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WINDOW: A COMPUTER PROGRAM FOR PLANNING ASTRONOMICAL OBSERVATIONS

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16. Abstract

A FORTRAN computer program called "WINDOW" has been written to simplify the planning of astronomical observations of a number of objects in a limited time. The program lists the azimuths at 15 minute intervals of up to 20 objects while they are in a given range of elevation angles — the window — and gives the elevation angle of each object at its time of transit. This work was motivated by the need to use observing time efficiently on flights of NASA-Ames' Lear Jet and C-141 observatories; WINDOW permits the investigator to prepare preliminary flight plans. However, the program is suited to planning ground-based observations as well. The program and a sample flight plan are described.

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WINDOW: A COMPUTER PROGRAM FOR PLANNING ASTRONOMICAL OBSERVATIONS

by

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Abstract

A FORTRAN computer program called "WINDOW" has been written to simplify the planning of astronomical observations of a number of objects in a limited time. The program lists the azimuths at 15 minute intervals of up to 20 objects while they are in a given range of elevation angles—the window—and gives the elevation angle of each object at its time of transit. This work was motivated by the need to use observing time efficiently on flights of NASA-Ames' Lear Jet and C-141 observatories; WINDOW permits the investigator to prepare preliminary flight plans. However, the program is suited to planning ground-based observations as well. The program and a sample flight plan are described.

Planning astronomical observations from the Lear Jet and C-141 observatories operated by NASA-Ames is complicated by the following considerations: (1) the telescopes operate in a restricted range of elevation angles or window: 14° - 28° for the Lear Jet, 35° - 75° for the C-141; (2) the flights are of limited duration: $2\frac{1}{2}$ hours for the Lear Jet, $7\frac{1}{2}$ hours for the C-141; (3) the telescopes can view only from the left sides of the aircraft, so that typically only half the flying time can be spent observing sources in a particular area of the sky; (4) the aircraft are moving about 500 miles per hour (air speed). To maximize observing time on a given flight, it is desirable to observe calibration objects and/or other objects when the aircraft is flying to or returning from the path required for observing the objects of primary interest. We developed program WINDOW to simplify (a) selection of feasible objects from a list of candidates,and (b) generation of a preliminary flight plan for use by the navigators.

The program computes and lists the azimuths at 15 minute intervals of up to 20 objects while they are in the window, and gives the elevation angle of each object at its time of transit. The entire calculation is done assuming fixed longitude and latitude for the observatory, so that no correction is made for motion of the aircraft. Since the aircraft heading for our airborne observations is approximately equal to the azimuth of the object plus ninety degrees, southerly objects (observed with the aircraft flying West) will require less heading change than indicated by the program, while northerly objects will require more heading change than indicated.

Typically the program is run for the list of candidate objects using longitude and latitude corresponding to the nominal position of the aircraft during the flight, which often is simply the position of the airfield where the plane is based (37.5° N. latitude 122° W. longitude for Moffett Field).

