

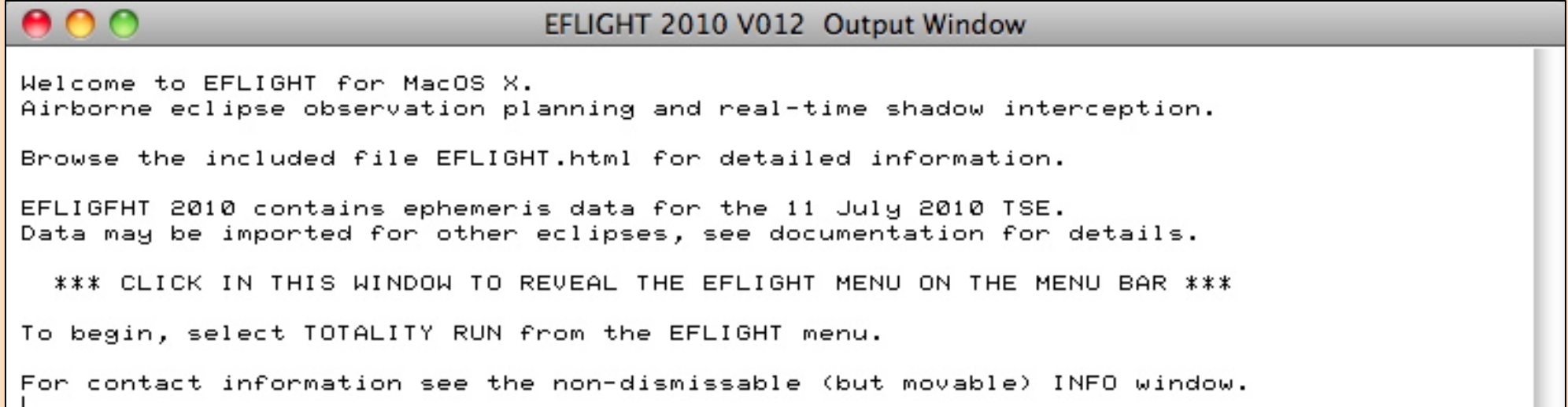
TOP 10 REASONS TO OBSERVE TSEs FROM JET AIRCRAFT

DEPLOYMENT/RELOCATION FLEXIBILITY To Find the BEST Spot in the Area of Operations for Observing	CLOUD OBSERVATION AVOIDANCE Clear Skies Virtually Assured
TOTALITY PROLONGATION Aircraft Speed Extends the Duration of Totality	SKY TRANSPARENCY Significantly Improved — Lower Particulate Scattering
SKY DARKNESS Much Higher Coronal Contrast, Visibility to Larger Distance	IMPROVED ASTRONOMICAL "SEEING" "r_nought" Decreases with Increasing Altitude
REDUCED ATMOSPHERIC TURBIDITY Vorticity & Sheer Decline in Power Above Tropopause	MORE PANCHROMATIC TRANSMISSIVITY IR and UV "Windows" Open Up or are Extended
UNPARALLELED HORIZON REACH & OBSERVATION VISTA Apparent Horizon ~ 400 km distant, depressed 3.5° @ 40,000 ft.	ESTHETIC, ETHERIAL, EXPERIENCE There is nothing quite like it...

WHY EFLIGHT?

Hitting a moving target (the moon's shadow) from a moving platform (a high speed aircraft) is intrinsically not too complex a problem, though it certainly is non-trivial. To do so, successfully, while optimizing an aircraft flight intercept to strike a desired balance between duration, observability (e.g., line-of-site restrictions due to aircraft windows), cost, and other constraints, must be approached with both care and rigor. By 1992, the availability and capabilities of portable (aka "laptop") computers had so rapidly evolved, that eclipse flight optimization and *re*-planning in reaction to *in situ* conditions became possible. As a result, the first version of EFLIGHT, an integrated eclipse flight planning and navigation S/W package, was engineered for the then fledgling Macintosh PowerBook 100 series laptop computers, and then successfully used to navigate a DC-10 precisely through the path of the 30 June 1992 eclipse. Since then, EFLIGHT has evolved into a fully integrated airborne eclipse observation planning and navigation tool. Many of its current capabilities are illustrated here. Got an airplane?

