RTCC MFD Input Reference Guide

by jalexb88 - 24/10/2020

PRELAUNCH

LAUNCH DELAY   - UTI, IU, LAU: Record new launch azimuth *After insertion, subtract delay from PTC GET*

TLI

TLI PAD

- Press TLI (M68) on MPT display, Use DMT (MSK 54) for TB6=TIG-9m38s, RPY(TLI), BT, DVC

- Use Checkout Monitor (MSK 1619) REF: MVE for VI and TLI cut-off GET

- RPY(SEP): Add 0 DV maneuver to MPT: Press INP (M66), CSM, TIG: TLI cutoff+15, THR: CSM RCS+X(2 quads), ATT: Inertial, BPA: P1, COO: LVLH=X Y Z (see mission-specific data)

- Use DMT (MSK 54) to view RPY(SEP)

- RPY(EXT): R(SEP)-56, P(SEP)+180, Y(SEP)+/-

TLI+90   MPT: TLI + Config change (CSM only)

- TAR, ENT, RTE: TIG: TLI TIG+90min, LNG: Atlantic (Apollo 16: MPL), TYP: Abort

TLC

P37/Direct Abort PAD   HDS-DWN

- TAR, ENT, RTE: TIG: Block Data, LNG: MPL, TYP: Abort

TLMCC   transfer: ITE: iterate

- TAR, MCC, TIG: flight plan

MCC 1&2:   - Free-Return Profile (Apollo 8,10,11): Option 3   - Hybrid/Non-FR Profile no LOI ellipse rotation (Apollo 12): Option 5   - Hybrid/Non-FR Profile with LOI ellipse rotation (Apollo 13+): Option 4

MCC 3&4:   Option 1 (on Apollo 13+, Option 4 may be used to ensure proper post-LOI ellipse)

Option 1: TAR, MCC, MAN: Option 1, SFP: 1 (no updated SFP) 2 (updated SFP)

Option 3: TAR, MCC, MAN: Option 3, SFP: 1

Option 4: TAR, MCC, MAN: Option 4, SFP: 1, Apollo 13-16: Tweak REVS1 until DOI DVZ = 0. *REVS1 & ETA1 parameter in LOI processor must match TLMCC processor*, Apollo 13-17: Adjust LOI ignition time (next page)

Option 5: TAR, MCC, MAN: Option 5, SFP: 1, Adjust LOI ignition time (below)

After final option 2-5 calculation, move column to SFP block 2 (TAR, MCC, MID, F30)

To adjust LOI ignition time (option 4-5 only):

Constant trans-lunar flight time (Apollo 13 & prior): If TLI is on-time, TAR, MCC, CON, F23: Adjust TLMIN/TLMAX (10-minute range) until LOI ignition/lunar landing time matches flight plan. If TLI is late, do not specify a TLMIN/TLMAX constraint.

Constant lunar arrival GMT (Apollo 14+): Find REV 2 Delta T (Common Functions), Note initial GET LOI (TAR, MCC, MID), then TAR, MCC, CON, F23: Adjust TLMIN/TLMAX (10-minute range) until new GET LOI = old GET LOI + REV 2 Delta T

FLY BY & PC+2   (fly-by targets a slow return ~90 hours, PC+2 targets a fast return ~48 hours)

- TAR, ENT, RTM, OPT: ATP Discrete, TIG: LOI-5/PC+2 hours, LNG: MPL, INC: Optimize DV, EIT: block data (tweak EIT to find lowest safe fly-by altitude)

For PC+2, TAR, ENT, CON, set VRMAX to 37500 fps, the revert to previous (36323 fps) afterwards

LIFTOFF TIME UPDATE (Apollo 14+)

- RTCC MFD: CFG, UPD, update liftoff time, then subtract nominal liftoff GMT (mission-specific data) from updated liftoff time, then DSKY: V55, add result (delay) to CMC clock

- Find nominal liftoff TEPHEM (mission-specific data)

- DSKY: V25N01E, 1706E, load nominal liftoff TEPHEM, V05N01E, 1706E, verify TEPHEM

- RTCC MFD: CFG, UPD, update liftoff time

- CSM SV update, V66

Add delay to PTC GET, TIG & Vector times, Flyby PAD TIG

LUNAR ORBIT

LOI   transfer: ITE: iterate   HDS-DWN

- TAR, LOI, INI: R1=REVS1(TLMCC), ETA=ETA1(TLMCC)

- TAR, LOI, DIS: Planned LOI-2 (Apollo 12 and before): Use plane solution. No LOI-2 (Apollo 13+): Use intersection solution.