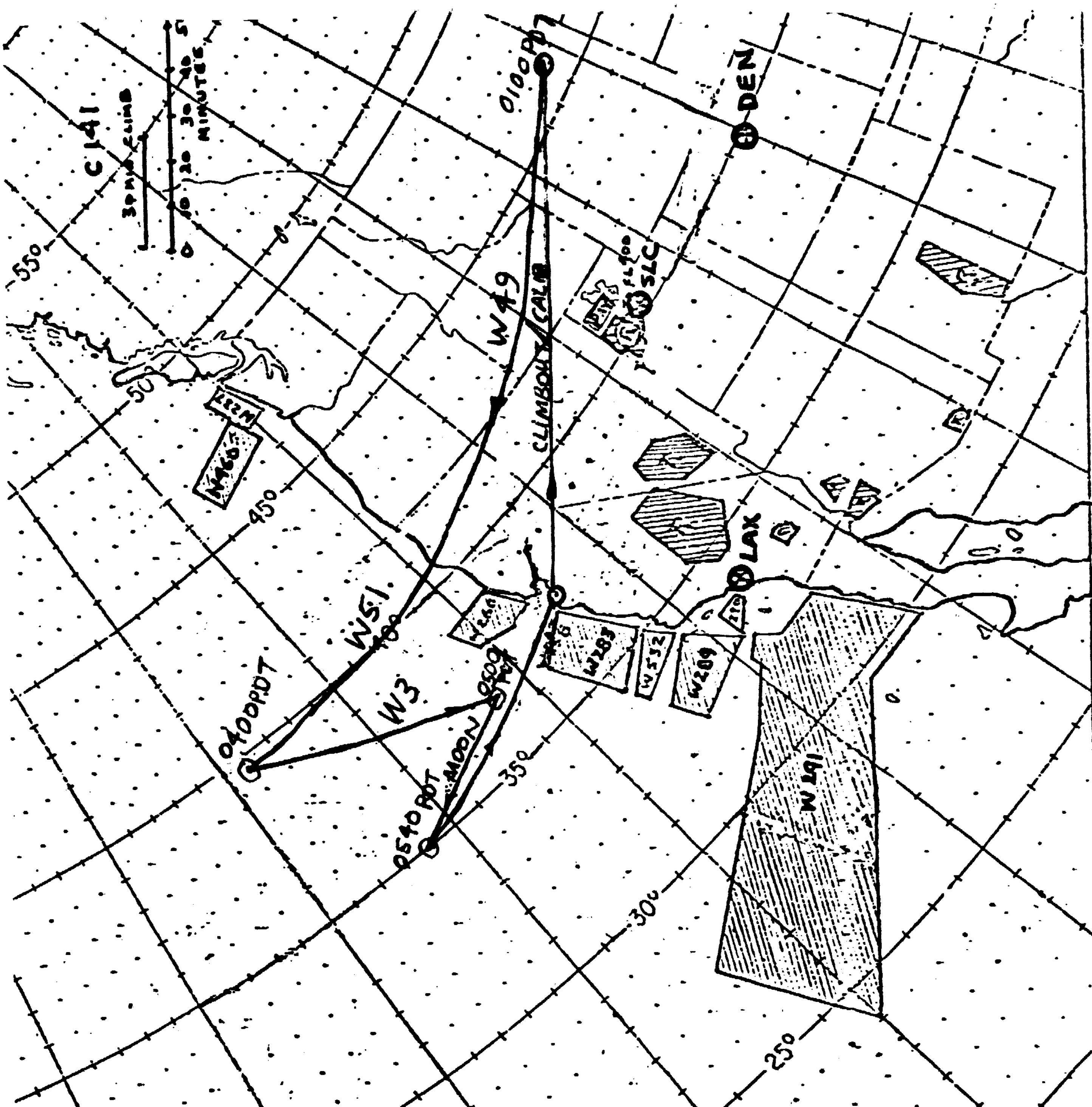
Trajectories of objects shown to be compatible for observation on a given flight are then used to generate a preliminary flight plan. This can be done by the navigators or the investigator. Aircraft trajectories corresponding to the suitable candidate objects are plotted on a map, as shown in Figure 1. Some trial and error is usually involved before the preliminary flight plan is satisfactory; care must be taken to avoid warning areas and international borders.

The detailed flight plan is made starting with the preliminary plan by the navigators. With little practice an investigator can use WINDOW to generate a preliminary plan which will be very close to the navigator's final plan. Successful flight plans with up to 12 observed objects in a 7½ hour flight have been made following this procedure. For ground-based work, the output of program WINDOW is suitable for planning multiple object observations with no further effort.

WINDOW is written in FORTRAN for use on the Ames CDC-7600; copies of the program are available on request from the authors. A version of the program used at NASA-Ames by the navigators runs on their HP 2100 computer.

The beginning of the FORTRAN program contains comment cards describing the use of the program, and a sample of input parameters. A copy of the beginning of the program, and its output corresponding to the flight plan of Figure 1 completes this report.

We are grateful to C. Swift for the coordinate transformation program and to J. Kroupa for the map showing the warning areas in the Western United States.



