APOLLO 16 SCENARIO PACK FOR AMSO

VERSION 1.0 (July 2008)

Description:

Apollo 16 scenarios demonstrating it can be done by the numbers. It was developed using AMSO ver 1.17 and IMFD ver 5.1.e.

Requirements

1. Orbiter Space Flight Simulator, version 2006 patched to 2006-P1 (build Sep 29 2006).

Link: http://orbit.medphys.ucl.ac.uk/orbit.html

2. Orbiter Sound version 3.5.

Link: http://orbiter.dansteph.com/index.php

3. Apollo Mission Simulator for Orbiter (AMSO), version 1.17.

Link: http://www.acsoft.ch/AMSO/AMSO.html

4. Interplanetary MFD, version 5.1.e.

Link: http://koti.mbnet.fi/jarmonik/Orbiter.html

Optional: BurnTimeCalc MFD, version 1.42a.

Link: http://www.orbithangar.com/

Installation

Extract the zip file into the root of your Orbiter directory.

Special notes for installation

(root)\Config\Earth\Base\AMSO\A16_Splashdown.cfg was included as an example. The only time this base is available is when running AMSO scenarios. All that is defined is the historic splashdown coordinates for Map MFD.

De-installation

Using the file list, delete those files from your Orbiter directories.

File list

1. (root)\Scenarios\AMSO\A16\

01 Apollo 16 Launch T Minus.scn
02 Apollo 16 EOI.scn
03 Apollo 16 Pre TLI.scn
04 Apollo 16 Post TLI.scn
05 Apollo 16 Pre TDE.scn
06 Apollo 16 TDE docked.scn
07 Apollo 16 Post TDE.scn
08 Apollo 16 1st MCC.scn
09 Apollo 16 Post 1st MCC.scn
10 Apollo 16 Pre LOI.scn
10a Apollo 16 Pre LOI.scn
11 Apollo 16 Post LOI_DOI.scn
12 Apollo 16 CSM LM Undock.scn
13 Apollo 16 CSM Circ.scn
14 Apollo 16 PDI.scn
15 Apollo 16 Touchdown.scn
16 Apollo 16 EVA1.scn
16a Apollo 16 EVA1.scn
17 Apollo 16 EVA2.scn
18 Apollo 16 EVA3.scn
18a Apollo 16 EVA3.scn
19 Apollo 16 P12 Ascent.scn
20 Apollo 16 LOR.scn
21 Apollo 16 Docking.scn
22 Apollo 16 LM jett.scn
23 Apollo 16 SS deploy.scn
24 Apollo 16 TEI.scn
25 Apollo 16 MCC.scn
26 Apollo 16 Mattingly EVA.scn
27 Apollo 16 MCC_2.scn
28 Apollo 16 CM_SM Sep.scn
29 Apollo 16 Reentry.scn
30 Apollo 16 Splashdown.scn

2. (root)\Config\Earth\Base\AMSO

A16_Splashdown.cfg

3. (root)\Add-on docs\A16 Scenario Pack Docs

*A16 Landing Site.jpg
*a16-18439-41.jpg
*a16.1655702_lw.jpg
*a16.uvcam_dmh.jpg
*a16pan1221232_mh.jpg
*a16pan1431346.jpg
*a16psrf6-4.jpg
*a16_lpi_trvrsmap.gif
*ALSEP.gif
APOLLO 16 SCENARIO PACK FOR AMSO.pdf
APOLLO 16 SCENARIO PACK FOR AMSO.doc
*Apollo-16-LOGO.jpg
*det18715.jpg

*courtesy of NASA

<u>Credits</u>

Martin Schweiger: for Orbiter Space Flight Simulator
DanSteph: for Orbiter Sound
AC Soft: for AMSO
Jarmonik: for Interplanetary MFD ver 5.1.e
Topper0710: for BurnTimeCalc MFD ver.1.42a

If I have overlooked anyone for due and proper credit, please let me know and I add them – and apologize profusely for the oversight.

