

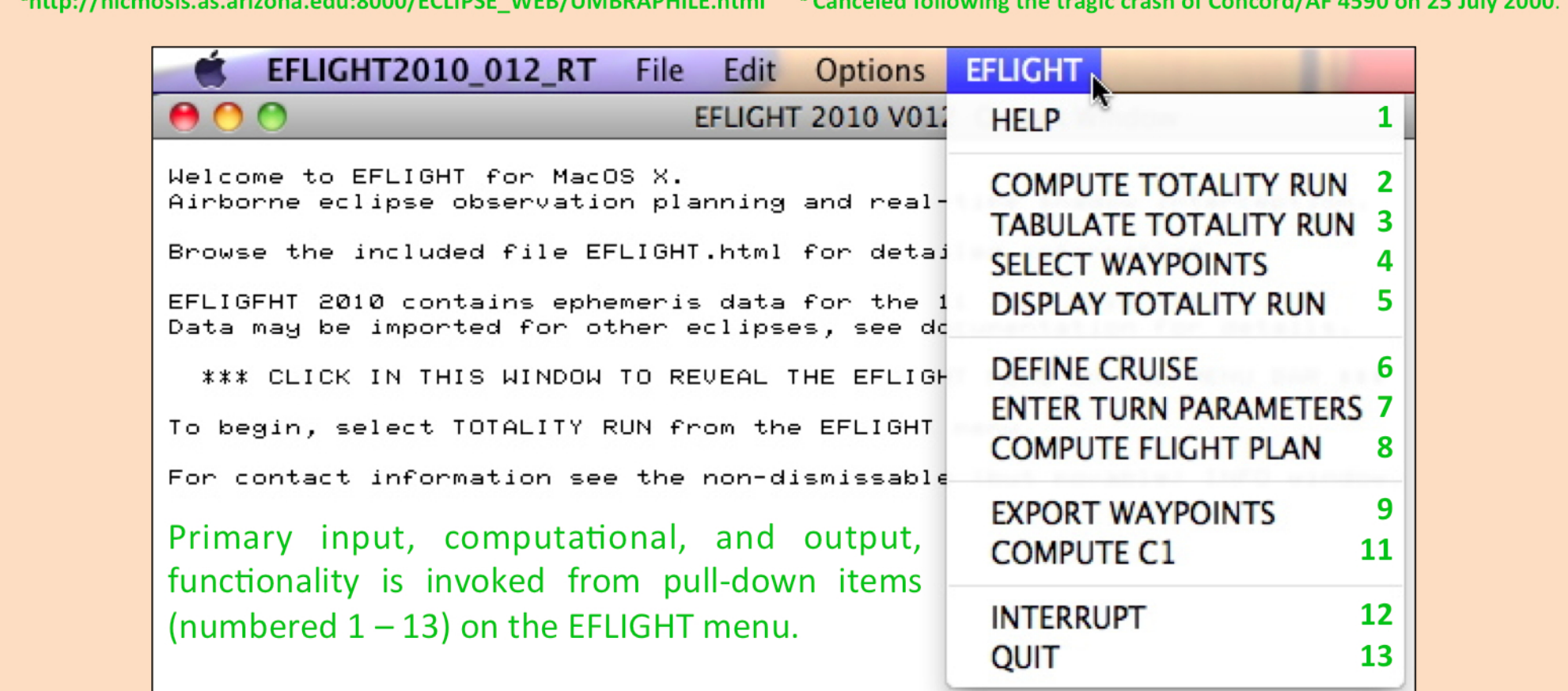
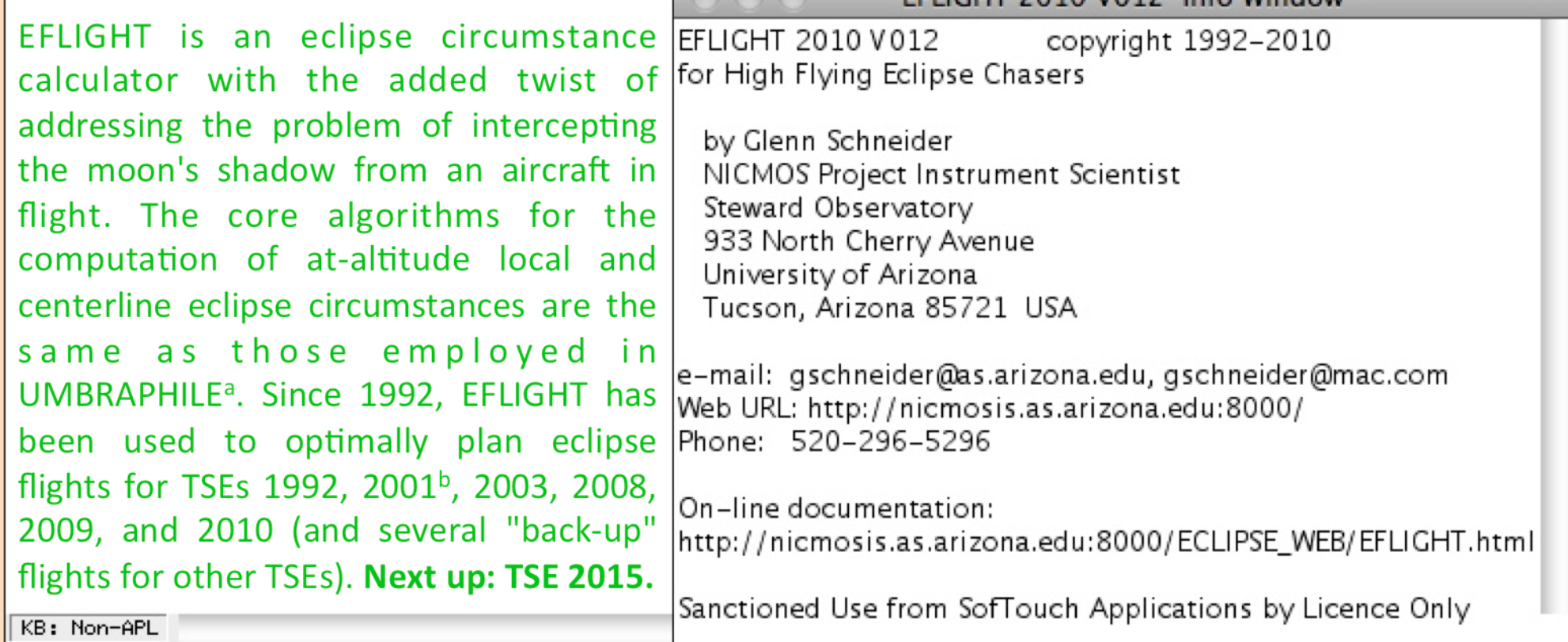
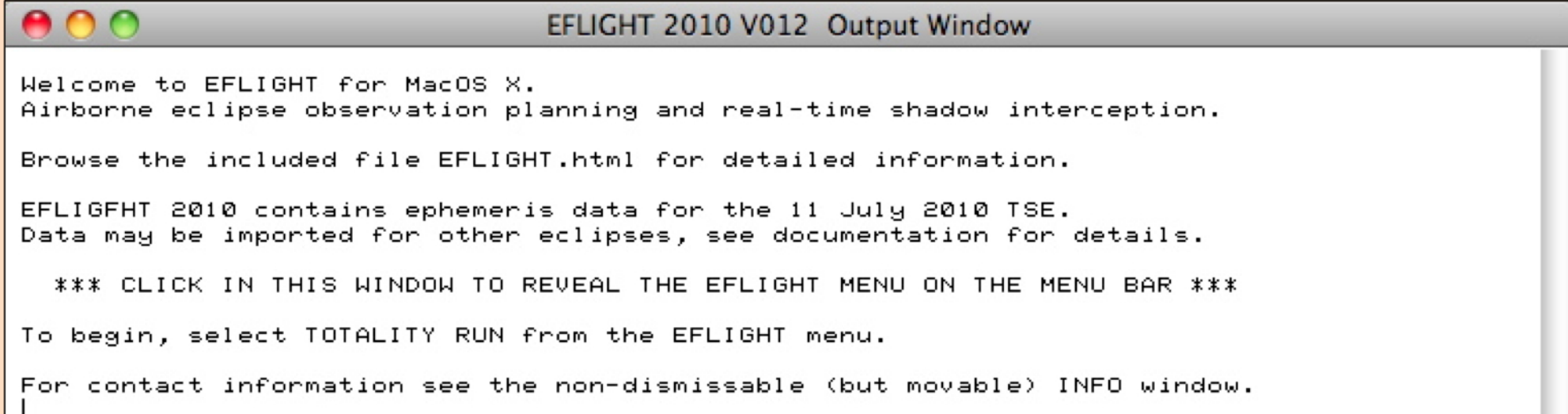
TOP 10 REASONS TO OBSERVE TSEs FROM JET AIRCRAFT

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"



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). → True Air Speed = [447.39] /hr

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").