C141
30 MIN CLIMB
0 10 20 30 40 50
MINUTES
0400PDT
0540PDT
0500PDT
0100PDT
W51
W3
W49
MOON
CLIMBOUT/CALIB
LAX
SLC
DEN
W291
W289
W532
W283
W260
W460
W237
550
500
450
400
350
300
250
200
150°W
145°W
140°W
135°W
130°W
125°W
120°W
115°W
110°W
105°W
100°W

Figure 1

```
      PROGRAM WINDOW(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
C
C A PROGRAM TO FACILITATE PLANNING ASTRONOMICAL OBSERVATIONS OF UP TO 20 OBJECTS
C *** INPUT *** FOR ALL CARDS COLUMNS 71 - 80 CAN BE USED FOR IDENTIFYING LABEL
C                   SOUTH DECLINATIONS AND LATITUDES AND EAST LONGITUDES MUST BE
C                   NEGATIVE ENTRIES THROUGHOUT
C                   THE MAXIMUM DURATION FOR AN OBSERVATION IS 14 DAYS
C                      1.START OF OBSERVATION CARD (DAY,MONTH,YEAR,HOUR) LOCAL TIME
C                      2. END  OF OBSERVATION CARD (DAY,MONTH,YEAR,HOUR) LOCAL TIME
C                       BY THE FOLLOWING FORMAT I2,A3,I2,3X,F10.2
C                      3.LATITUDE & LONGITUDE OF PLACE OF OBSERVATION (DEG,MIN,SEC)
C                       BY THE FOLLOWING FORMAT 6F10.2
C                      4.DIF IN HRS BETWEEN GREENWICH & OBSERVERS STANDARD MERIDIAN
C                       BY THE FOLLOWING FORMAT F10.2
C                      5.UPPER AND LOWER WINDOW ELEVATION ANGLES (DEGREES)
C                       BY THE FOLLOWING FORMAT 2F10.2
C                      6.NUMBER OF OBJECTS (N)
C                       BY THE FOLLOWING FORMAT F10.2
C                      7.OBJECT CARDS (UP TO 20 DIFFERENT OBJECTS)
C                       COLUMNS 1 - 10 AN ALPHAMERIC LABEL FOLLOWED BY THE RIGHT
C                       ASCENSION (HOURS,MINUTES,SECONDS) AND THE DECLINATION
C                       (DEGREES,MINUTES,SECONDS)
C                       BY THE FOLLOWING FORMAT A10,6F10.2
C     IF THE SUN IS DESIRED AS AN OBJECT SIMPLY LABEL A CARD AS "SUN       "
C      THE PROGRAM WILL THEN CALCULATE THE POSITION OF THE SUN (ACCURATE TO
C      WITHIN 10 SEC (150 ARCSEC) THROUGH 2000)
C     IF THE MOON IS DESIRED AS AN OBJECT, TWO OPTIONS ARE AVAILABLE
C      1.IF ONLY ONE CARD IS READ IN, THE MOON WILL BE TREATED AS A STATIONARY
C       OBJECT AND NO CORRECTION FOR POSITION ON THE EARTH WILL BE MADE
C      2.TO UPDATE THE MOON'S POSITION AS A FUNCTION OF TIME AND CORRECT FOR THE
C       OBSERVATION POSITION ON THE EARTH, 3 OR MORE INPUT CARDS MUST BE USED.
C       THE FIRST CARD MUST GIVE THE POSITION OF THE MOON FOR 0 HR U.T. THE DATE
C       OF THE BEGINNING OF THE OBSERVATION. SUBSEQUENT CARDS MUST GIVE THE
C       POSITION OF THE MOON FOR 0 HR U.T. ON SUBSEQUENT DATES. THE LAST CARD
C       MUST GIVE THE POSITION OF THE MOON FOR 0 HR U.T. ON THE DAY FOLLOWING
C       THE DATE OF THE END OF THE OBSERVATION.  FOR THIS OPTION THE LABEL MUST
C       BE "MOON      "
C**** FOR CLARITY A SAMPLE SET OF INPUT CARDS IS GIVEN NEXT***********************
C15JUN76   18.                                                       START OBS
C18JUN76   10.                                                       END OBS
C37.       25.       0.        122.      3.        0.                  NASA-AMES
C7.                                                                   DIF IN HR
C35.       75.                                                       WINDOW

C9.                                                                  # SOURCES
CSUN
CMOON      20.       7.        37.       -15.      -1.       -18.      15 JUN 76
CMOON      21.       0.        12.       -11.      -39.      -21.      16 JUN 76
CMOON      21.       49.       54.       -7.       -50.      -11.      17 JUN 76
CMOON      22.       37.       22.       -3.       -46.      -42.      18 JUN 76
CMOON      23.       23.       19.       0.        20.       33.       19 JUN 76
CJUPITER   3.        8.        18.       16.       36.       30.       16 JUN 76
CM51       19.       21.       22.       14.       25.       10.
CM49       19.       7.        50.       9.        1.        12.
CNGC7538   23.       11.       24.       61.       14.       0.
CM3        2.        21.       50.       61.       52.       54.
CDR21      20.       37.       14.       42.       9.        20.
CM17       18.       17.       33.       -16.      -12.      -15.
```