Contact me at: NukeET at gmail dot com

/Michael Clyde - NukeET

Scenario Descriptions:

01. Apollo 16 Launch T Minus

Sunday, April 16, 1972: Apollo 16 stands ready at 39A.

SCENARIO BEGINS AT: T-5:30.

AT EXACTLY 17:49:00 UTC, press the "J" key to retract the launch tower arms.

Press the "K" at EXACTLY 17:53:50 UTC to initiate the 10 sec launch countdown.

02. Apollo 16 EOI

Beginning GET=0h 11m 43s. Just after S-IVB shutdown and orbit insertion. S-IVB fuel =70.6%.

03. Apollo 16 Pre TLI

Beginning GET=2h 30m 38s. About T-9 min to Trans Lunar Injection.

70.6% fuel remaining in S-IVB. Highly recommended to perform the burn in real time (no time acceleration) and limit exterior viewing during the burn.

Set up IMFD as follows:

Left MFD: Target Intercept, Tgt=Moon, Operational Mode to Vel. Frame, Long=3.00, Lat=10.40, Rad=10.21M, TEj GET=2h 35m 39s, TIn GET=74h 28m 0s, guidance=Off Axis. See Fig. 1 and Fig. 2.

Right MFD: Set to Map and op mode shared to left (0), Proj=Ecliptic, SOI and Plan on, Set Tgt=Moon, Pe select to Ref Moon, Cnt to Moon-PeR. See Fig. 3. Don't forget to engage Auto Burn.

```
Interplanetary    Tgt Moon
Course            Src AS-511

Target Intercept             BV

Operation Modes:  Intercept:
Vel. Frame        TIn 259.0k   Z+
Prograde          GET 74:28:00

Lon 3.00°         Reserved     Z-
Lat 10.40°        LPC 111.79°
Rad 10.21M
                               Src
Enroute:
 dV 3.204k
 iV 1.036k                     Cnt
Tot 4.240k

                               AB
Ref Earth
Ecliptic          Adj-1x
```
Fig.1

```
Interplanetary    Tgt Moon
Course            Src AS-511

Target Intercept             BV

TEj 287.7         TIn 259.0k
GET 2:35:39       GET 74:28:00  Z+

EjA 8.71°         Off-Axis
InA 69.93°        Off Plane     Z-
EIn 0.53°         TOF-UnLock
PeA 202.4k        Smooth Adj
                  Prep. PlC    Src
Enroute:
 dV 3.204k
 iV 1.036k                     Cnt
Tot 4.240k

                               AB
Ref Earth
Ecliptic          Adj-1x   Offset
```
Fig. 2

```
Interplanetary         Cnt Moon-PeR
Map Course-Plan  Tgt Moon

Pe  3 of 3                     Cnt
Ref Moon

GET 74:28:10                   Z+
PeT 259.0k
PeV 2.533k
PeA 74.87k                     Z-
Hed 265.33°
EqI 169.45°
                               Sel
Lon 171.08°E
Lat 9.47°N
                               Dsp
Descartes
Ang -1.25°
GET 104:29:34                  Azo
Ref Earth
Ecliptic          Soi         1/2
```
Fig. 3

04. Apollo 16 Post TLI

Beginning GET=2h 40m 40s. S-IVB fuel remaining: 8.6%.

TLI ignition was at 2h 35m 39s (2m 2.5s late). Cutoff was at 2h 40m 36s (1m 17.6s late).

05. Apollo 16 Pre TDE

Beginning GET=2h 54m 59s. T-10 min to Transposition, Docking, and Extraction.

Historic times: separation from S-IVB @ 3h 4m 59s; docking @ 3h 21m 53s; stack separation from S-IVB @ 3h 59m 15s.

06. Apollo 16 TDE docked

Beginning GET=3h 21m 58s. Docked with LM.

Historic @ 3h 21m 53s (5 sec late)

07. Apollo 16 Post TDE

Beginning GET=003h 54m 15s. T-5 min to CSM/LM stack extraction.
Historic: GET=3h 59m 15s. AMSO is programmed to start the S-IVB APS evasive maneuver at T+9 min after stack separation.

