Bellcomm

955 L'Enfant Plaza North, S.W.
Washington, D. C. 20024
B71-11017

date: November 15, 1971

to: Distribution

from: K. P. Klaasen

subject: Acceptable Crew Work/Rest Cycles for the Lunar Touchdown Day on Apollo Missions - Case 310

ABSTRACT

Performing the first lunar surface EVA as soon as possible after touchdown is highly desirable. Rearrangement of the Apollo 15 timeline to provide for the EVA immediately after touchdown results in a total crew-awake time on touchdown day of nearly 25 hr for a full 7-hr EVA. A day of this length could result in excessive crew fatigue. In order to avoid such fatigue, a limit of 18 hr has been put on the total time scheduled from wake-up to cabin repressurization after EVA 1.

The length of the crew work period on touchdown day can be reduced to an acceptable value in the following ways:

1. shorten EVA 1,
2. shorten the time awake before EVA 1,
3. lengthen the time awake before touchdown and sleep before EVA 1.

Shortening EVA 1 is undesirable on Apollo 16 because of the resulting loss of lunar surface exploration time. If the Apollo 17 mission should allow for four EVA's, a short first EVA might be acceptable.

Time awake prior to EVA 1 can be reduced for Apollo 16 relative to Apollo 15 in these ways:

Eliminate DOI trim	1:12 hr/min
Eat and don PGA's in parallel	:20
Omit high-altitude landmark tracking	1:36
Omit two post-touchdown P57's	:15
Fly with PLSS's charged with H_2O	:13
	3:36

(NASA-CR-125963) ACCEPTABLE CREW WORK/REST CYCLES FOR THE LUNAR TOUCHDOWN DAY ON APOLLO MISSIONS (Bellcomm, Inc.) 19 p

N79-73095

Unclas
00/54 12179

The current timeline drawn up at MSC for Apollo 16 has incorporated all the above changes except the parallel eating and PGA donning. Incorporating these changes into the timeline will allow for a full 7-hr EVA to be scheduled immediately after touchdown without risking excessive crew fatigue.

If Apollo 17 should be constrained to three EVA's and should require a planned DOI trim and/or high-altitude landmark tracking, a timeline with a longer touchdown day and a sleep period on the surface before EVA 1 might be the only way to maintain full 7-hr EVA periods while still avoiding crew fatigue. Several options for providing such a timeline are available.

Bellcomm
955 L'Enfant Plaza North, S.W.
Washington, D. C. 20024

B71-11017

date: November 15, 1971

to: Distribution

from: K. P. Klaasen

subject: Acceptable Crew Work/Rest Cycles for the Lunar Touchdown Day on Apollo Missions - Case 310

MEMORANDUM FOR FILE

INTRODUCTION

Crew work/rest cycles during Apollo missions should be kept as close as possible to normal 24-hr days consisting of 16 hr of work followed by 8 hr of sleep. Such a cycle has the minimum impact on the circadian rhythm of the crew and thereby reduces the probability of degraded crew performance due to fatigue.

The Apollo 16 crew is scheduled to perform the first lunar surface EVA as soon as possible after touchdown with a sleep period to follow. Using the Apollo 15 Flight Plan (Reference 1) as a baseline, the other tasks that the crew must perform on touchdown day would require 10 hr 11 min from wake-up to touchdown (including an eat period, DOI trim, donning PGA's, LM entry and checkout, LM/CSM undocking, landmark tracking, and powered descent), 4 hr 10 min from touchdown to the beginning of EVA 1 (including post-touchdown activities, an eat period, and EVA preparations), and 3 hr 15 min from the end of EVA 1 to the beginning of the sleep period (including post-EVA activities, doffing of suits, an eat period, and pre-sleep activities). The PLSS consumables and the total lunar surface stay time allow for an EVA of up to 7 hr in duration. Assuming a 7-hr EVA, the total crew-awake time on touchdown day would be 24 hr 36 min under Apollo 15 Flight Plan assumptions (see Figure 1). A work day of this duration would likely result in crew fatigue during the lunar surface EVA period. Recovery from this fatigue would most likely be slow since the sleep experienced on the lunar surface in the past has been less than sound.