WINDOW OUTPUT

```
START OBSERVATION  15 JUN 76  AT 1800 HOURS LOCAL TIME
 END  OBSERVATION  18 JUN 76  AT 1000 HOURS LOCAL TIME

OBSERVER LATITUDE =   37. DEGREES    25. MINUTES     0. SECONDS
OBSERVER LONGITUDE=  122. DEGREES     3. MINUTES     0. SECONDS

DIF IN HRS GREENWICH & OBSERVERS STANDARD MERIDIAN=  7.

WINDOW LOWER ANGLE=  35. DEGREES,  UPPER ANGLE=  75. DEGREES

GREENWICH SIDERIAL TIME & POSITION OF SUN FOR 0 HR U.T.  15 JUN 76
   GREENWICH SIDERIAL TIME=  17. HOURS   35. MINUTES   36. SECONDS
   POSITION OF SUN  R.A.=   5. HRS   33. MIN   58. SEC    DEC.=  23. DEG   18. MIN   19. SEC

NUMBER OF OBJECTS (MAX=20) =   9
```

	OBJECT	R.A.(HRS	MIN	SEC)	DEC.(DEG	MIN	SEC)
1	SUN	5.	33.	58.	23.	18.	19.
2	MOON	20.	7.	37.	-15.	-1.	-18.
2	MOON	21.	0.	12.	-11.	-39.	-21.
2	MOON	21.	49.	54.	-7.	-50.	-11.
2	MOON	22.	37.	22.	-5.	-46.	-42.
2	MOON	23.	23.	19.	0.	20.	33.
3	JUPITER	3.	8.	18.	16.	36.	30.
4	M51	19.	21.	22.	14.	25.	10.
5	M49	19.	7.	50.	9.	1.	12.
6	NGC7538	23.	11.	24.	61.	14.	0.
7	W3	2.	21.	50.	61.	52.	54.
8	DR21	20.	37.	14.	42.	9.	20.
9	M17	18.	17.	35.	-16.	-12.	-15.

SIDERIAL	OBJECT 1	OBJECT 2	OBJECT 3	OBJECT 4	OBJECT 5	OBJECT 6	OBJECT 7	OBJECT 8	OBJECT 9	OBJECT 10	OBJECT 11	OBJECT 12	OBJECT 13	OBJECT 14	OBJECT 15	OBJECT 16	OBJECT 17	OBJECT 18	OBJECT 19	OBJECT 20	LOCAL

