3 DIM LIGHT PHOTOGRAPHY AND VISUAL OBSERVATIONS OF SPACE PHENOMENA FROM MANNED SPACECRAFT,

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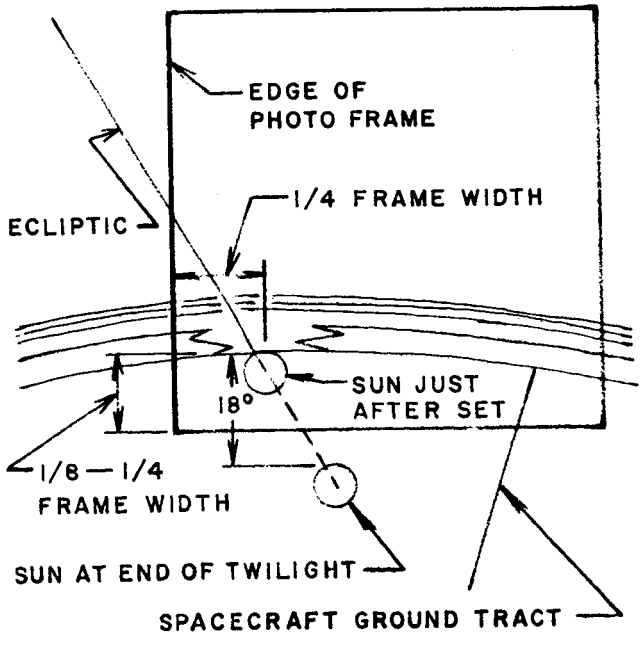
PREFACE

This document is essentially a copy of the written information given to the crews of Gemini VI and VII by the authors just prior to their flights as a result of a request from NASA Headquarters to have these experiments performed on an opportunity basis. The last two pages are exact copies of the checks lists on board both spacecraft.

1. Twilight Scene

This is a continuing study of Schirra's bands, aerosol layers, and other interesting structure. Evening twilight begins just as the sun completely sets and continues until the sun is approximately 18^{o} below the horizon; morning twilight occurs in reverse order. Hasselblad photography with color film and exposure times longer than normal daylight values permits photography of the higher and less bright atmosphere. 16 mm Mauer motion picture photography with color film allows a more complete coverage of the lower, but brighter atmosphere using a short exposure time. For these photographs the horizon point just above the sun. which has set or is about to rise, should be about 1/8 to 1/4 of the frame heighth from the bottom and 1/4 frame width from either side. If the comet filters (yellow and blue) are still on board, a very useful series of the twilight can be run using the high- speed, B&W (with filters this becomes a sensitive indicator of color for analytical purposes) film. Note that the order of exposures in each series is given for evening twilight; order must be reversed for morning twilight.



Camera lens and film type	Set-tings	1	2	3	4	5	6	7	8
Hasselblad, 250mm.SO 217	F	11	5.6	5.6	5.6	5.6	5.6	5.6	5.6
	T	1/500	1/500	1/125	1/30	1/8	1/2	2	10
16mm Mauer, 75mm,SO 217	F	32	22	16	11	8	5.6	4	2.5
	T	1/50	1/50	1/50	1/50	1/50	1/50	1/50	1/50
1fps	Run	10	10	10	10	10	10	10	210
Hasselblad, 250mm, 2475	F	45	45	22	11	5.6	11	5.6	5.6
	T	1/500	1/250	1/250	1/250	1/250	1/250	1/250	1/60
comet filters	Fltr	N	N	Y	Y	B	B	B	B

	9	10	11	12
Hasselblad, 250mm.SO 217	5.6	5.6		
	30	120		
Hasselblad, 250mm.2475, comet filters	5.6	5.6	5.6	5.6
	1/15	1/4	1	5
	B	B	B	B