In order to avoid such fatigue on touchdown day, the total time from wake-up to cabin repress after EVA 1 is being

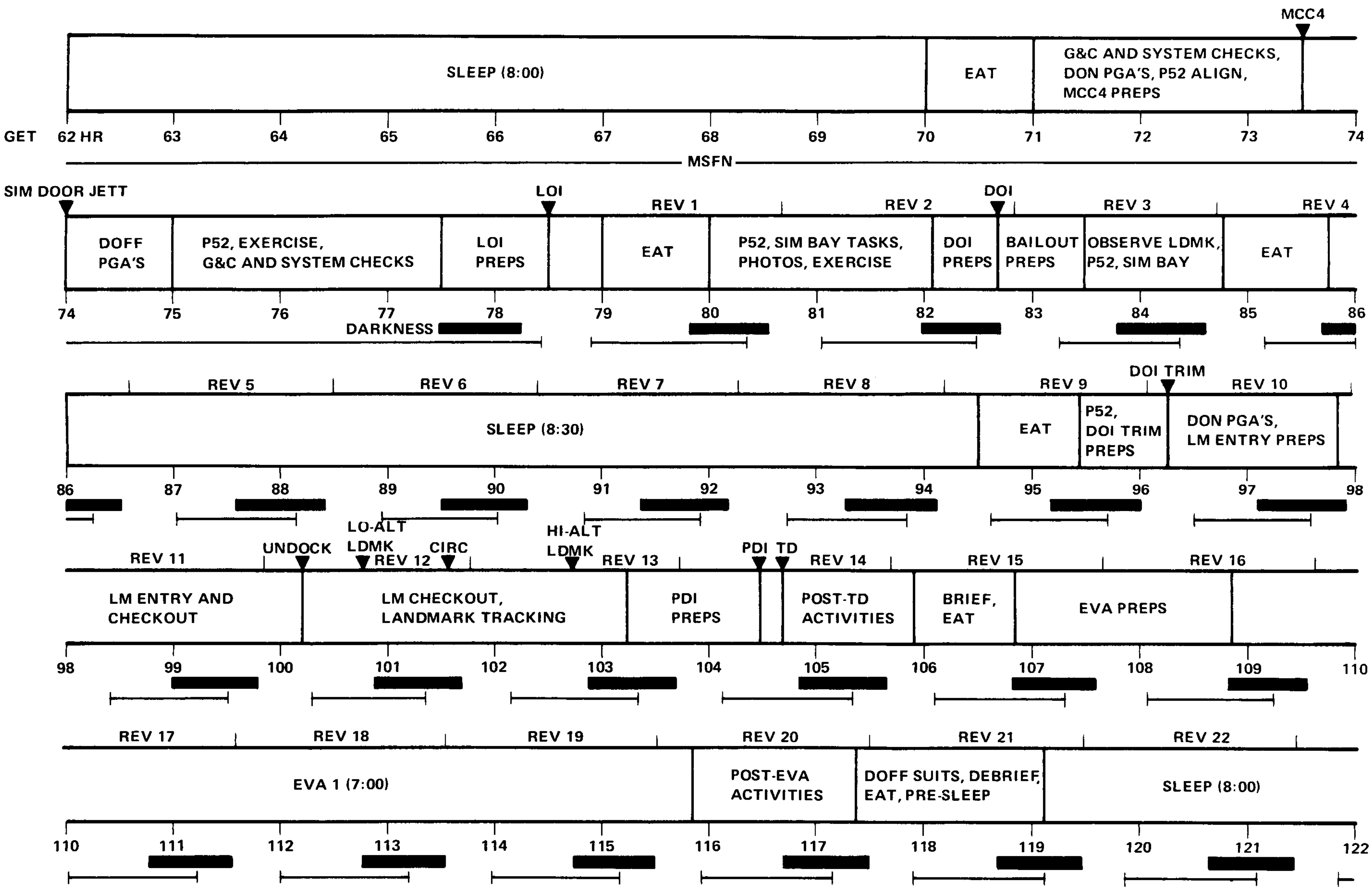


FIGURE 1 - APOLLO 15 TIMELINE ADJUSTED TO PROVIDE FOR EVA FIRST ON THE LUNAR SURFACE

limited to 18 hr. This constraint can be met on future Apollo missions by modifying the Apollo 15 Flight Plan in any of the following ways:

1. shorten EVA 1,
2. shorten the time awake before EVA 1,
3. lengthen the time awake before touchdown and sleep before EVA 1.

SHORTENING EVA 1

Shortening the duration of EVA 1 is a straightforward way to meet the 18-hr constraint. If other touchdown-day tasks remain as they were on Apollo 15, EVA 1 could be at most 4 hr in duration. The current Apollo 16 lunar surface stay time is 73 hr. This stay time is long enough to allow for three 7-hr EVA periods. Reducing EVA 1 to 4 hr, therefore, results in a scientific loss since geology exploration time is decreased. A 4,7,7-hr EVA sequence is also unattractive since the total of 18 hr of EVA time is less than the 20 hr planned for Apollo 15. Thus, shortening EVA 1 is an undesirable solution to the long-work-day problem when the mission is constrained to a 3-EVA plan as it is in Apollo 16.