08. Apollo 16 1st MCC

Beginning GET=30h 29m 17s. About T-10min to the burn. Set up IMFD as follows:

Left MFD: Target Intercept, Tgt=Moon, Operational Mode to Vel. Frame, leave guidance set to Realtime. Set TEj =30h 39m 1s. Set TIn=74h 28m 0s. Set Lon=-15.30, Lat=6.30, Rad=11.36M. See Fig. 4 and Fig. 5.

Historic: Ignition @ 30h 39m 0.7s, Cut Off @ 30h 39m 2.7s, Duration=2.0 sec.

Engage Auto Burn. Recommend doing burn in real time (no time acceleration) and highly recommend to perform the burn using interior view.

```
Interplanetary      Tgt Moon
Course              Src AS-511

Target Intercept                 Prv

TEj 576.2           TIn 158.3k
GET 30:39:01        GET 74:28:00    Nxt

EjA 0.67°           Realtime
InA 68.78°          Off Plane        +
EIn -0.01°          TOF-UnLock
PeA 526.5k          Smooth Adj
                    Prep. P1C        _
Enroute:
 dV 25.99
 iV 1.015k
Tot 1.041k                          Set


                                    Adj
Ref Earth
Ecliptic            Adj-1x       Offset
```
Fig. 4

```
Interplanetary      Tgt Moon
Course              Src AS-511

Target Intercept                 Prv

Operation Modes:    Intercept:
Vel. Frame          TIn 158.3k      Nxt
Prograde            GET 74:28:00

Lon -15.30°         Reserved         +
Lat 6.30°           LPC 111.84°
Rad 11.36M
                                     _

Enroute:
 dV 25.98
 iV 1.015k
Tot 1.041k                          Set


                                    Adj
Ref Earth
Ecliptic            Adj-1x
```
Fig. 5

09. Apollo 16 Post 1st MCC

Beginning GET=30h 45m 0s. MCC ignition was @ 30h 39m 1s, Cut Off @ 30h 39m 18s, Duration=17 sec. Fuel=98.1%.

Turn off plan on right MFD (Map). Turn on SOI. Center on self and zoom out in order to see both Earth's and Lunar SOI.

Using time acceleration, coast out to just outside Earth's SOI - recommend not to exceed 1000x. Change back to real time and bring up Planet Approach on left MFD. Change Ref=Moon. Set EqI equal to the same value displayed on right MFD - should be about 170.37 deg. Set PeA=95.9km. See Fig. 6 and Fig. 7. Again, using time acceleration, coast until just inside of Moon's SOI, about GET=69h 49m.

```
Interplanetary      Tgt Equator
Course              Src AS-511

Planet Approach                  Prv

EqI 170.37°         TEj 0.000
PeA 95.90k          GET 39:47:46    Nxt

RIn 170.37°         PeT Optim.
EIn -3.27°          PeT 123.0k       +
AgP 65.69°          GET 73:41:34
PeT 122.0k
Cir 891.4                            _
Min EqI ±3.270
Max EqI ±176.7
                                    Set
Enroute:
 dV 95.85
                                    Adj
Ref Moon
Ecliptic      Low   Adj-1x
```
Fig. 6

```
Interplanetary      Cnt AS-511
Map                 Tgt Moon

Pe  2 of 3                        Cnt
Ref Moon

GET 74:33:19                      Z+
PeT 125.1k
PeV 2.513k
PeA 93.30k                        Z-
Hed 265.77°
EqI 170.37°

                                  Sel
Lon 171.21°E
Lat 8.66°N

Descartes                         Dsp
Ang -0.35°
GET 104:29:34
                                  Azo
Ref Earth
Ecliptic       Soi                1/2
```
Fig, 7