DEFINING THE "UMBRAL INTERCEPT"

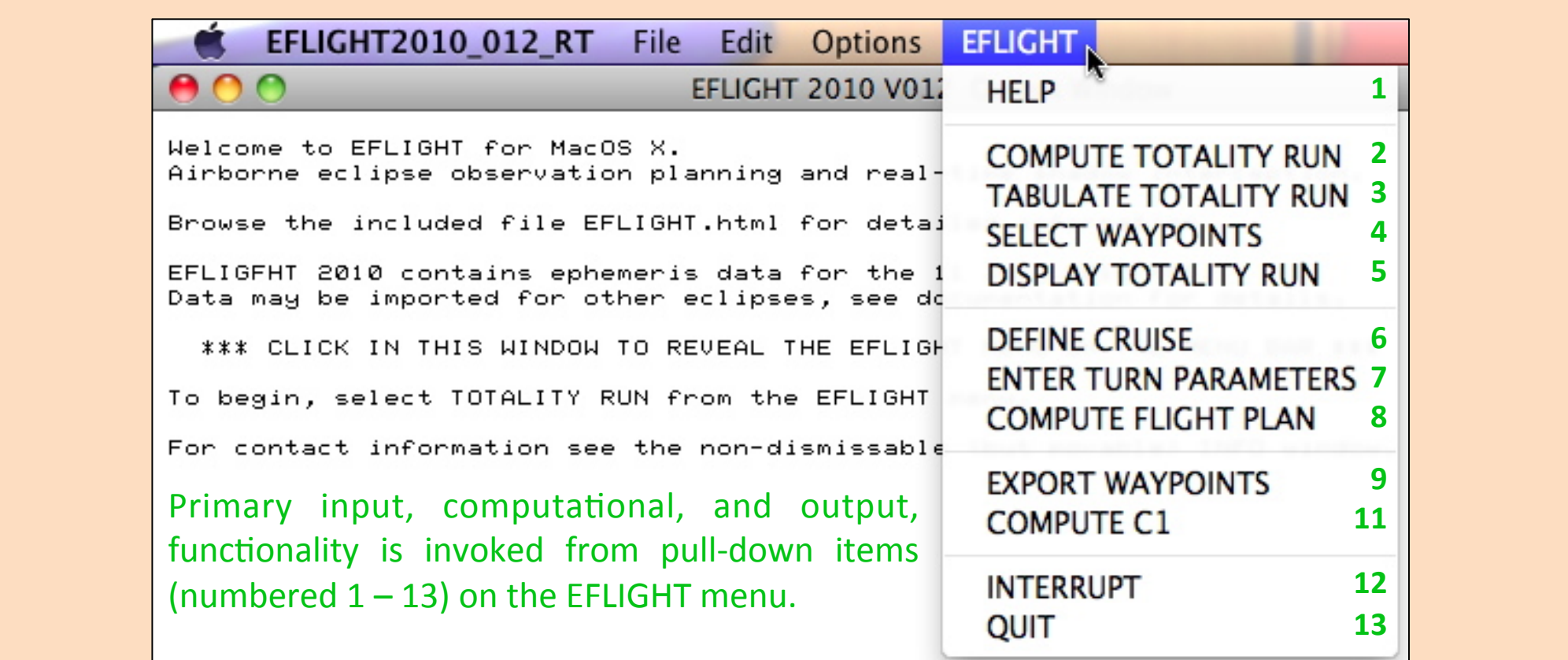


EFLIGHT is an eclipse circumstance calculator with the added twist of addressing the problem of intercepting the moon's shadow from an aircraft in flight. The core algorithms for the computation of at-altitude local and centerline eclipse circumstances are the same as those employed in UMBRAPHILE®. Since 1992, EFLIGHT has been used to optimally plan eclipse flights for TSEs 1992, 2001^b, 2003, 2008, 2009, and 2010 (and several "back-up" flights for other TSEs). Next up: TSE 2015.