Each mode has 2 solutions, if they are different, use the solution with the correct HPC, if both HPC are the same but different DV, use the lowest DV solution. If LOI DV is high, note LOI solution AZMN/AZMX range, if range is high, then tweak approach azimuth (TAR, LOI, ADS) until LOI DV is nominal. Do not go outside of azimuth limits (AMN, AMX).

LOI-2   transfer: ITE: iterate   HDS-DWN

- TAR, DES, MOD: Single CSM Maneuver, SEQ: CIR, DOI, TH1: threshold time before LOI-2 (nearest hour), TH2: threshold time before DOI (nearest hour)

<u>DOI</u>   transfer: ITE: iterate (if DPS: 10P: -15s, DPS: 0.4) *for Apollo 17 DOI-1, see common functions* HDS-DWN
If DOI-2/Trim: TAR, DES, INI, N: revs before PDI, Apollo 17 DOI-2: HDP: 40000 ft
Before DOI calculation, update RLS in RTCC MFD

- TAR, DES, MOD: LM Maneuver Sequence, SEQ: DOI, TH1: threshold time before DOI (nearest hour)

<u>TEI</u>   *For Apollo 13+ EOM/INC, see mission-specific data* HDS-DWN

- TAR, ENT, RTM, OPT: ATP Search, TIG: flight plan (block data), LNG: MPL (or EOM), EIT: flight plan (TEI usually targets a normal return ~60-80 hours, tweak EIT until TIG matches block data), INC: Optimize DV

- For Apollo 13+ nominal & 1 REV late TEI's: Use EOM/INC, see mission-specific data

<u>CIRC</u>   transfer: ITE: iterate

- TAR, ORB, TYP: Circularization or Apo/Peri change, PNT: Height=60 or Time, GET: flight plan

<u>PDI-0</u>   transfer: ITE: iterate, 10P: -15s, DPS: 0.4

- Find Peri GET: FDO Orbit Digitals LM, GET P = Peri GET (for later REV use GETR: U12,LEM,REV,desried REV)

- TAR, REN, DKI, INI, DH = 15, E: 26.6

- TAR, REN, DKI, OPT, MAN: Maneuver Line, RAD: Horizontal

- TAR, REN, DKI, PRO: CSI/CDH Seq, TIG: Peri GET, TPI: Sunrise-16min

<u>NO PDI+12</u>   (Apollo 12 and before)   transfer: ITE: iterate, 10P: -15s, DPS: 0.4   TPI Time = Sunrise-23min

- TAR, REN, TI, OPT: First Fixed, T1: PDI TIG+12min, T2: TPI Time-45min, OFF: P51,15,4.475,26.6,130;

- TAR, REN, TI, DIS, CLC, use solution with the valid TPI time, if needed, adjust T2 time

<u>NO PDI+12</u>   (Apollo 13 and later)   transfer: ITE: iterate, 10P: -15s, DPS: 0.4

- TAR, REN, DKI, INI, DH: 15, E: 26.6

- TAR, REN, DKI, TIG: PDI TIG+12min, TPI: Sunrise-16min

- TAR, REN, DKI, PRO: - Apollo 13 to 15 both PDIs & 16-17 PDI-2: HAM-CSI/CDH Seq   - Apollo 16-17 PDI-1: CSI/CDH Seq

- TAR, REN, DKI, OPT, MAN: Spec DTs, RAD: -50 ft/s, DT1: - Apollo 16 PDI-1: 50min   - Apollo 13-14-15-17 PDI-1/Apollo 16 PDI-2: 55min   - Apollo 13-14-15-17 PDI-2: 60min

For Apollo 17: Calculate DVX of No PDI+12 for no DOI-2 case

<u>PDI PAD, T1 & T2</u>   TPI Times: Apollo 12 & earlier: Sunrise-23min, Apollo 13 & later: Sunrise-16min

- Apollo 11 PDI Abort > 10 min phasing TIG: PDI TIG + 67 min

- Apollo 11 T2: MPT: DOI+PDI+Ascent, use Ascent Processor with inputs +5515.2, +19.6, LTO: PDI TIG + 21:24, Checkout Monitor (MVE) for insertion GET, Phasing TIG = insertion GET + 50 min, CSI TIG = Phasing TIG + 2h48m