10. Apollo 16 Pre LOI

Beginning GET=69h 49m 0s. T-10 min to SIM panel jettison, historic was @ 69h 59m 1s. Bring up Orbit Insert on left MFD. Change Eccentricity to Apoapis. Set ApA=281.0k. Engage Auto Burn. See Fig. 8 and Fig. 9.
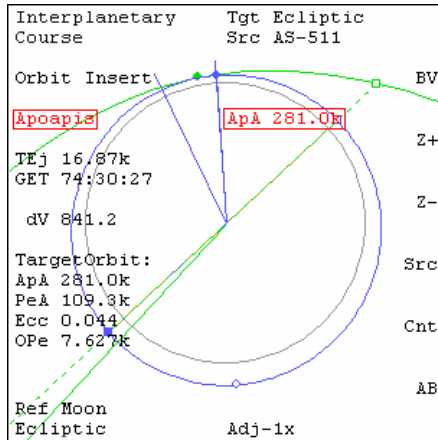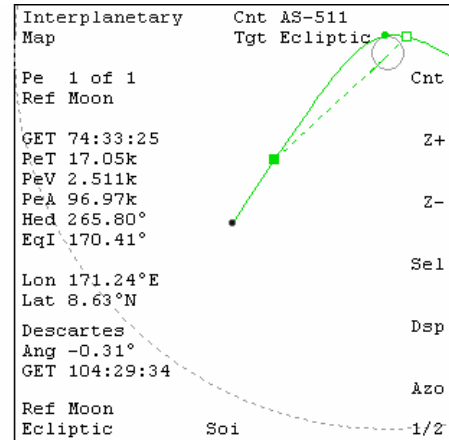

Fig. 8

Fig. 9

10a. Apollo 16 Pre LOI

Beginning GET=70h 0m 1s. Same as step 10, except SIM panel has been jettisoned and Orbit Insert data is already set up. Don't forget to engage Auto Burn.

11. Apollo 16 Post LOI_DOI

Beginning GET=74h 36m 0s. LOI ignition was at GET=74h 30m 14s (1m 46s late). LOI cutoff was at GET=74h 35m 53s (1m 10s late). Ecc=1 @ 74h 31m 42s. Fuel @ 45.6. Final orbit is 281.1km x 90.80km vs. historic 281.0km x 95.9km.

Just started orbit 1. Set both left and right MFDs to Orbit, one side showing only the data, the other just the orbit diagram (see Fig. 10 and Fig. 11). Coast for about 1.75 orbits. Start the descent orbit insertion autopilot (P17) no later than GET=78h 26m. Once the burn starts, get ready to disengage it by pressing the "K" key once. When PeA is about 25km, shift time speed to 0.1x. Press the up arrow key to stop the burn manually as close as possible to PeA=17.5km. Adjust as necessary to this value with linear RCS.

DOI ignition @ 78h 32m 24s(1m 21s early). Fuel =41.4%. 120.5km x 17.50km orbit, T=6.893ks.

Orient to retrograde, and at PeA, burn the SPS manually to reduce T to 6.884ks. Use linear RCS to fine tune this number. Try to approach this value from below, i.e., stop just as "3" changes to "4".

Coast to about GET=94h 15m. Manually orient the stack so that the LM is between the CSM and the Moon. Switch focus to the LM and activate. Switch back focus to the CSM.
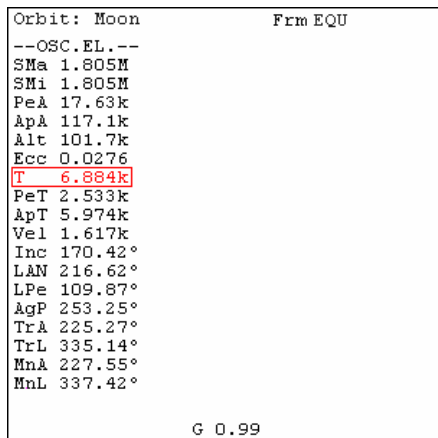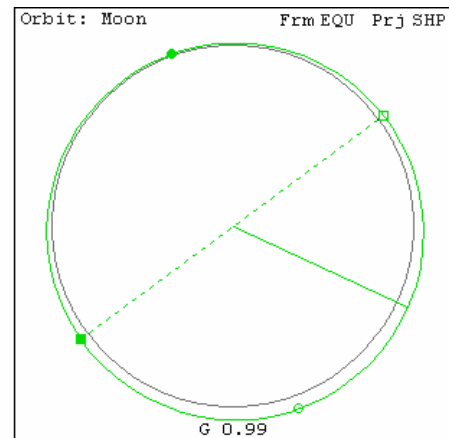

Fig. 10

Fig. 11

12. Apollo 16 CSM LM Undock

Beginning GET=96h 0m 0s. About T-13 min to undocking. Historic undocking occurred at GET=96h 13m 31s.