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On-line documentation:
http://nicmosis.as.arizona.edu:8000/ECLIPSE_WEB/EFLIGHT.html
Sanctioned Use from SoftTouch Applications by Licence Only

*http://nicmosis.as.arizona.edu:8000/ECLIPSE_WEB/UMBRAPHILE.html *Cancelled following the tragic crash of Concord/AF 4590 on 25 July 2000.



1. COMPUTE TOTALITY RUN – INPUT DIALOG

Specifies the Universal Time (with one second granularity) at which the aircraft is to be concentrically located in the moon's shadow.

Non-central mid-eclipse intercept: displacement from centerline (CL) → Intercept CL [0] km

Computation time window ± UT of mid-eclipse for Totality Run → Time Window = [7] [7] Min.

Aircraft true AIRSPEED in units of distance/hr (unit per CL displacement).
At mid-eclipse fly: (a) specified heading, (b) perpendicular Sun LOS to optimize passenger window viewing (best near the points of local noon/midnight), (c) parallel to shadow motion to maximize duration of totality (at path extrema requires flying "across the shadow").
Aircraft altitude above mean sea level (in feet) at mid-eclipse. → Altitude in feet AMSL = [39000]

Expected Winds Aloft at UT/Location of mid-eclipse. → WIND from [270] Deg., Speed = [55]

Border pad in latitude/longitude for graphical display output window.
Time granularity for CL computation and graphical display (right: CL and aircraft latitude/longitude tabulation/display output format). → Display Time Resolution: [1s] [5s] [10s] [30s] [60s]

Graphical output inter-frame cadence. / Coordinate display format. → Display Frame Delay = [0.5] s

Export time-correlated waypoints to ASCII (text) file. → Export Waypoint Table

Real-Time simulation: synchronize UT with offset to system clock. → RT SIMULATION

Size of graphical display window w.r.t. default. → Graphics Scale = [100] %

Output Format: [DDD.xxxxx] [DDMMSS.x] [DDMMSS.xxx]

CANCEL OK

1. COMPUTE TOTALITY RUN OPTIONAL BESSELIAN ELEMENT FILE IMPORT & COMPUTATION UT RANGE AND CADENCE

Start Time [HHMMSS.f] [191259.0]
End Time [HHMMSS.f] [192701.0]
Increment [HHMMSS.f] [000001]
Altitude [11887.2] meters