<u>T3, ASCENT (Concentric)</u>   TPI Times: Apollo 14 & earlier: Sunrise-23min, Apollo 15+: Sunrise-16min

- TAR, LLW, INI, TAR, VLH: +5535.6, VLV: +32.0 - TAR, LLW, THT: Desired TPI Time, CSI: 50

- CLC solution   - TAR, ASC, LTO: Desired LLW sol. GET, CLC - Go back to LLW and CLC again

<u>CSI/CDH</u>   transfer: ITE: do not iterate, TIM: impulsive TIG, if DPS: 10P: -15s, DPS: 0.4

- TAR, REN, SPQ, INI, DH: 15 (for CDH: use DH from CSI solution, if different), E: 26.6, TPI: Desired TPI Time

CSI: TAR, REN, SPQ, MOD: Optimum CSI, TIG: 1st guess *Use input time +/- 15 mins to find good solution*

CDH: TAR, REN, SPQ, MOD: CDH, TIM: Find GETI, TIG: 1st guess

See Rendezvous Evaluation Display after calculating a solution with SPQ or DKI

<u>TPI</u> transfer: ITE: do not iterate, TIM: impulsive TIG, if DPS: 10P: -15s, DPS: 0.4

- TAR, REN, TI, OPT: Both Fixed, OFF: P51,0,0,26.6,130;, T1: -1:0:0, T2: -1:0:0

<u>DIRECT ASCENT & TWEAK</u>   (Apollo 14+)   TPI Times: Apollo 14: Sunrise-18.5min, Apollo 15+: Sunrise-16min

- TAR, LLT, DT: Apollo 14: 38min, Apollo 15: 45min, Apollo 16/17: 47min, TTH: Liftoff threshold time,

RDO: +32.0, CLC solution, - TAR, ASC, CLC - Go back to LLT and CLC again

- Adjust DT so TPI GET = Desired TPI Time

- TAR, ASC, CLC - Go back to LLT and CLC again *Note insertion GET (Checkout Monitor MVE)*

Before liftoff, pre-fill tweak-burn values below & set MPT to inactive, - TAR, REN, TI, DIS, MPT, THR: L2

- TAR, REN, TI, OPT: Both Fixed, T1: Insertion GET +3min, T2: Desired TPI Time, OFF: P51,15,1.7,26.6,130;

After insertion: - TAR, REN, TI, DIS, CLC, MPT, CLC, read tweak-burn DV's

<u>PLANE CHANGE</u>   transfer: ITE: iterate (update stored RLS or set desired coordinates)   HDS-DWN

- TAR, DES, INI, AZI: Optimum or Desired,

- TAR, DES, MOD: CSM Prelaunch Plane Change, TH1: TIG-1hour, TH2: Align Time-1hour

<u>SHAPE</u>   transfer: ITE: iterate   HDS-DWN

- TAR, ORB, TYP: Apogee & Perigee change, PNT: Time, GET/ApA/PeA: flight plan

TEC

<u>TEMCC</u>

- TAR, ENT, RTE, TIG: flight plan, TYP: Corridor Control

COMMON FUNCTIONS

<u>Building a maneuver work-flow</u>

1. Update liftoff time, Activate MPT & initialize desired tables (CSM/LEM), set desired REFSMMAT in the MFD

2. Build maneuver (TAR), transfer to MPT, If preferred REFSMMAT desired, use G11 to store it in DMT, then G00 to transfer it to CUR if desired, i.e. G11,CSM,DMT,1,DES,U or D;   G00,CSM,DMT,CSM,CUR;

3. Use M58 to set desired orientation, i.e. CSM, 1, U/D; (Up/Down)

4. Use the DMT to display maneuver i.e. U02,CSM,1; or U02,CSM,1,,DMT;

5. Use the GOST to calculate optics data i.e. ATT: 1 Burn Angles, BST: GET 1 CUR, SXT: GET 1 CUR

<u>REFSMMATs</u>   *Use G00 to transfer to CUR i.e. G00,CSM,LCV,CSM,CUR;*

- LVLH (LCV): Use G03 i.e. G03,CSM,GET;   - Preferred (DMT): Use G11 i.e. G11,CSM,DMT,1,DES,U or D;

<u>Config change on MPT</u>

Add 0 DV maneuver to MPT: Press INP, MPT: CSM or LEM, TIG: Desired TIG, THR: C1 or L1, ATT: Inertial, BPA: P1, Page 2: DOC: Desired config., CLC