ORIGINAL PAGE IS
OF POOR QUALITY

```
-15JUN76-15JUN76-15JUN76-15JUN76-15JUN76-15JUN76-15JUN76-15JUN76-15JUN76-15JUN76-15JUN76-15JUN76-15JUN76-
10  .    .    .    .    .    .    .    .    .                                                        1730D
    .    .    .    .    .    .    .    .    .                                                        1745D
    .    .    .    .    .    .    .    .    .                                                        1800D
    .    .    .    .    .    .    .    .    .                                                        1815D
11  .    .    .    .    .    .    .    .    .                                                        1830D
    .    .    .    .    .    .    .    .    .                                                        1845D
    .    .    .    .    .    .    .    .    .                                                        1900D
    .    .    .    .    .    .    .    .    .                                                        1915D
12  .    .    .    .    .    .    .    .    .                                                        1930D
    .    .    .    .    .    .    .    .    .                                                        1945D
    .    .    .    .    .    .    .    .    .                                                        2000D
    .    .    .    .    .    .    .    .    .                                                        2015D
-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET.
13  .    .    .    .    .    .    .    .    .                                                        2030N
    .    .    .    .    .    .    .    .    .                                                        2045N
    .    .    .    .    .    .    .    .    .                                                        2100N
14  .    .    .    .    .    .    .    .    .                                                        2114N
    .    .    .    .    .    .    .    .    .                                                        2129N
    .    .    .    .    .    .    .    .    .                                                        2144N
    .    .    .    .    .    .    .    .    .                                                        2159N
15  .    .    .    .    .    .    .    .    .                                                        2214N
    .    .    .    .    .    .    .    .    .                                                        2229N
    .    .    .    .    .    .    .    .    .                                                        2244N
    .    .    .    .    .    .    .    .    .                                                        2259N
    .    .    .   102  109   .    .   60    .                                                        2314N
16  .    .    .   104  113   .    .   62    .                                                        2329N
    .    .    .   107  116   .    .   63    .                                                        2344N
    .    .    .   111  119   .    .   64    .                                                        2359N
-16JUN76-16JUN76-16JUN76-16JUN76-16JUN76-16JUN76-16JUN76-16JUN76-16JUN76-16JUN76-16JUN76-16JUN76-16JUN76-
    .    .    .   114  123   .    .   65    .                                                          14N
17  .    .    .   118  127   .    .   66    .                                                          29N
    .    .    .   122  132   .    .   67    .                                                          44N
    .    .    .   126  137   .    .   67   167                                                         59N
    .    .    .   132  142   36   .   68   171                                                        114N
18  .    .    .   137  148   37   .   69   176                                                        129N
    .    .    .   144  155   37   .   69   36T                                                        144N
    .    .    .   151  162   37   .   69   184                                                        159N
    .    .    .   159  169   37   .   69   188                                                        214N
19  .    .    .   168  177   37   .   68   193                                                        229N
    .    .    .   67T  62T   37   .   67    .                                                         244N
    .   147   .   185  191   37   .    .    .                                                         259N
    .   151   .   194  199   36   .    .    .                                                         313N
20  .   155   .   203  206   36   .    .    .                                                         328N
    .   159   .   211  212   35   .    .    .                                                         343N