☐ Read Data File

CANCEL OK

Besselian Element ASCII File
Format (common format for
UMBRAPHILE S/W)

```

ECLIPSE-11JULY2010.txt
; UMBRAPHILE DATA FILE FOR 11 JUL 2010 TOTAL SOLAR ECLIPSE
; FOR UMBRAPHILE X (and 2006 B)
; For an explanation see: http://nicmosis.as.arizona.edu:8000/
;
SOURCE = 'USNOAA' ; Must be 'USNOAA' or 'NASARP'
OTYPE = 'TRIG' ; Must be 'TRIG' or 'DIRECT'
;
; POLYNOMIAL COEFFICIENTS AND ELEMENTS FOR COMPUTING BESSELIAN ELEMENTS
;
Range = -0.842, 5.125 ; Range in TDT for valid coefficients
T0 = 17 ; Base time for series expansion
DELTA_T = 0.448 ; Delta-T in seconds (0 if U.T. elements*)
XCOEF = -1.58732374, 0.25717591, 0.00005274, -0.00000099
YCOEF = -0.319780259, -0.13592638, -0.00013323, 0.00000236
SINCOCOE = 0.37544119, -0.00008592, -0.00000007, 0.00000000
COSOCOE = 0.52064624, 0.00003476, 0.00000005, 0.00000000
XCOEF = 0.00000000, 0.00000000, 0.00000000, 0.00000000
MUOCOE = 73.61337250, 15.00005678, 0.00000192, -0.00000004, -0.00417007
L1COEF = 0.53466066, -0.00001711, -0.00001236, 0.00000000 ; Umbra
L2COEF = -0.01172074, -0.00000703, -0.00001220, 0.00000000 ; Penumbra
tanf1 = 0.0045998 ; Umbra Shadow
tanf2 = 0.0045768 ; Penumbra Shadow
SD = 28, 16, 83.8 ; Solar Declination at Mid-Eclipse
MUP = 0.26180942 ; Time derivative of MU in radians/hour
;
Notes:
(1) Delta-T = +6.8 seconds is "built-in" to these polynomial
representations of the Besselian elements. For a different vltue
of absolute Delta-T set DELTA_T = Delta-T minus 66.0.
(2) A correction of (+0.50", -0.25") has been applied to the
latitude and longitude of the moon to compensate for the
displacement of the mean center of figure from the dynamical
center of mass.
;
; ANCIALLY INFORMATION
; UT of Mid-Eclipse (geocentric conjunction) = 19h 50m 54.8

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EFLIGHT X - Eclipse Flight Planning & Navigation S/W: Making Every Second Count!

G. Schneider (The University of Arizona)

THE "TOTALITY RUN"

U.T. Intercept: 19:20:00.0 TOTALITY DURATION = 9m 23.0s
Flight Altitude: 39000 ft
Mid-Ecl Heading: 114.94° Cnt hhhmmss.f Alt° Az° P° 3RD 19:24:41.8 +46.7 22.5 292.3
Air Speed: 447.4km/h LATITUDE: -017° 56' 14.1" LONGITUDE: -126° 46' 59.5"
Wind Speed: 55.0m/h A Second: -25s
Wind Direction: 270.0°

HHMMSS Umbra Long Umbra Lat WidKm Uaz° Ual° AirCr Long AirCr Lat MidT MidD LOS Bearing ACaz ACAL
191300 12829.2800 1737.8748 265.0 30.2 45.0° 12705.651M 1748.9808 -4204 -58.1m +2.3 112.26 27.2 45.9