If the lunar surface stay time could be increased a few hours and the necessary provisions included in the LM payload so that four EVA's were feasible, a short EVA 1 might become quite acceptable. For example, a surface stay of 77 hr would allow an EVA sequence of 4,6,6,4 hr, and longer stay times would allow even more EVA time. Such an EVA sequence might be particularly attractive at a landing site that has interesting geological objectives in three or more diverse directions. Therefore, a short first EVA might be acceptable on Apollo 17.

SHORTENING PRE-EVA 1 AWAKE TIME

In order to perform a full 7-hr first EVA immediately after touchdown, the time from wake-up on touchdown day to the beginning of EVA 1 must be $\leq$ 11 hr. The time required for the tasks scheduled on Apollo 15 was about 14 hr. Thus, at least 3 hr must be deleted from the Apollo 15 timeline to allow a 7-hr EVA 1.

The 10 hr 11 min from wake-up to touchdown on Apollo 15 was fixed by the tasks required and the orbital mechanics of the spacecraft. Touchdown was scheduled on rev 14. Two landmark tracking passes over the area of the landing site were required prior to touchdown. Since the period of the lunar orbit is slightly less than 2 hr, these passes required almost 4 hr.

Undocking of the LM from the CSM occurred about 30 min before the first landmark tracking pass on rev 12. The DOI trim burn was scheduled to be performed shortly after apolune and could have been placed either about 2 hr or 4 hr before undocking. Since the LM activation and checkout tasks required before undocking take about 2-1/2 hr, DOI trim was scheduled about 4 hr before undocking near the beginning of rev 10. The DOI trim was preceded by a 1-hr eat period and by about 45 min of DOI trim preparations. Thus, the required DOI trim maneuver and landmark tracking passes coupled with the LM activation and checkout time determined the 10-hr 11-min time period required. Unless one or more of these constraining activities is eliminated or reduced, the only possibilities for reducing crew awake time on touchdown day lie in the time period between touchdown and EVA 1.

An examination of the tasks scheduled on Apollo 15 and the times required to complete these tasks yields five possible ways to decrease the crew awake time on touchdown day prior to EVA 1:

1. eliminate DOI trim,
2. eat and don PGA's in parallel,
3. omit the high-altitude landmark tracking,
4. omit two post-touchdown P57 IMU realignments,
5. fly with the PLSS's charged with H_2O.

Eliminating the DOI Trim

The need for a possible DOI trim maneuver to correct the orbit of the spacecraft has been recognized ever since SPS DOI was first planned on Apollo 13. Since the SPS DOI burn is performed about 22 hr before PDI, gravitational anomalies have time to perturb the orbit enough so that the LM altitude at PDI can become unacceptable. Therefore, a DOI trim might be necessary on touchdown day.

The DOI trim was not actually incorporated into the nominal flight plan, however, until Apollo 15. Both Apollo 13 and 14 were directed to the Fra Mauro landing site, and the required lunar orbit inclination was small. The spacecraft passed over territory whose gravitational field is quite well known, and the orbital perturbations were fairly predictable. Therefore, the DOI trim burn was not made a part of the nominal flight plan. Instead, provisions were made to awaken the crew about 30 min early and omit the scheduled TV transmission if a DOI trim was in fact required.

Apollo 15, on the other hand, was directed to the Hadley-Apennine site and required an orbital inclination of 26°. This orbit passed over several known mascons whose gravitational fields were not well mapped. In addition, the high Apennine Mountains surrounding the site decreased the nominal clearance between the lunar surface and the LM at PDI and necessitated a smaller altitude error at perilune.

Due to these two considerations, the necessity of a DOI trim maneuver was more likely on Apollo 15, and the burn was included in the nominal flight plan. Figure 2a shows the planned Apollo 15 timeline from wake-up to LM entry.

The Apollo 16 lunar orbit is again of low inclination. Thus, the probability of needing a DOI trim burn is reduced close to that of Apollo 13 and 14. Elimination of the DOI trim from the nominal Apollo 16 schedule is, therefore, a reasonable way to reduce the crew awake time on touchdown day. The TV transmission, which was to be performed on Apollo 15 if no DOI trim was required, should also be eliminated. Figure 2b shows the timeline from wake-up to LM entry with the DOI trim, TV transmission, and associated tasks eliminated. Crew awake time would be reduced by 1 hr 12 min relative to that shown in Figure 2a by eliminating these tasks.

The problem of what to do if a DOI trim is required on Apollo 16 must then be answered. Of the two possibilities, waking the crew early or delaying touchdown one rev, waking the crew early seems more acceptable since delaying touchdown would increase the sun elevation angle during LM descent above the nominal value and would also put the entire mission 2 hr behind the timeline. Thus, the crew should be awakened about 1 hr early if a DOI trim becomes necessary.