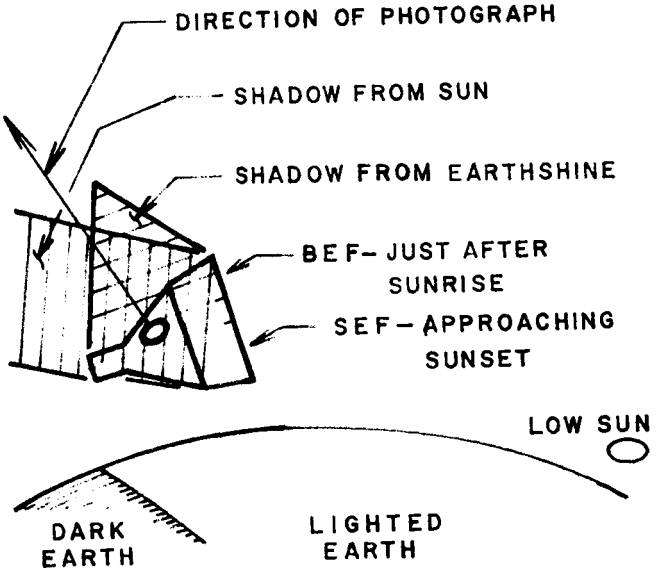
2. Nighttime Earth Cloud Cover

This is a study of nighttime earth cloud cover under various moonlight conditions and particularly under a no-moon situation. It is desirable to select an area where cloud cover is about 5/10 and where some ground light such as city lights are visible to use as a tracking reference point to hold the cloud pattern stationary in the photograph during the longer exposures particularly if the pilots are unable to perceive the clouds themselves. In moonlight with pilots dark adapted the viewable cloud pattern should be directly used for tracking. Thunderstorms must be entirely avoided so that lightening will not render the exposures useless. These photographs are only possible with the very fast B&W film with the camera wide open; in fact, it can be carried out whether or not the pilots can see the clouds that they are photographing.

Camera, lens, film, & F-stop	Ambient lighting conditions	Settings	1	2	3	4
Hasselblad, 80mm, 2475 F 2.8	No moon	T	8	16		
	Quarter moon	T	1/4	1/2	1	2
	Full moon	T	1/30	1/15	1/8	1/4

3. Day Sky Background

Pilots have reported difficulty in observing stars in the daytime. Most of the problem probably lies with the scattered sunlight and/or earthshine on the windows and the pilots' associated lack of dark adaptation. However, the effect of the day airglow layers above the spacecraft altitudes is unknown and could be a significant contribution in masking the starlight in the day sky. A relatively simple study of day airglow can be made using the very high-speed B&W film, which is not affected by dark adaptation problems, while pointing the camera approximately radially away from the earth and while holding the spacecraft in an attitude that does not allow window scattering. The most appropriate time to accomplish this are in the early daytime morning or the late daytime afternoon so that at least one window can be positioned with about 35° roll to be in the doubly shadowed region. Stability of attitude during the exposures is not cirtical, although it is desirable because the film may also be registering known stars which the pilots may be unable to see.



Camera, lens, film, & F-stop	Settings	1	2	3
Hasselblad, 80mm 2475, F2.8	T	5	30	120

4. Night Airglow Edge-On

(i.e., above earth's horizon)

This is a continuing study of the night airglow to determine more about its structure and brightness which may eventually lead to a more basic physical understanding of this phenomenon. It complements information gained from previous manned flights and from unmanned rockets launched specifically for the purpose of studying airglow. In the latter case the missions were considered highly successful if only a few good exposures were obtained, and NASA is continuing to launch several of these unmanned rockets each year. One or more good series from a manned vehicle would be extremely valuable in the total study, and this is particularly true using the more sensitive, light gathering, B&W film.

Camera, lens, film, & F-stop	Setting	1	2	3	4	5
Hasselblad, 80mm 2475, F2.8	T	1/2	1	2	4	8

5. Zodiacal Light and Gegenschein

This would continue the study begun on MA-9 using high-speed, color film and further investigated on GT-5 using Tri-X B&W (ASA 400), but would now use the more sensitive B&W film. The zodiacal light series should be taken 5-10 minutes after sunset of 10-5 minutes prior to sunrise. The Gegenschein is very localized, and the camera should be aimed at approximately $5^h\ 20^m$ Right Ascension and $+23.1^o$ Declination--the antisolar point on the ecliptic which is in the constellation Taurus, the Bull, near the horns between Auriga and Orion. Gegenschein should be given very little emphasis on this flight; however, because it will be in the Milky Way and probably obscured by it.