<u>Find VIO, GET 0.05 G, V400K, GET 400K</u>   "height": 0.05G = 48.4, 400K = 65.83

- Checkout monitor (MSK 1619): U02,CSM,ALT,"height",GET of EI-10 hours;

GET = GET 0.05 G/400K, V = VIO/V400K

<u>Find RTGO</u>   (after RTE solution calculated)

- TAR, ENT, SPL: Actual Range = RTGO

<u>Find REV 2 Delta T</u>   MPT: MCC+LOI

REV 2 GMT = nominal liftoff GMT (mission-specific data) + flight plan REV 2 GET

- Checkout monitor (MSK 1619): U02,CSM,GMT,REV 2 GMT,,MCT;

- LONG C: REV 2 longitude, Delta T = 1 minute per 3-degree difference from 180. If LONG C is West (-) of 180, Delta T is negative. If LONG C is East (+) of 180, Delta T is positive. For example, LONG C: +177, Delta T = 1 minute.

<u>Find Orbit Period, P+Delta T</u>   (Apollo 11 T3 PAD)

From CSM, Orbit Digitals (MSK 46), TO=Period (P), L: U13,CSM,liftoff REV,LDG SITE LONG;, Liftoff GET - GET L = Delta T

<u>Apollo 17 DOI-1</u>   transfer: ITE: iterate   HDS-DWN

- TAR, ORB, TYP: Apo & Peri Change, PNT: Time, GET: flight plan, REF: Pad/LS, ApA: 60.0, PeA: 13.17, Tweak GET until LONG P = 31.36

<u>Height Adjustment Maneuver (HAM)</u>   Use DKI with CSI/CDH Seq, Spec DTs, DT1=HAM to CSI time, Horiz. Man.

MISSION-SPECIFIC DATA

<u>TLI PAD RPY(SEP) LVLH INPUTS</u>

CSM LVLH P: +120 Y: +/-40 R: 0 = LVDC LVLH P: +41.6 Y: +/-120.8 R: +/-131.9
CSM LVLH P: +120 Y: +/-30 R: 0 = LVDC LVLH P: +48.6 Y: +/-130.9 R: +/-139.1

- Apollo 8: P: +60.0 Y: +180.0 R: +180.0   - Apollo 10: P: +41.6 Y: +120.8 R: +131.9
- Apollo 11 July 16: P: +41.6 Y: +120.8 R: +131.9 July 18/21: P: +41.6 Y: -120.8 R: -131.9
- Apollo 12: P: +48.6 Y: -130.9 R: -139.1   - Apollo 13/14/15/16: P: +41.6 Y: -120.8 R: -131.9
- Apollo 17: P: +41.6 Y: +120.8 R: +131.9

<u>EOM (End Of Mission Target) / Return Inclination</u>

- Apollo 13: -157.497 / 40A   - Apollo 14 -171.53 / 40A   - Apollo 15: -158.0 / 40A   - Apollo 16: -158.7 / 61.8A
- Apollo 17: -166.0 / 66.5D

<u>LM Impact Burn Targets</u>

- Apollo 12: 149:28:17, DVX: -181.2 DVY: +60.3 DVZ: -1.5   - Apollo 13: 144:32:20, DVX: -180.0 DVY: 45.0 DVZ: 0
- Apollo 14: 147:52:59, DVX: -180.0 DVY: +36.5 DVZ: 0   - Apollo 15: 179:06:23, DVX: -161.1 DVY: +57.3 DVZ: +94.6   - Apollo 16: 179:16:29, DVX: -134.5 DVY: -80.0 DVZ: +168.0   - Apollo 17: 195:39:13, DVX: -219.2 DVY: +56.0 DVZ: +168.0

<u>Nominal Liftoff GMT / TEPHEM</u>

- Apollo 14: 20:23:00 / 00006 35223 16024   - Apollo 15: 13:34:00 / 00000 32251 26157   - Apollo 16: 17:54:00 / 00011 13352 37740   - Apollo 17: 02:53:00 / 00020 34666 32261

<u>LM Undocking Longitude</u>

- Apollo 12: 83.0 E   - Apollo 13: 87.0 E   - Apollo 14: 88.0 E   - Apollo 15: 110.5 E   - Apollo 16: 121.0 E
- Apollo 17: 136.0 E