Eat and Don PGA's in Parallel

If the DOI trim maneuver and its associated tasks are eliminated, the timeline between wake-up and LM entry on touchdown day becomes similar to that of Apollo 14 and consists mainly of an eat period and PGA donning. On Apollo 15, the eat period lasted 1 hr and called for all the crewmen to eat together. PGA donning in the CM is a serial operation requiring about 20 min for each crewman. While one man is donning his PGA, the others have a few tasks to do such as an IMU realignment, a MSFN uplink and update, hatch opening, and the like; however, a significant amount of their time is spent simply waiting to don their PGA's. If one crewman donned his PGA while the other crewmen ate, some of this idle time could be eliminated. Figure 2c shows a timeline from wake-up to LM entry using parallel eating and PGA donning with as much idle time eliminated as possible. About 20 min could be saved by using this procedure.

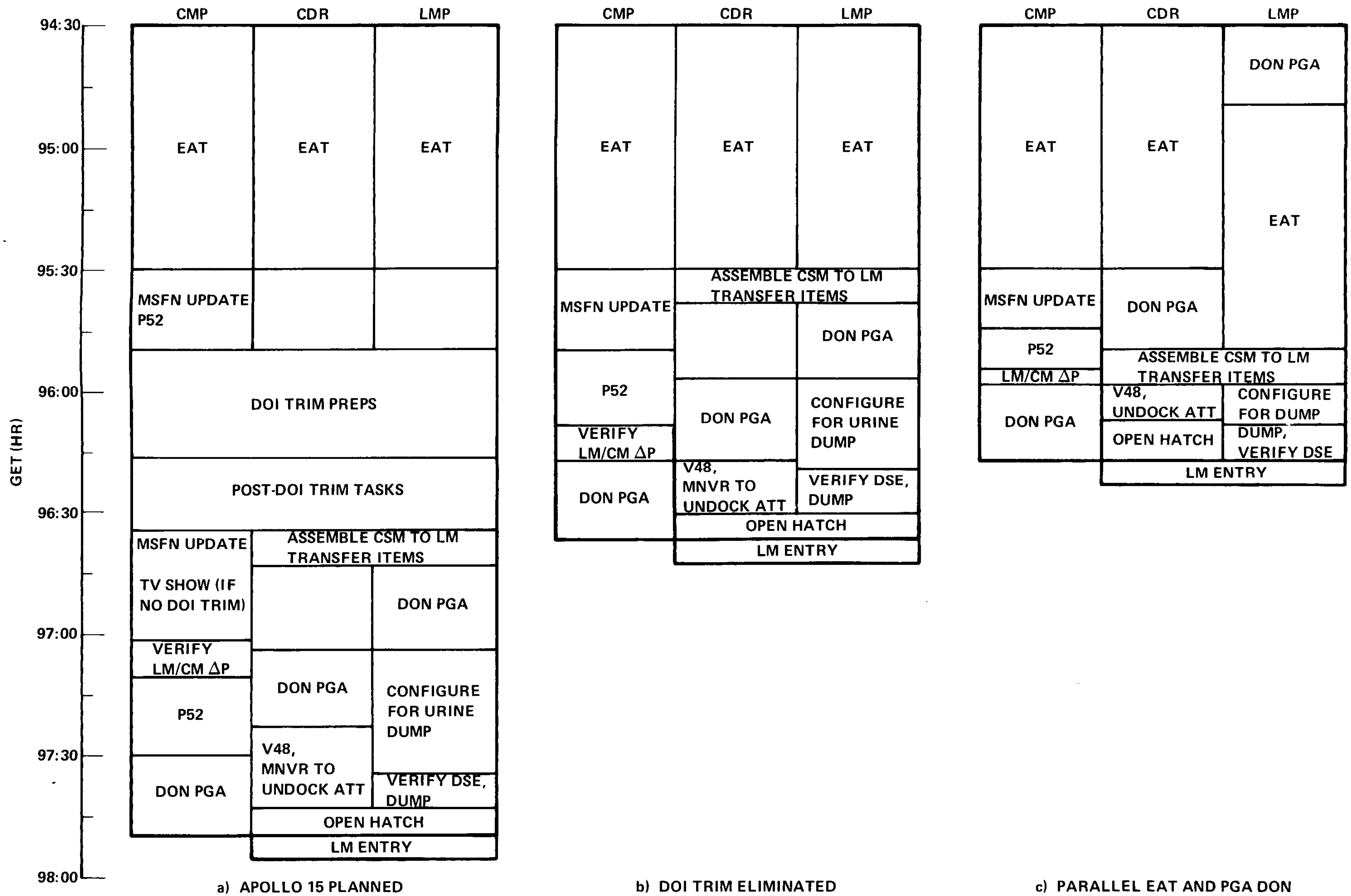


FIGURE 2 - TIMELINE FROM WAKE-UP TO LM ENTRY ON TOUCHDOWN DAY

Omit High-Altitude Landmark Tracking

Tracking of landmarks near the targeted landing point is used to improve the accuracy of the lunar landing and thereby to reduce DPS propellant requirements and to increase the probability of successfully reaching the desired landing point. On Apollo 15, two landmark tracking passes over the landing site were scheduled. The first was to take place on rev 12 shortly after undocking as the spacecraft passed over the site in the low 60 x 8 nm orbit. The second tracking pass was on the next rev, after the CSM circularization burn into a 60 nm circular orbit. The high-altitude tracking data adds no information to that derived from the low-altitude data; however, the second pass does serve as a good back-up in case tracking data are not obtained or are not acceptable on the first pass and also serves to increase confidence in any data that are obtained on the first pass.