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. → Autoscale + [1.2] Deg.

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

Graphical output inter-frame cadence. / Coordinate display format. → [] Export Waypoint Table [] RT SIMULATION

Export time-correlated waypoints to ASCII (text) file. → []

Real-Time simulation: synchronize UT with offset to system clock. → []

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

Output Format: [] DDD.xxxxx [] DDDMMSS.x [] DDDMM.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 [DDDMMSS.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 V. (and 2086 B)
; For an explanation see: http://nicosis.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 = 0.448 ; Delta-T in seconds (0 if U.T. elements*)
XCOEF = -1.58726374, 0.00005274, -0.00000099, 0.00000000
YCOEF = -0.31970295, -0.13592638, -0.00013323, 0.00000236
SINCOEF = 0.37544119, -0.00008592, -0.00000007, 0.00000000
COSCOEF = 0.52084624, 0.00003476, 0.00000005, 0.00000000
X2COEF = 0.00000000, 0.00000000, 0.00000000, 0.00000000
MUOEF = 73.61337258, 15.00005878, 0.00000192, -0.00000004, -0.00417087
11COEF = 0.53466868, -0.00001711, -0.00001236, 0.00000000 ; Umbra
12COEF = -0.01172074, -0.00000763, -0.00001228, 0.00000000 ; Penumbra
tanf1 = 0.0045998 ; Umbra Shadow