191301 12828.9394 1737.9428 265.0 30.2 45.0° 12705.921M 1749.0335 -4194 -57.9m +2.3 112.26 27.2 45.9
191302 12828.5994 1738.0098 265.0 30.2 45.0° 12705.3864 1749.0885 -4184 -57.8m +2.3 112.26 27.2 45.9
191303 12828.2574 1738.0778 265.0 30.2 45.0° 12705.2504 1749.1385 -4174 -57.7m +2.3 112.26 27.2 45.9
191304 12827.9164 1738.1448 265.0 30.2 45.0° 12705.1184 1749.1905 -4164 -57.6m +2.3 112.26 27.2 45.9
191305 12827.5754 1738.2128 265.0 30.1 45.0° 12704.9844 1749.2425 -4154 -57.4m +2.3 112.26 27.2 45.9
191306 12827.2334 1738.2808 265.0 30.1 45.1° 12704.8494 1749.2945 -4144 -57.2m +2.2 112.26 27.2 45.9
191307 12826.8944 1738.3488 265.0 30.1 45.1° 12704.7154 1749.3465 -4134 -57.1m +2.2 112.26 27.2 45.9
191308 12826.5534 1738.4168 265.0 30.1 45.1° 12704.5814 1749.3985 -4124 -57.0m +2.2 112.26 27.2 45.9

4 SELECT (NAVIGATION) WAYPOINTS

Waypoint Selection Time Granularity
1s 5s 10s 30s 60s

OK

191300 12829.2800 1737.8748 265.0 30.2 45.0° 12705.651M 1748.9808 -4204 -58.1m +2.3 112.26 27.2 45.9
191301 12828.9394 1737.9428 265.0 30.2 45.0° 12705.921M 1749.0335 -4194 -57.9m +2.3 112.26 27.2 45.9
191302 12828.5994 1738.0098 265.0 30.2 45.0° 12705.3864 1749.0885 -4184 -57.8m +2.3 112.26 27.2 45.9
191303 12828.2574 1738.0778 265.0 30.2 45.0° 12705.2504 1749.1385 -4174 -57.7m +2.3 112.26 27.2 45.9
191304 12827.9164 1738.1448 265.0 30.2 45.0° 12705.1184 1749.1905 -4164 -57.6m +2.3 112.26 27.2 45.9
191305 12827.5754 1738.2128 265.0 30.1 45.0° 12704.9844 1749.2425 -4154 -57.4m +2.3 112.26 27.2 45.9
191306 12827.2334 1738.2808 265.0 30.1 45.1° 12704.8494 1749.2945 -4144 -57.2m +2.2 112.26 27.2 45.9
191307 12826.8944 1738.3488 265.0 30.1 45.1° 12704.7154 1749.3465 -4134 -57.1m +2.2 112.26 27.2 45.9
191308 12826.5534 1738.4168 265.0 30.1 45.1° 12704.5814 1749.3985 -4124 -57.0m +2.2 112.26 27.2 45.9

5. DISPLAY TOTALITY RUN – Sample Individual Frames from Real-Time (or Asynchronous) Dynamical Graphical Display

U.T. = 19:17:25.0, Next: 00m00.0s, CIL: +02m06.2s, MID: -02m35.0s, CILL: -07m16.8s

175
185
195
205

128E 126E 124E

128E 126E 124E

175
185
195
205

U.T. = 19:24:27.0, Next: 00m00.0s, CIL: +09m08.2s, MID: +04m27.0s, CILL: -00m14.8s

175
185
195
205

128E 126E 124E

128E 126E 124E

5. DISPLAY TOTALITY RUN – Sample Individual Frames from Real-Time (or Asynchronous) Dynamical Graphical Display

U.T. = 19:17:25.0, Next: 00m00.0s, CIL: +02m06.2s, MID: -02m35.0s, CILL: -07m16.8s