The high-altitude landmark tracking could be eliminated simply by accepting the resulting loss of redundancy. The chances of not getting any landmark tracking are increased in this case since only one opportunity exists. On Apollo 15, landmark tracking was made mandatory due to the combination of a large no-landmark-tracking error ellipse and hazardous terrain closely surrounding the landing site. The large error ellipse resulted from relatively inaccurate pre-mission landing site coordinates (since only Lunar Orbiter data were available) and larger expected orbit perturbations due to the mascons to be overflown. On Apollo 16, the no-landmark-tracking error ellipse is smaller since the landing site has been tracked and photographed on a previous Apollo mission and its coordinates are more accurately known, and the lunar orbit perturbations are smaller and more predictable. In addition, the Descartes site of Apollo 16 does not have the topographical hazards that were present at Hadley. Therefore, landmark tracking, although highly desirable, should not be mandatory. Omission of the high-altitude tracking from the nominal flight plan should be permissible on Apollo 16. A decision will still have to be made as to whether or not touchdown will be delayed one rev in order to get landmark tracking if it is not obtained on the low-altitude pass. The 3σ landing errors with no landmark tracking are about 8700 ft crosstrack and 4700 ft downtrack as compared to about 4300 ft crosstrack and 3300 ft downtrack with landmark tracking. This larger error ellipse makes larger landing point redesignations and increased use of LM descent propellant more likely.

By eliminating the requirement for high-altitude landmark tracking, one rev can be dropped between undocking and touchdown as long as the LM checkout tasks remaining after undocking and the PDI preparations can be accomplished in the 2-1/2 hr remaining. An examination of the Apollo 15 flight plan indicates that the times allotted for these tasks were adjusted to fill the time required for the high-altitude tracking rev.

Figure 3a shows the planned Apollo 15 timeline from LM entry to undocking, and Figure 3b shows a timeline containing the same tasks with only the normally required task times included. The normal task times were estimated using data from the Flight Plans for Apollo missions 11 through 15 (References 1-5) and from the LM Operational Procedures Handbook (Reference 6). The timeline from LM entry to undocking contained about 20 min or 15% of pad time.