13. Apollo 16 CSM Circ

Beginning GET=103h 10m 0s. About T-11 min to the orbit circularization burn. Beginning fuel=41.3%.

Use autopilot P19. Ignition @ 103h 33m 50s (12m 7s late); cutoff @ 103h 33m 56s (12m 8s late). Historical ignition was at 103h 21s 43s.

Orbit: 110.0km x 1090.6km, T=7128 s. End fuel=40.4%.

14. Apollo 16 PDI

Beginning GET=104h 7m 0s. About T-10 min to PDI. Orient to PDI attitude and engage autopilot P63.

PDI ignition @ 104h 16m 52s (33s early).

15. Apollo 16 Touchdown

Beginning GET=104h 29m 36s.

Touchdown @ 104h 29m 36s (on time). End fuel @ 11.2%.

Switch focus back to CSM. Engage prograde autopilot and coast to apoapis. Burn either linear RCS or main to increase T by 8 sec, so T=7.136ks. See Fig. 12. Switch focus back to the LM.

Fig. 12

16. Apollo 16 EVA1

Beginning GET=118h 40m 0s. About T-13 min to start of first EVA.

Historical times: EVA started at 118h 53m 38s, and ended at 126h 4m 40s.

16a. Apollo 16 EVA1

Beginning GET=126h 0m 0s. About 5 min from the end of EVA1.

All items deployed and EVA1 samples collected.
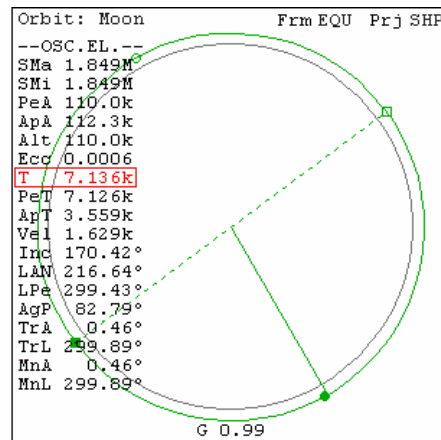
17. Apollo 16 EVA2

Beginning GET=142h 30m 0s. About 10 min from start of EVA2.

Historical times: EVA started at 142h 39m 35s and ended at 150h 2m 44s.

18. Apollo 16 EVA3

Beginning GET=165h 20m 0s. About 11 min from start of EVA3.

Historical times: EVA started at 165h 31m 28s and ended at 171h 11m 31s.

NOTE: At GET=169h, switch focus to the CSM and engage orbit/base alignment autopilot.

CSM plane change ignition @ 169h 7m 6s (1m 14s late), cutoff @ 169h 7m 21s (1m 22s late).

18a. Apollo 16 EVA3

Beginning GET=171h 11m 0s. About 30 sec left to the end of EVA3.

Samples stowed, LRV parked at VIP site, SWC retrieved.

19. Apollo 16 P12 Ascent

Beginning GET=175h 15m 0s. About T-16 min to liftoff.

Press "J" to start liftoff preparation. Engage P12 ascent autopilot.

Ignition @ 175h 31m 50s (2s late), cutoff @ 175h 38m 19s (36s early).

NOTE: There is a camera preset for the LRV camera.

20. Apollo 16 LOR

Beginning GET=177h 6m 38s. About 35 min to historic docking @ 177h 41m 18s.

LM and CSM in station keeping mode.

21. Apollo 16 Docking

Beginning GET=177h 36m 0s. About T-5 min to docking.

Historic occurred at 177h 41m 18s.

22. Apollo 16 LM jett

Beginning GET=194h 55m 0s. About T-5 min to LM ascent stage jettison.