tanf2 = 0.0045768 ; Penumbra Shadow
SD = 28.16, 83.8 ; Solar Declination at Mid-Eclipse
MUP = 0.26188842 ; 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 value
of absolute Delta-T set DELTA = Delta-T minus 66.8.
(2) A correction of (+0.59", -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.
;
ANCILLARY INFORMATION
; UT of Mid-Eclipse (geocentric conjunction) = 19h 50m 54.8

```

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

G. Schneider (The University of Arizona)

THE "TOTALITY RUN"

EFLIGHT-TABULATE TOTALITY RUN

U.T. Intercept: 19:20:00 | TOTALITY DURATION = 9m 23.0s

Flight Altitude: 39000 ft

Mid-Ecl Heading: 114.94° | Air Speed: 447.4nm/h | Wind Speed: 55.0nm/h | Wind Direction: 270.0°

HHMMSS Umbra Long Umbra Lat HdkW Uaz* Ual* AirCr Long AirCr Lat MidT MidD LOS Track ACaz ACal

191300 12829.2800 1737.8748 265.0 30.2 45.0* 12705.654M 1748.980S -4204 -58.1nm +2.3 112.26 27.2 45.9

191301 12828.959H 1737.942S 265.0 30.2 45.0* 12705.921M 1749.033S -4198 -57.9nm +2.3 112.26 27.2 45.9

191302 12828.959H 1738.009S 265.0 30.2 45.0* 12705.386M 1749.088S -4188 -57.8nm +2.3 112.26 27.2 45.9

191303 12828.959H 1738.077S 265.0 30.2 45.0* 12705.386M 1749.138S -4178 -57.7nm +2.3 112.26 27.2 45.9

191304 12827.916H 1738.144S 265.0 30.2 45.0* 12705.118H 1749.190S -4168 -57.6nm +2.3 112.26 27.2 45.9