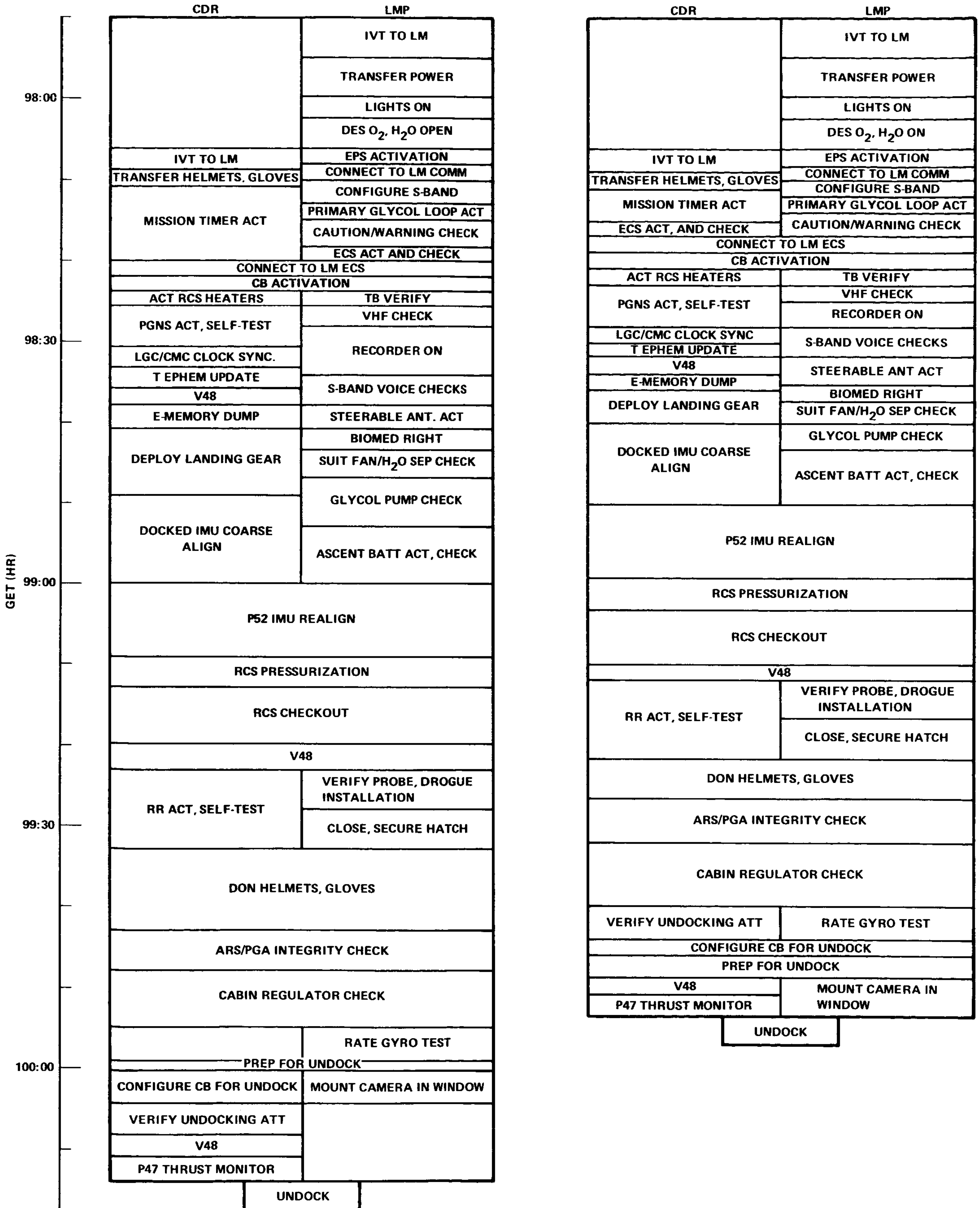
Figure 4a shows the planned Apollo 15 timeline from undocking to PDI, and Figure 4b shows a timeline of these tasks without any pad time included. This section of the Apollo 15 timeline contained about 1 hr 35 min of pad, most of it consisting of idle time during the high-altitude tracking rev. If this rev is eliminated, not only will much of this idle time be dropped, but some tasks associated with the second pass over the landing site can also be eliminated. These tasks consist of observation and photography of the landing site, observation of the ground-track and an IMU realignment. They require about 22 min. By dropping all pad time plus the tasks mentioned, the time required from undocking to PDI can be reduced from 4 hr 15 min to 2 hr 18 min. The timeline should contain some pad time to allow for contingencies or delays, however. If the 15% pad included in the time block from LM entry to undocking is also included in the block from undocking to PDI, this latter block will be 2 hr 39 min long. This timeline is shown in Figure 5. Using this timeline, the necessary tasks from undocking to PDI can just be accomplished in the time available without the high-altitude tracking rev if undocking is moved ahead slightly (about 20 min).

Omit Two Post-Touchdown P57 Realignments

On Apollo 15, three P57 lunar surface IMU realignments were scheduled in succession immediately after touchdown. A realignment after touchdown is necessary for an emergency lift-off since the accelerations experienced during powered descent tend to introduce errors in the alignment. The two additional realignments on Apollo 15 served as back-ups to increase the confidence in and accuracy of the initial realignment. One realignment should be sufficient for future missions. Eliminating the two additional realignments saves about 15 min.