Switch focus to LM and activate LM crew definitive leave ("J" key). Switch focus back to CSM and orient stack to jettison attitude - LM between Moon and CSM.

Jettison at historic GET of 195h 0m 12s. If this procedure is done on time, the LM ascent stage will do the de-orbit burn at 195h 3m 13s - so the historic CSM separation burn is not needed.

23. Apollo 16 SS deploy

Beginning GET=195h 57m 0s. About T-5 min to sub satellite deployment.

Deploy the sub satellite at historic 196h 2m 9s.

24. Apollo 16 TEI

Beginning GET=200h 0m 0s. About T-21 min to Trans Earth Injection. Fuel @37.9%.

Set up IMFD as follows:

Left MFD: Base Approach. Set Ref=Earth, Src=Moon, Approach for=Re Entry(old), TEj=200h 21m 33s, Set Ret=234958 sec. Under Target, GET should equal 265h 37m 31s. See Fig. 13.

Right MFD: COp mode shared with ID-0. Then select Orbit-Eject. Change Higher orbit setting to Base-Approach, Off Axis. Change TEj to GET=200h 21m 33s. Engage Auto Burn. See Fig. 14
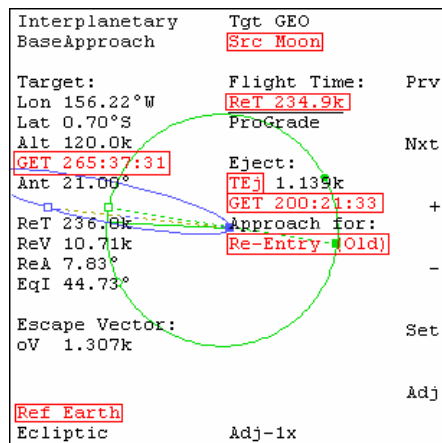
```
Interplanetary      Tgt GEO
BaseApproach        Src Moon

Target:             Flight Time:   Prv
Lon 156.22°W        ReT 234.9k
Lat 0.70°S          ProGrade
Alt 120.0k                         Nxt
GET 265:37:31       Eject:
Ant 21.00°          TEj 1.139k
                    GET 200:21:33    +
ReT 236.0k          Approach for:
ReV 10.71k          Re-Entry (Old)
ReA 7.83°                            -
EqI 44.73°

Escape Vector:                     Set
oV  1.307k

                                   Adj
Ref Earth
Ecliptic            Adj-1x
```
Fig. 13

```
Interplanetary
Orbit-Eject

 oV 1.307k
 TEj 1.138k         BaseApproach    Prv
 GET 200:21:33      Off-Axis
                    n/a
                                    Nxt
EqI 168.41°
ELa 3.45°
EjA 15.20°                           +
EIn 5.66°
 Tn -1.709k
 P1C 160.7 (+)                       -

Enroute:
 dV 1.057k                          Set

                                    Adj
Ref Moon
Ecliptic            Adj-1x
```
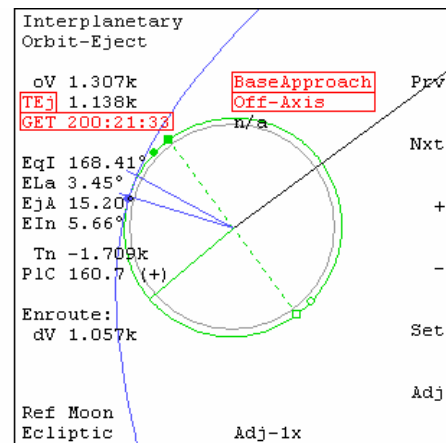**Fig. 14**

Change to BV view and note total under dV remaining. We want to burn all but 75 m/s dV. Get close to 75 m/s remaining - switch to 0.1X - click on AB to stop the burn early. See Fig. 15.

```
Interplanetary
Orbit-Eject

Vel. Frame                     BV

dV Applied      dV Required
dVf   948.66    dVf  1020.94   Z+
dVp  -225.26    dVp  -242.49
dVo   125.09    dVo   134.59
Tot   983.03    Tot  1057.93   Z-


dV Remaining
dVf    72.27    Main Engine:
dVp   -17.23    TtB 0.000s
dVo     9.50     BT 10.59
Tot    74.90

                               AB
Ref Moon
Ecliptic        Adj-1x
```
Fig. 15

NOTE: As mentioned in the author's scenarios for Apollo 11, using IMFD Base Approach isn't very precise for TEI and trans Earth MCCs. The author "hinted" that the TEI burn used too much Delta-V. I experimented with this TEI scenario and discovered stopping the burn early (about 75 m/s left) was the most "ideal".