Camera, lens, film, & F-stop	Series subject	Set-ting	1	2	3	4	5
Hasselblad, 80mm	Zodiacal Light	T	1/16	1/4	1	3	5
2475, F 2.8	Gegenschein	T	10	30	60	120	

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6. Aurorae

This phenomenon is most apparent when looking toward the magnetic poles at night; thus, for this flight the spacecraft will have to be yawed approximately 90° South when in the southernmost latitudes of the trajectory. Color, apparent brightness compared to the airglow, striations, position (it may appear below spacecraft altitude so that pitch down 20-30° may be required), and edge characteristics are all important parameters to note and photograph. The aurorae are classified here as "bright" if color is distinguishable and "dim" if only light without color is apparent. If the phenomenon definitely looks white and the pilots feel that it is bright enough that they should certainly notice color if it were present, then the aurora is "bright" because white light is actually the perception of combined colors.

Camera, lens, film, & F-stop	Series subject	Setting	1	2	3
Hasselblad, 80mm,	Bright	T	1/8	1/2	2
2475, F 2.8	Dim	T	1	4	15

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7. Meteors

This phenomenon should appear below the spacecraft against the dark earth disk, and the important features are apparent color and brightness, path direction and extent, and particularly the number seen per period, for instance). An annual meteor shower, Geminid, ("from Gemini" because they appear to a ground observer looking up as if they originate from the region of Gemini) will be in evidence from about 10-15 December which add about one count per minute extra to the

normal, random count on the ground. The pilots should notice a similar effect because the area seen through their windows with the normal eye position (9-10 inches from window) is approximately equal to that available to a ground observer. If the pilots move their eyes well forward towards the window, the probability for seeing and the count number should go up considerably. Therefore, when making counts over defined time periods it is important to fix the head with respect to window distance and note as data the position used as well as known or estimated attitudes and rates. Making several separate counts with the eyes at a different distance each time would also be very useful. When the count rate reaches several (>3) per minute, and this can be enhanced by observing the region between horizon and nadir where more earth surface area is in view, photography might be attempted. Slow spacecraft rates are not objectionable for photography or visual observations so long as the earth's disk is in view most of the time. Two methods for photography are recommended, time exposures for specified periods to collect a number of meteor streaks, or for a variable period where the pilot holds the shutter open until he observes a meteor steak pass through the field of view after which he immediately closes the shutter. The former method will be called the "total countmethod" and the latter will be called an "individual record method". In both cases the light from the meteor makes its own exposure through a wide open camera using high-speed film. The longer time exposures may collect more information but will also suffer from a masking or general over-exposure effect caused by the night airglow, cloud reflected airglow, and cloud-earth reflected moonlight; so, both methods should be used on these first attempts until results show which might be the more preferable. The no-moonlight condition would have an obvious advantage here.

Camera, lens, film, & F-stop	Method used	Set-ting	1	2	3
Hasselblad, 80mm 2475, F 2.8	Total count	T	30	120	300
	individual record	T	As required to make record		

8. Comet Observations (Ikeya-Seki)

Observe important parameters only; no photographs unless pilots consider it warranted. The comet will be located at about $9^h\ 00^m$ Right Ascension and -35^o Declination in the constellation of Pyxis with a Milky Way background and will be of very low magnitude making it very difficult to view. However, the pilots should be on the lookout for other, undiscovered comets near the sun, and hence, not viewable from the earth.

9. Lightning

The methods of observation will be exactly like those for meteors (see Item 7 above). Likewise, there are two methods for photography--the "total count method" and "individual record method". The phenomenon should be considerably brighter, and events located near the horizon should be much more useful as photographic subjects through the telescopic lens. The individual record method of photography for the lightning and meteors should probably be combined so that the shutter should be closed when either event breaks the darkness, whichever occurs first.