Fly with PLSS's Charged with H_2O

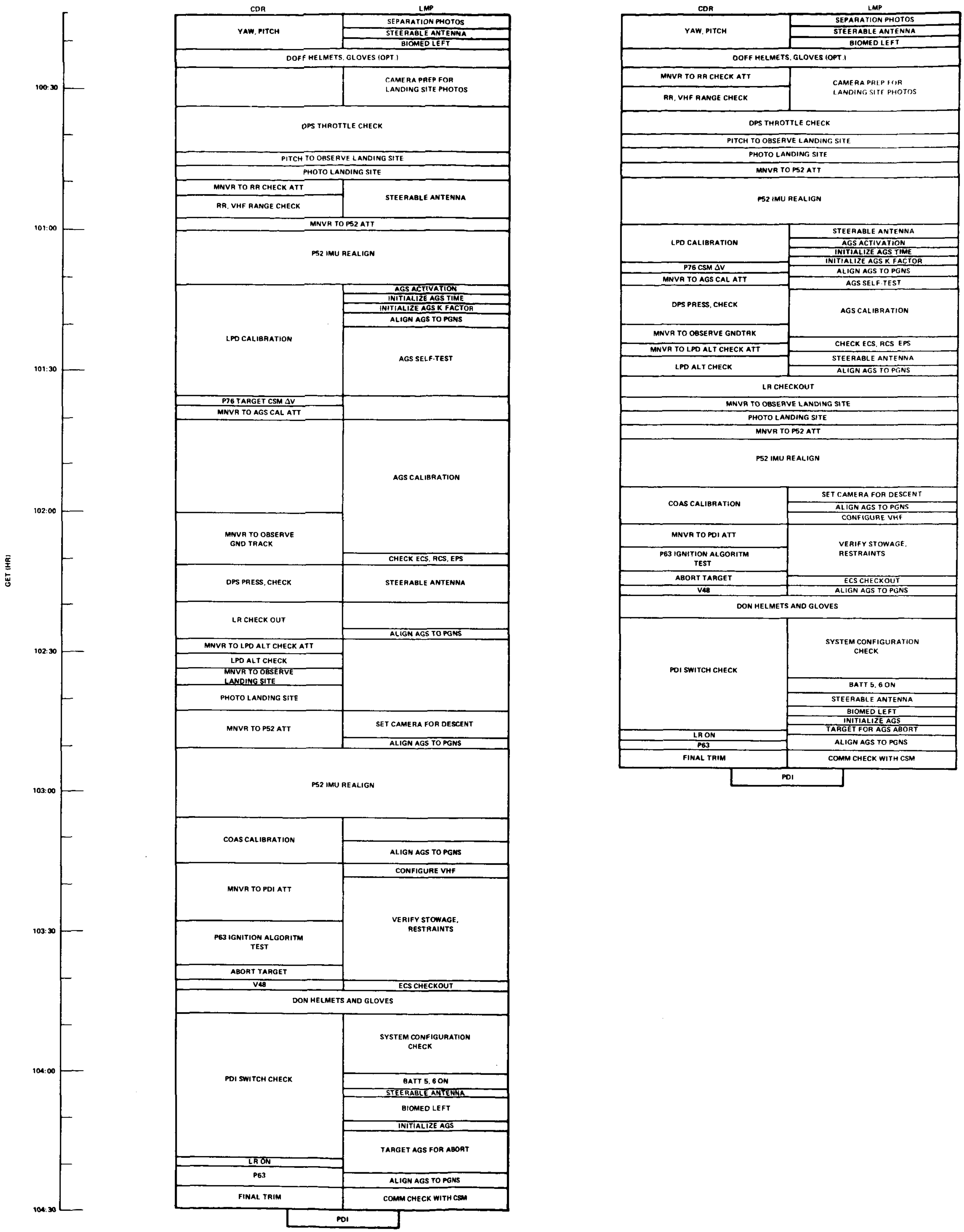
On Apollo 15, the PLSS's had to be charged with H_2O on the lunar surface before EVA 1 using LM descent supplies. By filling the PLSS's with H_2O before launch, about 13 min could be saved.