End fuel=12.4%. Once Moon's gravitational influence equals/drops below 0.4, change Src=self on left MFD.

Historic times: TEI ignition @ 200h 21m 33s (on time). Cutoff @ 200h 24m 15.36s

25. Apollo 16 MCC_1

Beginning GET=214h 30m 21s. About T-5 min to the burn. Fuel @ 12.4%.

Set right MFD to Map: Azo=off, Dsp=on, SOI=on, Center on self. Plan should be turned off. See Fig. 17.

On left MFD, set TEj=214h 35m 3s. Engage Auto Burn. See Fig. 16.

Historic times: ignition @ 214h 35m 3s (on time), cutoff @ 214h 35m 24s (1.4s early).

```
Interplanetary    Tgt GEO              Interplanetary   [Cnt AS-511]
BaseApproach      Src AS-511           Map              Tgt Ecliptic

Target:           Flight Time:    BV   Pe  1 of 2                 Cnt
Lon 156.22°W      ReT 183.7k           Ref Earth
Lat 0.70°S        ProGrade
Alt 120.0k                        Z+   RIn 17.63°                 Z+
GET 265:37:31     Eject:               PeT 195.5k
Ant 21.00°        [TEj] 219.1          PeV 6.384k
                  [GET 214:35:03]  Z-  PeD 19.08M                 Z-
ReT 183.9k        Approach for:        PeA 12.71M
ReV 10.71k        Re-Entry (Old)       Ecc 0.951
ReA 7.91°                         Src  Cir 1.813k                 Sel
EqI 45.41°
                                       Next Node:
Enroute:                               Tn  195.8k                 Dsp
dV  130.4                              RIn 17.63°
                                       PlC 1.961k (-)

                                  AB                              Azo
Ref Earth                              Ref Earth
Ecliptic          Adj-1x               Equator     [Soi]  [All]  1/2
FIG. 16                                FIG. 17
```
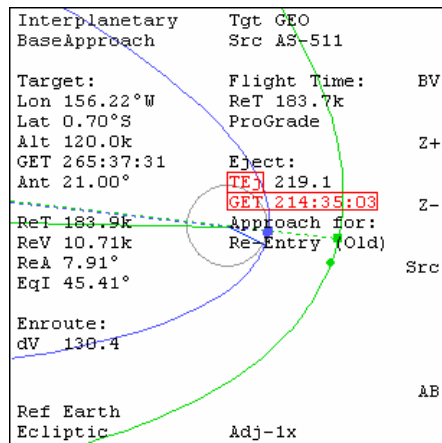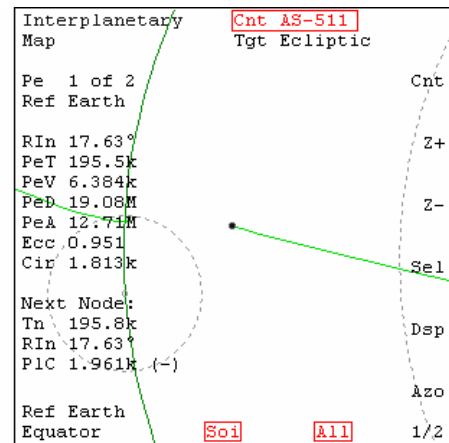
26. Apollo 16 Mattingly EVA

Beginning GET=218h 34m 0s. About T-5 min to CMP Ken Mattingly's EVA for film retrieval.
Historic times: start @ 218h 39m 46s, end @ 220h 3m 28s, duration=1h 23m 42s.
NOTE: AMSO only gives you 1hr life support for the EVA. Once the EVA is finished, coast to about GET=238h 44m.