191305 12827.575H 1738.212S 265.0 30.1 45.0* 12704.384M 1749.242S -4158 -57.4nm +2.3 112.26 27.2 45.9

191306 12827.235H 1738.280S 265.0 30.1 45.1* 12704.049M 1749.294S -4148 -57.2nm +2.2 112.26 27.2 45.9

191307 12826.894H 1738.348S 265.0 30.1 45.1* 12704.715H 1749.346S -4138 -57.1nm +2.2 112.26 27.2 45.9

191308 12826.553H 1738.416S 265.0 30.1 45.1* 12704.381M 1749.398S -4128 -57.0nm +2.2 112.26 27.2 45.9

"Local" circumstances for contacts II and III are computed for specified mid-eclipse UT intercept, air speed, direction, winds aloft and altitude.

UT correlated position (long./lat.) of umbra shadow axis at height AMSL, shadow width (km), solar azimuth & altitude angle from umbra center with aircraft long./lat., time and distance (in seconds and km) to mid-eclipse intercept, solar Line-of-Site deviation from window normal angle, aircraft track (w.r.t. true north), solar azimuth and altitude angle from aircraft.

4 SELECT (NAVIGATION) WAYPOINTS

Waypoint Selection Time Granularity: [1s] [5s] [10s] [30s] [60s]

CANCEL OK

OK

191300

191400

191500

191600

191700

191800

191900

192000

192100

192200

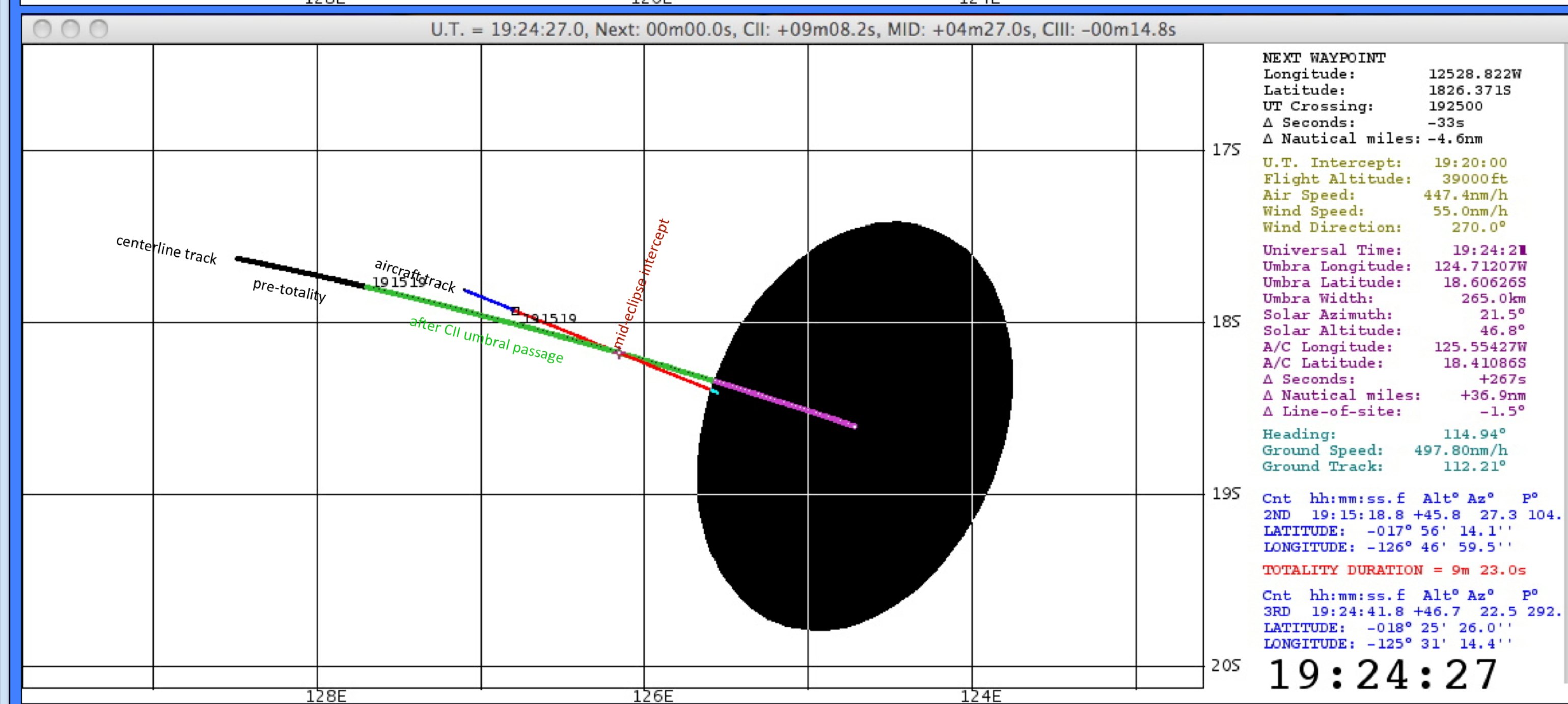
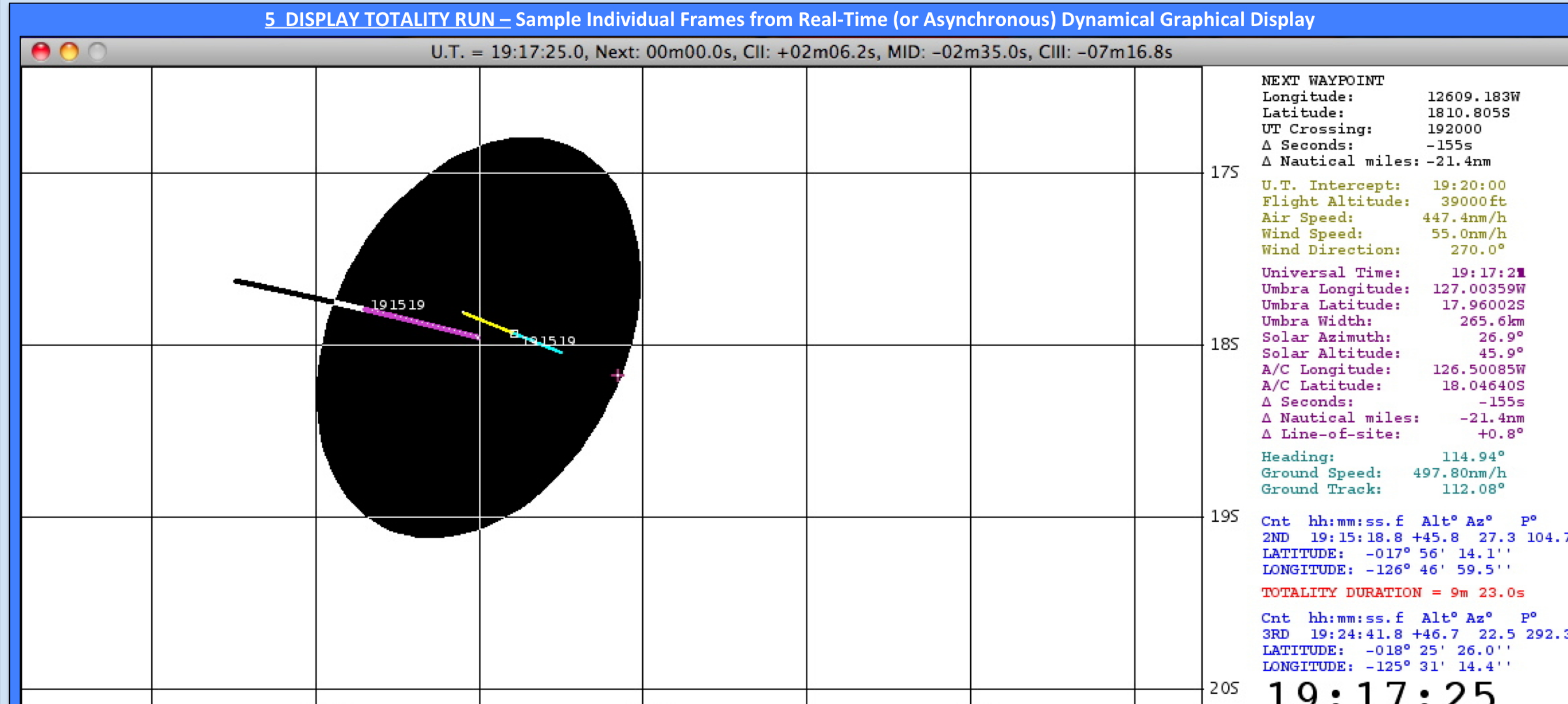
192300

192400

192500

192600

192700