    .   163   .   218  218   33   .   85T   .                                                         358N
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	,	168	.	225	224	32	35	.	.	413N
21	,	173	.	230	229	30	35	.	.	428N
	,	178	.	235	233	28	36	.	.	443N
	,	42T	.	240	238	26	36	.	.	458N
	,	186	.	244	241	23	36	.	.	513N
22	,	191	.	248	245	19	36	294	.	528N
	.	196	.	251	248	16	36	293	.	543N
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	,	200	.	254	251	12	36	292	.	558D
	,	205	.	257	,	8	36	292	.	613D
23	,	209	.	260	,	3	35	292	.	628D
	,	213	.	,	,	64T	34	292	.	643D
	,	.	99	,	,	355	33	293	.	658D
	,	.	102	,	,	351	32	294	.	713D
0	,	.	105	,	,	347	30	294	.	728D
	,	.	108	,	,	343	28	295	.	743D
	,	.	111	,	,	340	26	296	.	758D
	,	.	115	,	,	337	24	297	.	813D
1	,	.	119	,	,	334	21	298	.	828D
	.	.	123	,	,	332	18	299	.	843D
	86	.	128	,	,	330	14	301	.	858D
	88	.	134	,	,	328	10	.	.	912D
2	91	.	141	,	,	327	6	.	.	927D
	94	.	148	,	,	326	66T	.	.	942D
	96	.	156	,	,	325	359	.	.	957D
	99	.	166	,	,	324	354	.	.	1012D
3	102	.	175	,	,	324	350	.	.	1027D
	105	.	69T	,	,	324	347	.	.	1042D
	108	.	194	,	,	324	343	.	.	1057D
	112	.	204	,	,	324	340	.	.	1112D
4	117	.	212	,	,	324	337	.	.	1127D
	122	.	220	,	,	324	335	.	.	1142D
	128	.	226	,	,	325	332	.	.	1157D
	136	.	232	,	,	325	331	.	.	1212D
5	146	.	237	,	,	.	329	.	.	1227D
	157	.	242	,	,	.	328	.	.	1242D
	.	.	246	,	,	.	327	.	.	1257D
	76T	,	250	.	,	.	326	.	.	1312D
6	.	.	253	,	,	.	325	.	.	1327D
	209	.	256	,	,	.	325	.	.	1342D
	220	.	259	,	,	.	325	.	.	1357D
	228	.	262	,	,	.	325	.	.	1412D
7	236	.	264	,	,	.	325	.	.	1427D
	241	.	.	,	,	.	325	.	.	1442D
	246	.	.	,	,	.	325	.	.	1457D
	251	.	.	,	.	.	326	.	.	1512D

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8258  .    .    .    .    .    .    .    .                                                          1520D
 258  .    .    .    .    .    .    .    .                                                          1541D
 261  .    .    .    .    .    .    .    .                                                          1556D
 264  .    .    .    .    .    .    .    .                                                          1611D
9266  .    .    .    .    .    .    .    .                                                          1626D
 269  .    .    .    .    .    .    .    .                                                          1641D
 272  .    .    .    .    .    .    .    .                                                          1656D
 274  .    .    .    .    .    .    .    .                                                          1711D
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   .  .    .    .    .    .    .    .    .                                                          1911D
12 .  .    .    .    .    .    .    .    .                                                          1926D
   .  .    .    .    .    .    .    .    .                                                          1941D
   .  .    .    .    .    .    .    .    .                                                          1956D
   .  .    .    .    .    .    .    .    .                                                          2011D
13 .  .    .    .    .    .    .    .    .                                                          2026D
-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-
   .  .    .    .    .    .    .    .    .                                                          2041N
   .  .    .    .    .    .    .    .    .                                                          2056N
   .  .    .    .    .    .    .    .    .                                                          2111N
14 .  .    .    .    .    .    .    .    .                                                          2125N
   .  .    .    .    .    .    .    .    .                                                          2140N
   .  .    .    .    .    .    .    .    .                                                          2155N
   .  .    .    .    .    .    .    .    .                                                          2210N
15 .  .    .    .    .    .    .    .    .                                                          2225N
   .  .    .    .    .    .    .    .    .                                                          2240N
   .  .    .    .    .    .    .    .    .                                                          2255N
   .  .    .   102  109   .    .   60    .                                                          2310N
16 .  .    .   104  113   .    .   62    .                                                          2325N
   .  .    .   107  116   .    .   63    .                                                          2340N
   .  .    .   111  119   .    .   64    .                                                          2355N
-17JUN76-17JUN76-17JUN76-17JUN76-17JUN76-17JUN76-17JUN76-17JUN76-17JUN76-17JUN76-17JUN76-17JUN76-17JUN76-