Camera & Film	Lens & F-stop	Method Used	Set-ting	1	2	3	4
Hasselblad & 2475	250mm F 5.6	Total count	T				
		Individual record	T	10	30	120	300
				As required to make record			
Hasselblad & 2475	80mm F 2.8	Total count	T	10	30	120	300
		Individual record	T	As required to make record			

10. Artificial Night Lighting on the Earth's Surface

This refers to such lighting as cities, ships, gas wells, forest fires, specular reflection of moon, planet, or starlight

by water or metallic/glossy surfaces, etc. Scintillation or lack of scintillation (whether point source or finite surface source is involved here) is an important characteristic peculiar to this type of light and should be noted as data. The cause of this effect is, of course, the atmosphere just as a ground observer sees stars twinkle while planets, moon and satellites usually do not.

Camera & Film	Lens & F-Stop	Set-ting	1	2
Hasselblad 2475	80mm F 2.8	T	1/8	1/2
Hasselblad 2475	250mm F 5.6	T	1/4	1

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11. Galactic Pole-to Edge Survey

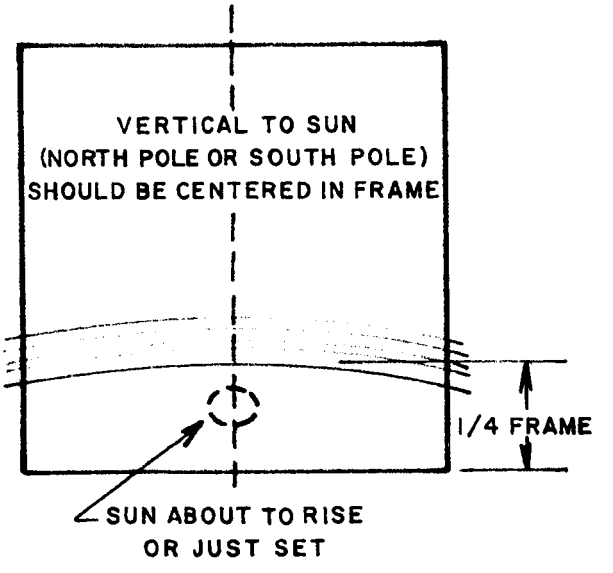
This study attempts to measure the amount of galactic light present as a part of the total light seen from the earth (i.e., all starlight, zodiacal light, and airglow). Knowledge of a more exact quantity, aside from its intrinsic value, will provide astronomy and astrophysics with a better means of calculating photometric results where galactic light is a contributing contaminant to the measurement of light from other sources. It will also indicate the upper level of exposure times possible in future photographic experiments from manned and unmanned space vehicles. This study must be considered as very low priority because the camera field must be held to $\pm \frac{1^o}{2}$ during each of these long exposures with no cabin light or moonlight reflections on the window. There are four series of photographs suggested; the third requires the yellow and blue comet filters, and the fourth requires the sun to be up with no sun or earthshine reflections on the window which would require accurate inertial platform pointing since the pilots will probably not be able to see constellations to be photographed.

Camera & Film	Series	Subject & Conditions	Lens & Settings	1	2	3	4	5	6	7	8	9
Hasselblad 2475	A	No sun, Orion with Moon 45° away or square of Pegasus with moon 45° away	Lens F-stop Time	80mm 2.8 60	80mm 2.8 120	80mm 2.8 240	80mm 5.6 120	80mm 5.6 240	250mm 5.6 120	250mm 5.6 240		
Hasselblad 2475	B	No sun, each constellation in the zodiac except those within 15° of sun	80mm F 2.8, 90 sec	Do each constellation in zodiac beginning at sunset and continuing to sunrise.								
Hasselblad 2475	C	No sun, Aquarius with moon 45° away or Cancer with moon 45° away	Lens F-stop Time Filter	80mm 2.8 60 N	80mm 2.8 120 N	80mm 2.8 240 N	80mm 2.8 60 Y	80mm 2.8 120 Y	80mm 2.8 240 Y	80mm 2.8 60 B	80mm 2.8 120 B	80mm 2.8 240 B
Hasselblad 2475	D	Sun up with no glare on window, same subject as in series A Above	Lens F-stop Time	80mm 2.8 60	80mm 2.8 120	80mm 2.8 240	80mm 5.6 120	80mm 5.6 240	250mm 5.6 120	250mm 5.6 240		