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

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] [1820.00] [N] [S] Longitude [14500.00] [E] [W]

CR2 [PEBRO] [1900.00] [N] [S] Longitude [14000.00] [E] [W]

CR3 [PATIA] [1915.00] [N] [S] Longitude [13500.00] [E] [W]

CR4 [PATUI] [1920.00] [N] [S] Longitude [13000.00] [E] [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

PAPAE > PATIA Outbound Cruise 1st Half [35.0] [240.0] nM/h Deg

PATIA > SVITS Outbound Cruise 2nd Half [50.0] [260.0]

SV1 > SV2 Ingress Shadow Viewing [55.0] [270.0]

TR1 > 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] CANCEL

Turning Radius (nM) [10.90]

Fixed Rate (Deg/sec) [0.6666] OK

Entry+Exit (Seconds) [8.0]

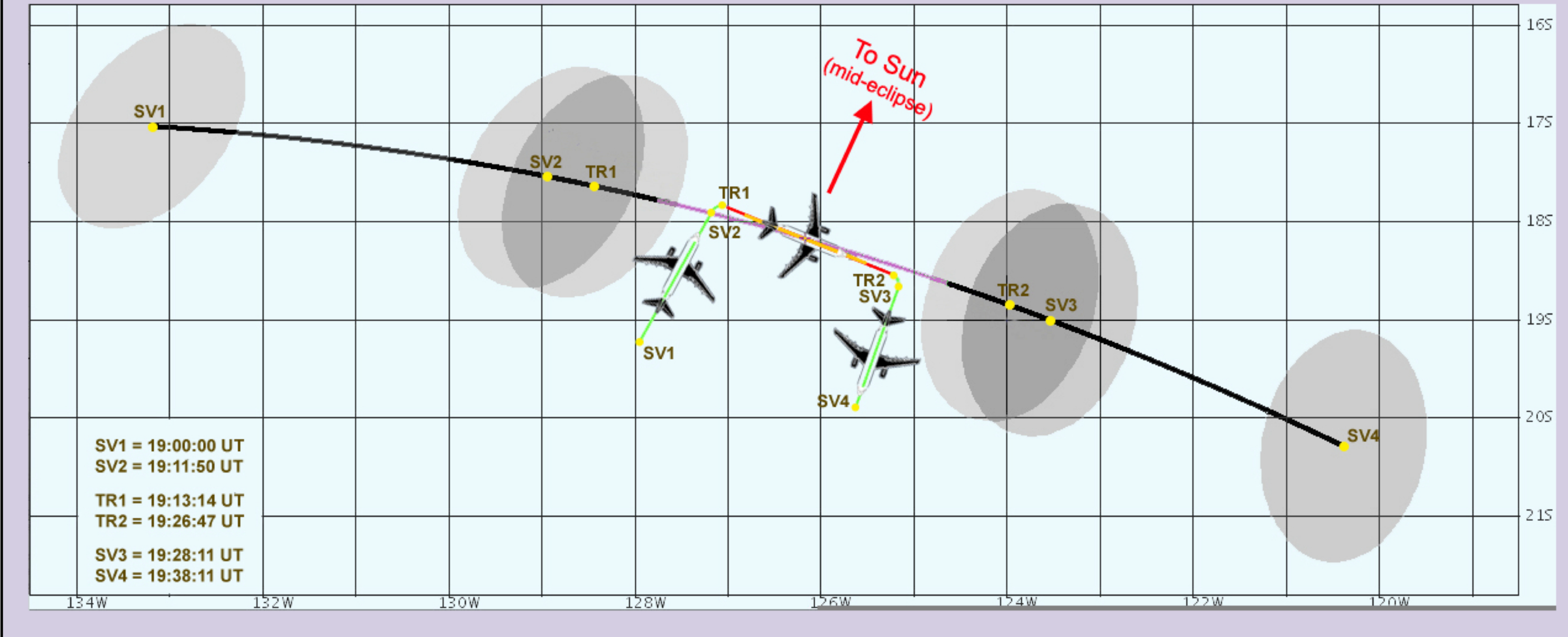
7(b) ENTER TURN PARAMETERS – A/C nose deviation angle during shadow viewing to keep windows in fuselage shadow

For INGRESS Shadow Viewing Leg SV1 >> SV2:

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

CANCEL OK

Schematic Visualization of Time Correlated Umbra Projection and Aircraft Flight Plan: (SV1, SV2)/(SV3, SV4) = Ingress/Egress Shadow Viewing; (TR1, TR2) = Totality Run



EFLIGHT 2010 SHADOW INTERCEPT: MID-TOTALITY & UMBRA APPROACH



TSE 2008 CII: STUNNING VIEW OF THE SKY ABOVE AND SEA-ICE BELOW ENABLED BY EFLIGHT PRECISION NAVIGATION