   .  .    .   114  123   .    .   65    .                                                          10N
17 .  .    .   118  127   .    .   66    .                                                          25N
   .  .    .   122  132   .    .   67    .                                                          40N
   .  .    .   126  137   .    .   67   167                                                         55N
   .  .    .   132  142   36   .   68   171                                                         110N
18 .  .    .   137  148   37   .   69   176                                                         125N
   .  .    .   144  155   37   .   69   367                                                         140N
   .  .    .   151  162   37   .   69   184                                                         155N
   .  .    .   159  169   37   .   69   188                                                         210N
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19	.	.	.	168	177	37	.	68	193	225N
	.	.	.	67T	62T	37	.	67	.	240N
	.	.	.	185	191	37	.	.	.	255N
	.	.	.	188	199	36	.	.	.	310N
20	.	139	.	203	206	36	.	.	.	325N
	.	143	.	211	212	35	.	.	.	339N
	.	147	.	218	218	33	.	85T	.	354N
	.	151	.	224	224	33	35	.	.	409N
21	.	156	.	230	229	30	35	.	.	424N
	.	161	.	235	233	28	36	.	.	439N
	.	166	.	240	238	24	36	.	.	454N
	.	171	.	244	241	23	36	.	.	509N
22	.	176	.	248	245	19	36	294	.	524N
	.	46T	.	251	248	16	36	293	.	539N
-SUNRISE-SUNRISE-SUNRISE-SUNRISE-SUNRISE-SUNRISE-SUNRISE-SUNRISE-SUNRISE-SUNRISE-SUNRISE-SUNRISE-SUNRISE-										
	.	185	.	254	251	12	36	292	.	554D
	.	190	.	257	.	8	36	292	.	609D
23	.	196	.	260	.	3	35	292	.	624D
	.	200	.	.	.	64T	34	292	.	639D
	.	205	99	.	.	355	33	293	.	654D
	.	210	102	.	.	351	32	293	.	709D
0	.	214	105	.	.	347	30	294	.	724D
	.	218	108	.	.	343	28	295	.	739D
	.	222	111	.	.	340	26	296	.	754D
	.	226	115	.	.	337	24	297	.	809D
1	.	.	119	.	.	335	21	298	.	824D
	.	.	123	.	.	332	18	299	.	839D
	.	.	128	.	.	331	14	301	.	854D
	87	.	134	.	.	328	10	.	.	909D
2	90	.	141	.	.	327	6	.	.	924D
	93	.	148	.	.	326	66T	.	.	938D
	95	.	155	.	.	325	359	.	.	953D
	98	.	166	.	.	324	354	.	.	1008D
3	101	.	175	.	.	324	350	.	.	1023D
	104	.	69T	.	.	321	347	.	.	1038D
	107	.	194	.	.	320	343	.	.	1053D
	111	.	204	.	.	323	340	.	.	1108D
4	115	.	212	.	.	323	337	.	.	1123D
	120	.	220	.	.	324	335	.	.	1138D
	127	.	226	.	.	325	332	.	.	1153D
	134	.	232	.	.	325	331	.	.	1208D
5	143	.	237	.	.	.	329	.	.	1223D
	154	.	242	.	.	.	328	.	.	1238D
	.	.	246	.	.	.	327	.	.	1253D
	76T	.	250	.	.	.	326	.	.	1308D
6	.	.	254	.	.	.	325	.	.	1323D

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   206  .  256  .  .  .  325  .  .                                                  1338D
   217  .  259  .  .  .  325  .  .                                                  1353D
   226  .  262  .  .  .  325  .  .                                                  1408D
  7234  .  264  .  .  .  325  .  .                                                  1423D
   240  .   .   .  .  .  325  .  .                                                  1438D
   245  .   .   .  .  .  325  .  .                                                  1453D
   250  .   .   .  .  .  326  .  .                                                  1508D
  *254  .   .   .  .  .   .   .  .                                                  1523D
   257  .   .   .  .  .   .   .  .                                                  1537D
   260  .   .   .  .  .   .   .  .                                                  1552D
   263  .   .   .  .  .   .   .  .                                                  1607D
  *265  .   .   .  .  .   .   .  .                                                  1622D
   268  .   .   .  .  .   .   .  .                                                  1637D
   271  .   .   .  .  .   .   .  .                                                  1652D
   273  .   .   .  .  .   .   .  .                                                  1707D
10  .   .   .   .  .  .   .   .  .                                                  1722D
    .   .   .   .  .  .   .   .  .                                                  1737D
    .   .   .   .  .  .   .   .  .                                                  1752D
    .   .   .   .  .  .   .   .  .                                                  1807D
11  .   .   .   .  .  .   .   .  .                                                  1822D
    .   .   .   .  .  .   .   .  .                                                  1837D
    .   .   .   .  .  .   .   .  .                                                  1852D
    .   .   .   .  .  .   .   .  .                                                  1907D
12  .   .   .   .  .  .   .   .  .                                                  1922D
    .   .   .   .  .  .   .   .  .                                                  1937D
