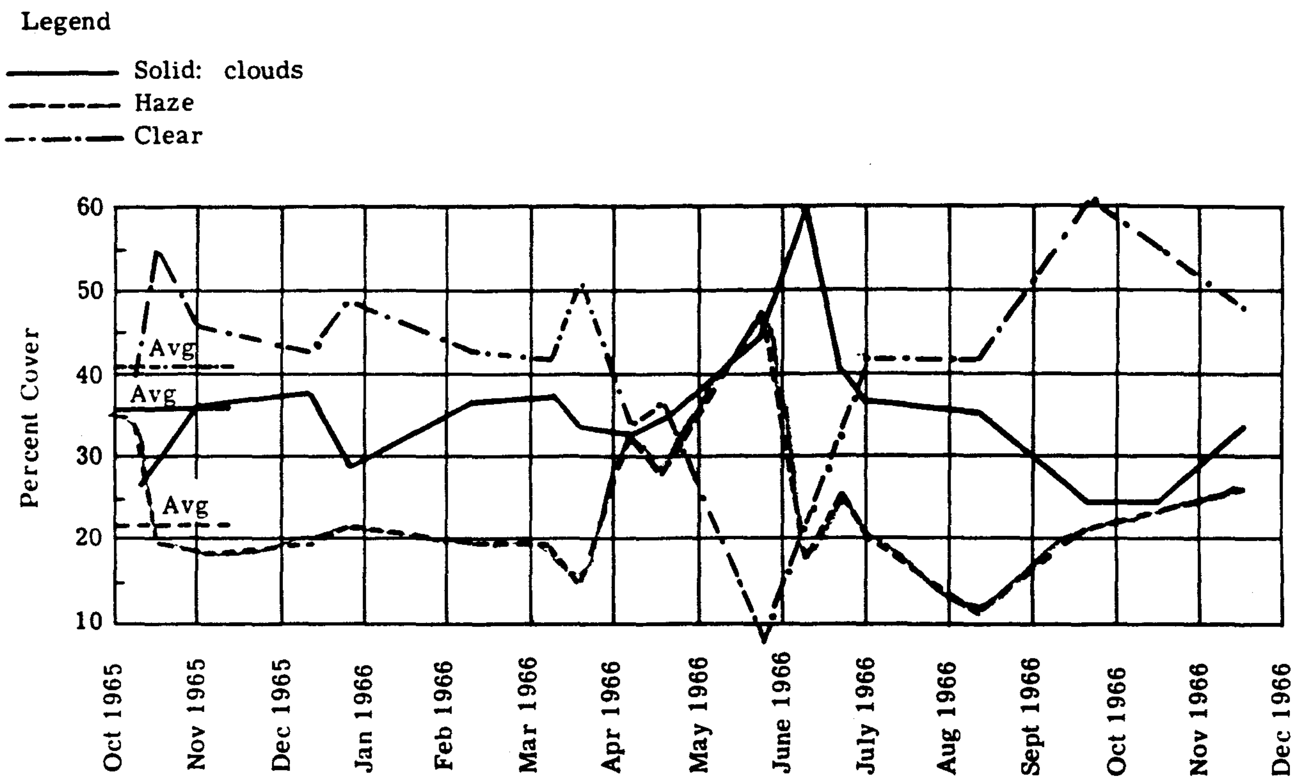


Fig. 2-6 — Percentage cloudy, hazy, and clear photography for the year time period obtained from subjective evaluation of the index material

Table 2-2 — Average Percentage Cloud, Haze, and Clear Weather Photography and PIER General Evaluation

Mission Number	Itek Evaluation, percent			General Rating Based on Remarks	PIER Remarks
	Cloud	Haze	Clear		
1025	26	27	47		
1026	37	19	44		
1027	38	20	42	Good	Image quality very good
1028	29	22	49	Best	Very good, best of recent missions
1029	36	20	44	Good	Good, not as good as no. 1028
1030	36	18	46	Good	As good as any (portion); atmosphere bad
1031	34	30	36	Poor	Image quality good; atmosphere bad
1033	52	33	15	Poor	Good and comparable to no. 1031; haze bad
1034	39	28	33	Poor	Not as good as recent missions
1035	27	12	61	Best	Image quality consistently good; good atmosphere
1036	36	22	42	Good	Consistently good, better than no. 1034 and equal to no. 1033
1037	34	18	48	Best	Consistently good, equal to no. 1035; atmosphere good

3. CONCLUSIONS

The purpose of this study was very simple, that is, to find out if the index film could be used to evaluate the effect of weather on mission performance. It is well known that weather affects performance; however, to what degree has always been in question. One of the main reasons for this study was to prepare for the KH-4B System analysis program. In that project we are going to be attempting to isolate those factors which degraded camera performance. Such items as IMC error, exposure, roll rates, etc., will be assessed. As important, in this evaluation, is the impact of weather on the photography, and to try to know when photography was degraded due to weather and not to some system problem. With this general background, the following conclusions are reached from this study.

1. There seems to be no physical measurement (i.e., D_{min}, D_{max}, D_{avg}, and LATD) that relates to weather conditions. These measurements all relate to the more gross effect of terrain and solar altitude changes.

2. Visual inspection of the photography seems to be a valuable tool in assessing weather conditions. A visual inspection can rather easily determine the percentage of clouds, haze (and/or fog), and clear photography. As shown in the body of the report, for the year tested, this kind of analysis correlates well with general system performance (from a photographic point of view).

3. The percent clear (and/or percent haze) photography seems to be a much more meaningful criterion (vis-a-vis camera performance) than percent cloud cover. Percent cloud cover only tells what information was not recorded at all. Further, there is no necessary relationship between cloud cover and clear photography, whereas the percentage of clear versus hazy photography is an almost inverse relationship, hence, directly related. Current cloud counting analysis procedures should be dropped as an indicator of the effect of weather on camera performance.

4. In the KH-4B analysis program, visual analysis of the DISIC photography is recommended. It would make most sense to perform this analysis on a pass by pass basis. This will allow the correlation of weather (and its degrading effects) with camera performance on a more meaningful basis.