12. Sunlit Airglow

This study compares sunlit airglow from several different viewing angles as well as with the non-illuminated airglow. By comparison of similar spectral regions (narrow bands of wavelengths) fundamental to the composition of airglow, differences and similarities should become strikingly apparent. The high-speed B&W film is rendered color sensitive by the use of three narrow bandpass filters which allow high transmission (approximately 80% average) of the desired spectral region while completely removing the spectral continuum on either side by interference techniques. The central wavelengths of the transmitted bands are 6300Å (Å = Ångstrom unit = 10^{-8}cm, also 6300Å = 0.63 micron) 6225Å and 5300Å. The first of these, 6300Å is a strong emission line from atomic oxygen. Thesecond, 6225Å, indicates emission from the hydroxyl radical (OH) which is another strong component of the airglow but occurring at low altitudes. The last, 5300Å, is examining a frequency band in which there is no known strong emission from other components; thus, it represents a study of the "continuum" which is simply due to scattered sunlight and a general background within the airglow. Thus, the filter study will show not only how much (derived by a comparison of intensities relative to the continuum) of the oxygen and OH components are present, but also exactly where in altitude they are located (position above horizon in the frame). It will also answer a question posed by unmanned rocket studies, "Is the high altitude airglow enhanced towards the sunlit poles (i.e., is its intensity a function of latitude)?" It is important that the sun always be below the horizon by about one to two minutes of time to obtain the proper exposure values with filter factors included. Other considerations are as follows; the moon should not be in camera field-of-view and should not cause glare or scattering on the window, all cabin light off or covered, and no bright cities or lightning should be included in the exposures. The study consists of 5 series in descending order of priority with No. 1

being a view of the horizon with first photograph 60 seconds after sunset, No. 5 the same scene with the last photograph 60 seconds prior to sunrise, and No. 4 the same scene of either pre-sunrise of post-sunset but chosen so that the spacecraft is as far North as possible. Series No. 2 is also pre-sunrise or post-sunset but with the spacecraft pointed within $\pm 5^{o}$ of the South horizon at a time when the sunrise or set is as far South as possible. Series No. 3 can be taken at any time within ±10 minutes of local midnight pointed at either the North or South horizon $\pm 5^{o}$ (spacecraft can be at any latitude for this series). Nos. 1, 2, 4 and 5 use a six-photograph series. The order shown below is for sunset; it MUST BE REVERSED FOR SUNRISE. (i.e., start with settings for photograph 6 and work up to photograph 1).



Camera, lens, film, & F-stop	Series No.	Subject and conditions	Set	1	2	3	4	5	6
Hasselblad, 80 mm, 2475, F 2.8	1	Horizon scene at sunset +60sec., no moonlight or cabin lights on window	T Ftr	1/8 6300	1/8 6225	1/8 5300	10 5300	10 6225	10 6300
Hasselblad, 80 mm, 2475, F 2.8	2	Southernmost sunset +60 sec or sunrise -60 sec, spacecraft pointed South $\pm$ 5°		Same as in No. 1 above, reverse order is using sunrise					
Hasselblad, 80 mm, 2475, F 2.8	3	Local midnight $\pm$ 10 min, Spacecraft pointed North or South $\pm$ 5°	T Ftr	10 6300	10 6225	10 5300			
Hasselblad, 80mm,	4	Northernmost sunset +60 sec or sunrise -60 sec, spacecraft pointed North $\pm$5°		Same as in No. 1 above, reverse order if using sunrise					
Hasselblad, 80mm, 2475, F 2.8	5	Horizon scene pre-sunrise with last photograph complete at -60 sec.		Reverse order of settings given in No. 1 above					

General Comments and Notes on Technique

1. Give liberal time "hacks" or "marks" on star, planet or moon limb rise or set when passing through each edge of layers or when aligned with feature at same parallel altitude above earth or airglow curvature. Identify marker star or planet, if known.

2. Use reticle or any useful objects to make accurate measurements of angular distances (i.e., moon widths where Diameter Full Moon = 0.5^{o} or bolt to bolt on window frame and even finger widths with fingers on window edge and head held fixed in a known, braced position in all cases).