175
185
195
205

128E 126E 124E

128E 126E 124E

U.T. = 19:24:27.0, Next: 00m00.0s, CIL: +09m08.2s, MID: +04m27.0s, CILL: -00m14.8s

175
185
195
205

128E 126E 124E

128E 126E 124E



BACK ON THE GROUND AFTER TSE PLANNED & EXECUTED WITH EFLIGHT 2008 (2m 52s TOTALITY, 82.6"N) TSE 2008 HIGH CONTRAST/DARK SKY CORONA FROM 36,000 FT. AMSL

END-TO-END EFLIGHT PLANNING

8. COMPUTE FLIGHT PLAN – additional end-to-end inputs

TAKE-OFF > START CRUISE, END CRUISE > LANDING

DDMM.ff Longitude DDDMM.ff E
Airport Latitude [1732.40] S Longitude [14936.68] W

Take-off to Cruise PAPAE [38.16] minutes, [268.0] nM
CR6 Cruise to Landing [24.00] minutes, [150.0] nM

SHADOW VIEWING LEG DURATION (Nearest UTC Minute)
Ingress (SV1 > SV2) [10] minutes Egress (SV3 > SV4) [9] minutes

ADDITIONAL INTRA-TOTALITY WAYPOINTS
at Mid-Eclipse +/- [2.5] minutes

CANCEL OK

6(a) DEFINE CRUISE – from airport to pre-CL shadow viewing leg by great circle or by navigation waypoints.

Compute Cruise Waypoints Via Great Circle from/to Airport
Manually Enter Cruise Waypoints (e.g. on Standard Airway)

CANCEL OK

CR1 [PAPAE] DDMM.ff Longitude DDDMM.ff E
[1820.00] S [14500.00] W
CR2 [PEBRO] [1900.00] S [14000.00] W
CR3 [PATIA] [1915.00] S [13500.00] W
CR4 [PATUI] [1920.00] S [13000.00] W

CANCEL OK

6(b) DEFINE CRUISE – anticipated winds aloft for all primary at-altitude flight legs.

SPECIFY WINDS ALOFT BEFORE/AFTER TOTALITY RUN

ANTICIPATED WINDS ALOFT

	nM/h	Deg
PAPAE > PATIA Outbound Cruise 1st Half	35.0	240.0
PATIA > SVITS Outbound Cruise 2nd Half	50.0	260.0
SV1 > SV2 Ingress Shadow Viewing	55.0	270.0
SV1 > TR2 TOTALITY RUN	55.0	270.0
SV3 > SV4 Egress Shadow Viewing	55.0	270.0
CR4 > CR5 Inbound Cruise Leg 1	40.0	250.0
CR5 > CR6 Inbound Cruise Leg 2	40.0	225.0

CANCEL OK

7(a) ENTER TURN PARAMETERS – entry of aircraft performance during constant radius turns

CONSTANT RADIUS (RF) TURNS

Bank Angle (Degrees)	15.0
Turning Radius (nM)	10.90
Fixed Rate (Deg/sec)	0.6666
Entry+Exit (Seconds)	8.0

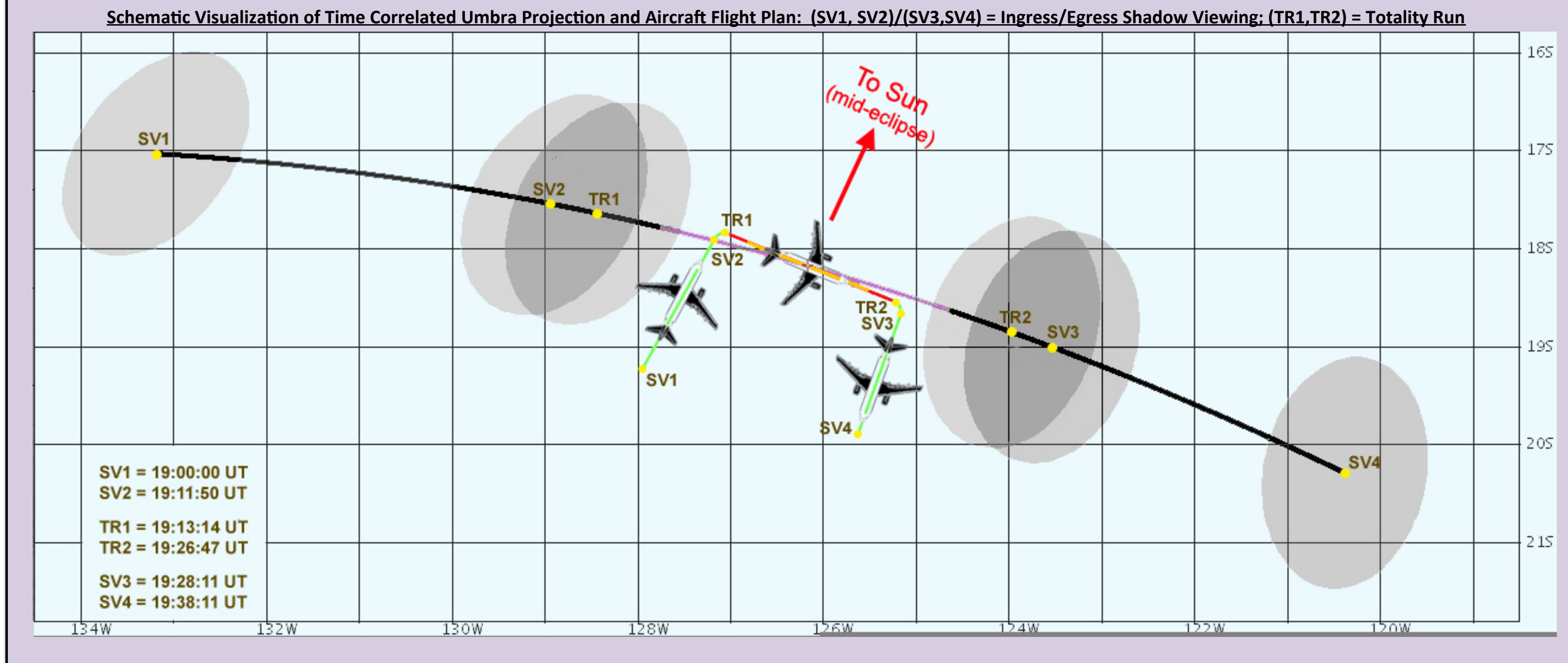
CANCEL OK

7(b) ENTER TURN PARAMETERS – A/C nose deviation angle during shadow viewing to keep windows in fuselage shadow

For INGRESS Shadow Viewing Leg SV1 → SV2:

Orient Aircraft NOSE [2.0] deg. WEST of Solar Azimuth at SV2

CANCEL OK



EFLIGHT 2010 SHADOW INTERCEPT: MID-TOTALITY & UMBRA APPROACH TSE 2008 CIL: STUNNING VIEW OF THE SKY ABOVE AND SEA-ICE BELOW ENABLED BY EFLIGHT PRECISION NAVIGATION