27. Apollo 16 MCC_2

Beginning GET=238h 44m 33s. NOTE: This mid course correction is about a day early.

Right MFD: Turn Plan on, and wait for PeA to decrease to a value of 43.50km (this happens around GET of 243h 34m). If you use time acceleration, recommended not to exceed 100x. Return to real time, and engage Auto Burn on left MFD. Once the burn is completed, turn Plan off, and adjust PeA as needed with linear RCS, so PeA=43.50 km, using the orientation from the just completed Auto Burn. See Fig. 18 and Fig. 19.
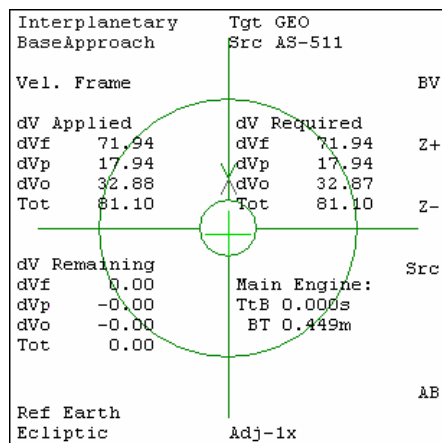
```
Interplanetary    Tgt GEO              Interplanetary   Cnt AS-511
BaseApproach      Src AS-511           Map              Tgt Ecliptic

Vel. Frame                        BV   Pe  1 of 2                 Slf
                                       Ref Earth
dV Applied        dV Required
dVf    71.94      dVf    71.94    Z+   RIn 21.35°                 Soi
dVp    17.94      dVp    17.94         PeT 79.43k
dVo    32.88      dVo    32.87         PeV 11.11k
Tot    81.10      Tot    81.10    Z-   PeD 6.414M
                                       [PeA 43.50k]
                                       Ecc 0.987
dV Remaining                      Src  Cir 3.231k                 Int
dVf     0.00      Main Engine:
dVp    -0.00      TtB 0.000s           Next Node:
dVo    -0.00      BT 0.449m            Tn  79.42k                 Plan
Tot     0.00                          RIn 21.35°
                                       PlC 4.141k (-)

                                  AB                              Find
Ref Earth                              Ref Earth
Ecliptic          Adj-1x               Equator     Soi    All    2/2
Fig. 18                                Fig. 19
```

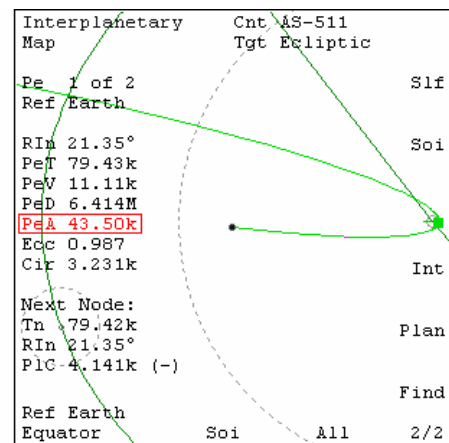### 28. Apollo 16 CM_SM Sep

Beginning GET=265h 17m 0s. About T-5 min to CM separation from SM. Engage prograde autopilot. At GET=265h 22m 23s, jettison the SM. Once the CM is clear, engage retrograde autopilot. Historic was @ 265h 22m 23s.

29. Apollo 16 Reentry

Beginning GET=265h 24m 4s. After CM/SM separation. GET @ PeA=265h 41m 15s. ReT=265h 39m 8s (1m 37s late).

NOTE: Beginning at entry interface, pitch down to-10 deg. Hold this attitude until RCS is unable to do so any longer.
You should be able to get within 30 km of the actual splashdown location.

30. Apollo 16 Splashdown

Beginning GET=265h 50m 5s, splashdown at same, 1 min early.

Location: 156.451 deg W, 0.609 deg S, 27.57 km from actual.

Historic @ 265h 15m 56s, location: 156.22 deg W, 0.70 deg S.