    .   .   .   .  .  .   .   .  .                                                  1952D
    .   .   .   .  .  .   .   .  .                                                  2007D
13  .   .   .   .  .  .   .   .  .                                                  2022D
-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-SUNSET-
    .   .   .   .  .  .   .   .  .                                                  2037N
    .   .   .   .  .  .   .   .  .                                                  2052N
    .   .   .   .  .  .   .   .  .                                                  2107N
14  .   .   .   .  .  .   .   .  .                                                  2122N
    .   .   .   .  .  .   .   .  .                                                  2137N
    .   .   .   .  .  .   .   .  .                                                  2151N
    .   .   .   .  .  .   .   .  .                                                  2206N
15  .   .   .   .  .  .   .   .  .                                                  2221N
    .   .   .   .  .  .   .   .  .                                                  2236N
    .   .   .   .  .  .   .   .  .                                                  2251N
    .   .   .  102 109 .  .   60 .                                                  2306N
16  .   .   .  104 115 .  .   62 .                                                  2321N
    .   .   .  107 116 .  .   63 .                                                  2336N
    .   .   .  111 119 .  .   64 .                                                  2351N
-18JUN76-18JUN76-18JUN76-18JUN76-18JUN76-18JUN76-18JUN76-18JUN76-18JUN76-18JUN76-18JUN76-18JUN76-18JUN76-18JUN76-18JUN76-
    .   .   .  114 123 .  .   65 .                                                     6N
17  .   .   .  118 127 .  .   66 .                                                    21N
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      ,    .    .   122  132    .    .   67    .                36N
      ,    .    .   126  137    .    .   67  167                51N
      ,    .    .   132  142   36    .   68  171               106N
 18   ,    .    .   137  148   37    .   69  176               121N
      ,    .    .   144  155   37    ,   69   36T              136N
      ,    .    .   151  162   37    ,   69  184               151N
      ,    .    .   159  169   37    .   69  188               206N
 19   ,    .    .   168  177   37    ,   68  193               221N
      ,    .    .    67T  62T  37    ,   67    .               236N
      ,    .    .   185  191   37    .    .    .               251N
      .    .    .   194  199   36    ,    .    .               306N
 20   ,    .    .   203  206   36    ,    .    .               321N
      ,  128    .   211  212   35    ,    .    .               336N
      ,  132    .   218  218   33    .   85T   .               350N
      ,  136    .   224  224   32   35    .    .               405N
 21   ,  140    .   230  229   30   35    .    .               420N
      ,  144    .   235  233   28   36    .    .               435N
      ,  148    .   240  238   26   36    .    .               450N
      ,  153    .   244  241   23   36    .    .               505N
 22   ,  158    .   248  245   19   36  294    .               520N
      ,  163    .   251  248   16   36  293    .               535N
      .  169    .   254  251   12   36  292    .               550N
 =SUNRISE=SUNRISE=SUNRISE=SUNRISE=SUNRISE=SUNRISE=SUNRISE=SUNRISE=SUNRISE=SUNRISE=SUNRISE=SUNRISE=SUNRISE=
      ,  174    .   257    ,    8   36  292    .               605D
 23   ,   50T   .   260    ,    3   35  292    .               620D
      ,  185    .     ,  64T   34  292    .                      635D
      ,  190   90     ,    ,  355   33  293    .               650D
      ,  196  102     ,    ,  351   32  294    .               705D
  0   ,  201  105     ,    ,  347   30  294    .               720D
      ,  207  108     ,    ,  343   28  295    .               735D
      ,  211  111     ,    ,  340   26  295    .               750D
      ,  216  115     ,    ,  337   24  297    .               805D
  1   ,  221  119     ,    ,  334   21  298    .               820D
      ,  225  123     ,    ,  332   18  299    .               835D
      .  229  128     ,    ,  330   14  301    .               850D
     87  232  134     ,    ,  328   10    .    .               905D
  2  89    .  141     ,    ,  327    6    .    .               920D
     92    .  148     ,    ,  326   66T   .    .               935D
     95    .  156     ,    ,  325  359    .    .               950D
     97    .  166     ,    ,  324  354    .    .              1004D
   3100    .  175     ,    ,  324  350    .    .              1019D
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