3. Recommended photographic exposures are given for bracketing light levels with changes in aperature levels generally followed by increases in exposure time to obtain best results where the ambient light level is diminishing (order of settings would be reversed if light level is increasing) or where the values of light level is not accurately known. In the latter case results from pilots' photographs will greatly improve the accuracy with which light levels will be known. When sequences call for exposures greater than one second, "Bulb" setting on the Hasselblad and hold-down of shutter release for the specified time will be required. It is very important to mark (voice tape with written backup after sequence is complete) start and stop of "Bulb" exposures; in fact, this is more important than trying to obtain the exact exposure value specified. If the pilots feel that drift rates are introducing unacceptable smearing (beyond their ability to compensate in the case of the hand-held photographs), they should terminate the exposure short of the desired time, note "stop" of exposure, and try for longer exposure if and when the opportunity again occurs. In the case of the very long exposures, it is expected that photography will be difficult, and the amount of smearing versus the continuation of exposure will be left entirely to the pilots' judgement.

4. Visual observations along with or independent of photography are extremely valuable and should generally include:

(a) Subject or feature being studied, if known.

(b) Other associated or significant features (i.e., stars, planets, or constellations) in view or nearby to tie-down general location of observation, particularly if the basic phenomenon is unknown, large in extent, or seen only occasionally (i.e., aurorae, upper airglow, lightening or meteors near the horizon, terrain features during the day, or lights of known cities and visible coastlines at night).

(c) Estimate of attitudes and, when important, rates if platform is not or cannot be used. If horizon is in the view of photographs, then only an estimate of yaw would be required.

(d) Pertinent configuration of spacecraft (i.e., window glare, internal cabin lighting, sunlight inside the cabin) and important external conditions under which the observations are made (i.e., sun or moon flare off of water, haze, or spacecraft skin). Such conditions might enhance or hinder visual as well as photographic observations.

5. Quantitative information about features being observed and/or photographed should be as objective as possible and might include:

(a) Stratification (layering), striation (streaks or lines of varying thickness and/or color), and sectoring (separations or disjointment of parts).

(b) Color and hues (compared to other colors available in the same scene at the same time such as "bluer than" or "same shade of red as").

(c) Angular size or angular thickness (See Item 2 above).

(d) Angular separations and distance between layer edges, point sources or opposite sides of the same phenomenon (see Item 2 above).

(e) Relative brightness compared to the brightness of similar phenomenon (i.e., compare point source of light to point source and extended region brigheness to another region, but do not compare point source to region brightness except that the point source is completely occulted by the region). Brightness comparisons should denote whether two or more phenomenon are of equal brightness, or, if not equal, which is the brighter. If possible, brightness of point sources should be bracketed by finding known stars in the same field of view that are just a little brighter and dimmer when the exact same magnitude is not available.

(f) Edge characteristics should include information on straightness, curvature, folded curve, scalloped, and whether the edge brightness is sharp or diffuse.

(g) Count of stars or meteors should include the number of stars visible within a clearly specified region of the celestial sphere (i.e., head of Hydra, square of Pegasus) or the number of meteors seen over a specified time interval including the time when the count is started or stopped.

(h) Exact time of sunrise, sunset, moonrise, and moon-set (i.e., instant when upper limb descends from or returns to view) whenever conveniently observable.

(NOTE: Photography of most of the night-time and dim light phenomenon has only recently gained a great chance for success because of the newly available, very high-speed, black and white, Kodak film No. 2475 (ASA 1200-2400 but can be pushed above 4000). The film was rapidly obtained and moved through flight qualification just prior to the aborted GT-6 flight for use on the Ikeya-Seki comet observations.)

DIM LIGHT PHOTOGRAPHY

CODING: 1 = HASSELBLAD 2 = 16 MM MAURER
3 = 2475 B & W 4 = SO 217 COLOR
A = 80 MM LENS B = 250 MM LENS
C = F-STOP 2.8 D = F-STOP 5.6
X = 75 MM LENS Y = 1 FPS, 1/50

1. TWILIGHT BANDS: POST-SUNSET OR PRE-SUNRISE

EQUIP		1	2	3	4	5	6
CODE	F	11	5.6	5.6	5.6	5.6	5.6
14B	T	1/500	1/500	1/125	1/30	1/8	1/2
CODE	F	32	22	16	11	8	5.6
24XY	T	10	10	10	10	10	10

7	8	9	10
5.6	5.6	5.6	5.6
2	10	30	120
4	2.5		
10	210		

REVERSE ORDER OF SEQUENCE FOR PRE-SUNRISE; HORIZON JUST ABOVE SUNSET IN LOWER LEFT OR RIGHT CORNER

2. NIGHT CLOUD COVER: CODE 13AC, TRACK CLOUDS

CONDITIONS VS TIME	1	2	3	4
NO MOON	8	16	-	-
QUARTER MOON	1/4	1/2	1	2
FULL MOON	1/30	1/15	1/8	1/4

3. SUNLIT AIRGLOW: CODE 13AC,

NO	SUBJECT/COND	SET	1	2	3
1	SUNSET +60 SEC HORIZON SCENE, SET POINT CENTERED IN LOWER PART OF PHOTO	T	1/8	1/8	1/8
		FTR	6300	6225	5300
		-	4	5	6
		T	10	10	10
		FTR	5300	6225	6300
2	SMOST SET/RISE +/-60 SOUTH HZ	(SAME TIME/FILTER SEQUENCE AS NO.1)			
3	NORTH OR SOUTH HORIZON AT MID NIGHT ±10 MIN	SET	1	2	3
		T	10	10	10
		FTR	6300	6225	5300
4	NMOST SET/RISE +/-60 NORTH HZ	(SAME TIME/FILTER SEQUENCE AS NO.1)			
5	SUNRISE -60 SEC AT HORIZON	(REVRS TIME/FILTER SEQUENCE AS NO.1)			

4. DAY SKY BACKGROUND: CODE 13AC, WINDOW SHADED FROM SUN & EARTHSHINE - POINT CAMERA TOWARD SKY, 3 EXP; 5, 30, 120 SEC

5. NIGHT AIRGLOW EDGE-ON: CODE 13AC - 5 EXP; 1/2, 1, 2, 4, 8 SEC WITH HORIZON IN FIELD

6. AURORAE: CODE 13AC
TWO TYPES OF AURORA

BRIGHT	1/8	1/2	2
DIM	1	4	15

7. METEORS:
CODE 13AC

TOTAL COUNT	30	120	300
INDIVIDUAL RECORD	AS REQUIRED		

8. LIGHTNING: USE WITH BOTH CODES; 13AC 13BD

TOTAL COUNT	10	30	120	300
INDIVIDUAL RECORD	AS REQUIRED			

DO WITH METEORS

9. ARTIFICIAL LIGHTING: CODE 13AC, 1/8, 1/2; AND CODE 13BD, 1/4, 1 SEC

10. GALACTIC SURVEY: CODE 13, HOLD +1/2 DEG

SUBJECT/COND	1	2	3	4	5	6	7
ORION OR PEG	80	80	80	80	80	250	250
ASUS, MOON	2.8	2.8	2.8	5.6	5.6	5.6	5.6
45 DEG AWAY	60	120	240	120	240	120	240

CODE AC, EACH EXP 90 SEC, DO EACH ZODIACAL CONSTELLATION TO WITHIN 15^{0} OF SUN

11. ZODIACAL LIGHT & GEGENSCHEIN: CODE 13AC
5-10 MIN INTO DARK

ZODIACAL GEGENSCH	1/16	1/4	1	3	5
	10	30	60	120	-

12. COMET: CODE 13AC OR 13BD IF PHOTOS TAKEN

FOLLOWING LIST OF KEY WORDS/PHRASES AS REF

TIME HACK STAR TRANSITS
ANGULAR MEASUREMENTS
LOCATE POSITION
ADJACENT STARS/PLANETS
ESTIMATE ATTITUDE/RATES
GLARE & LIGHTING
LAYERS/STREAK/THICKNESS/SEPERATION/HUE/COLOR/BRIGHTNESS/EDGE FEATURES/COUNT