a) APOLLO 15 PLANNED

b) APOLLO 15 TASKS WITH TIME PADS REMOVED

FIGURE 3 - TIMELINE FROM LM ENTRY TO UNDOCKING



a) APOLLO 15 PLANNED

b) APOLLO 15 TASKS WITH TIME PADS REMOVED

FIGURE 4 - TIMELINE FROM UNDOCKING TO PDI

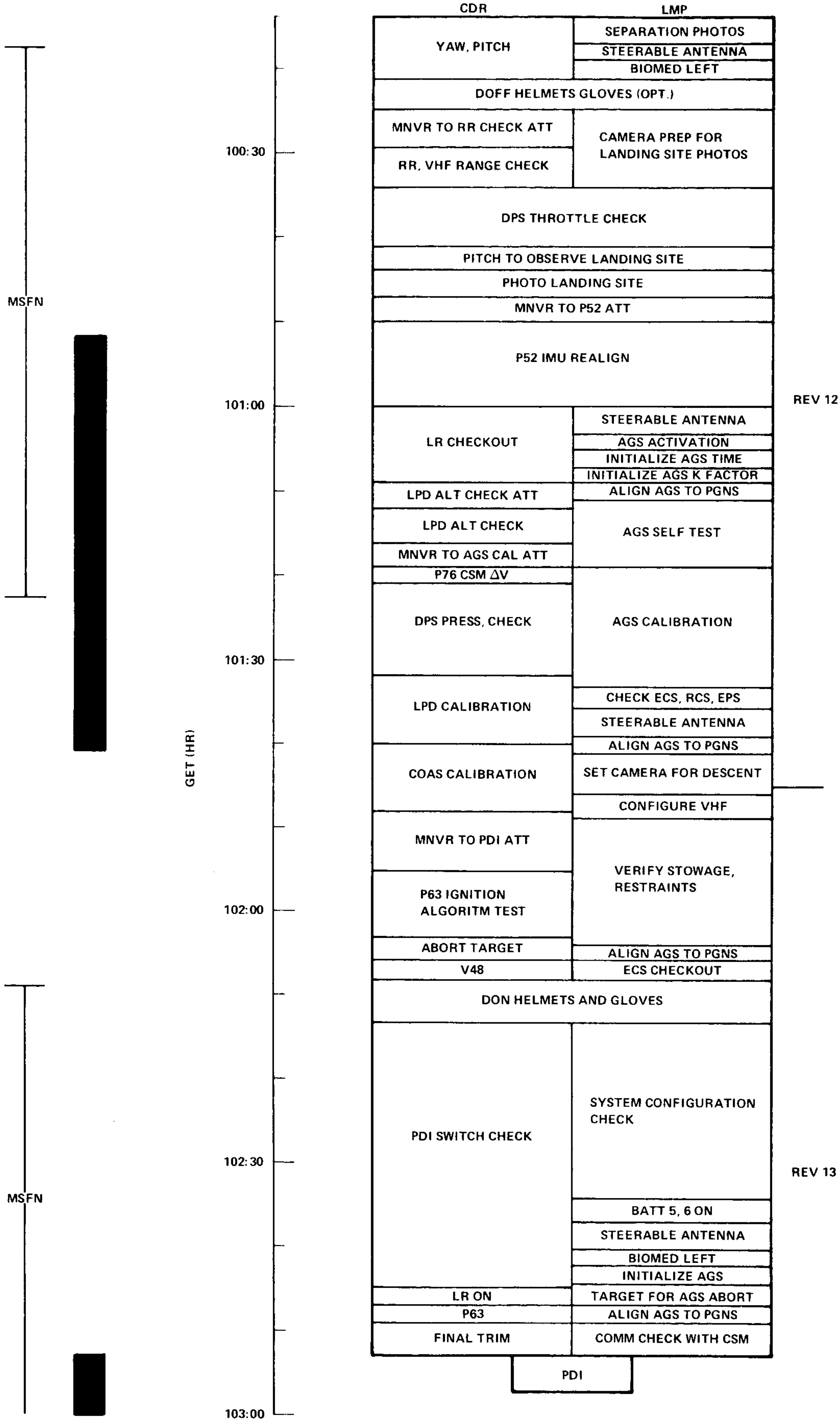


FIGURE 5 - TIMELINE FROM UNDOCKING TO PDI WITH NO HIGH-ALTITUDE LANDMARK TRACKING REV AND 15% PAD IN TASK TIMES

Summary

Incorporating all five changes mentioned above into the Apollo 15 timeline would result in the timeline shown in Figure 6 for the Apollo 16 touchdown day. This timeline includes 10 hr 45 min from wake-up to the beginning of EVA 1 and allows for a full 7-hr EVA within the 18-hr limit from wake-up to EVA 1 repress. The time reductions relative to the Apollo 15 timeline consist of:

1.	Elimination of DOI trim	1:12 hr/min
2.	Eat and don PGA's in parallel	:20
3.	Omit high-altitude landmark tracking	1:36
4.	Omit two post-touchdown P57's	:15
5.	Fly with PLSS's charged with H_2O	:13
	Total time saved	3:36

The current timeline drawn up at MSC for Apollo 16 has incorporated all the above changes except the parallel eating and PGA donning.

Use of such a compressed timeline, however, increases the probability of having to reduce the duration of EVA 1 in order to stay within the 18-hr limit from wake-up to repress. If a DOI trim should be required and the crew awakened 1 hr early, the EVA would have to be reduced by 1 hr. If touchdown should be delayed one rev in order to obtain landmark tracking or because of contingencies or timeline delays during LM checkout, the EVA would have to be reduced by 2 hrs. Such considerations make it advisable to establish a minimum duration for EVA 1 below which the crew should sleep first in order to preserve as much EVA time as possible.

LENGTHENING PRE-TOUCHDOWN AWAKE TIME WITH SLEEP FIRST ON SURFACE

Sleeping on the lunar surface prior to the first EVA is unattractive for several reasons. Any delay in beginning the EVA is undesirable. Crew sleep prior to their first activity on the moon's surface is likely to be difficult because of their excitement. In addition, the sun elevation angle during the EVA's is higher than for the EVA-first case thereby increasing the PLSS feedwater required to cool the crewmen. However, on a mission for which (1) including a DOI trim in the nominal flight plan is advisable, (2) landmark tracking is mandatory making the high-altitude pass necessary, and (3) a short first EVA is unacceptable, sleeping first on the surface might be the

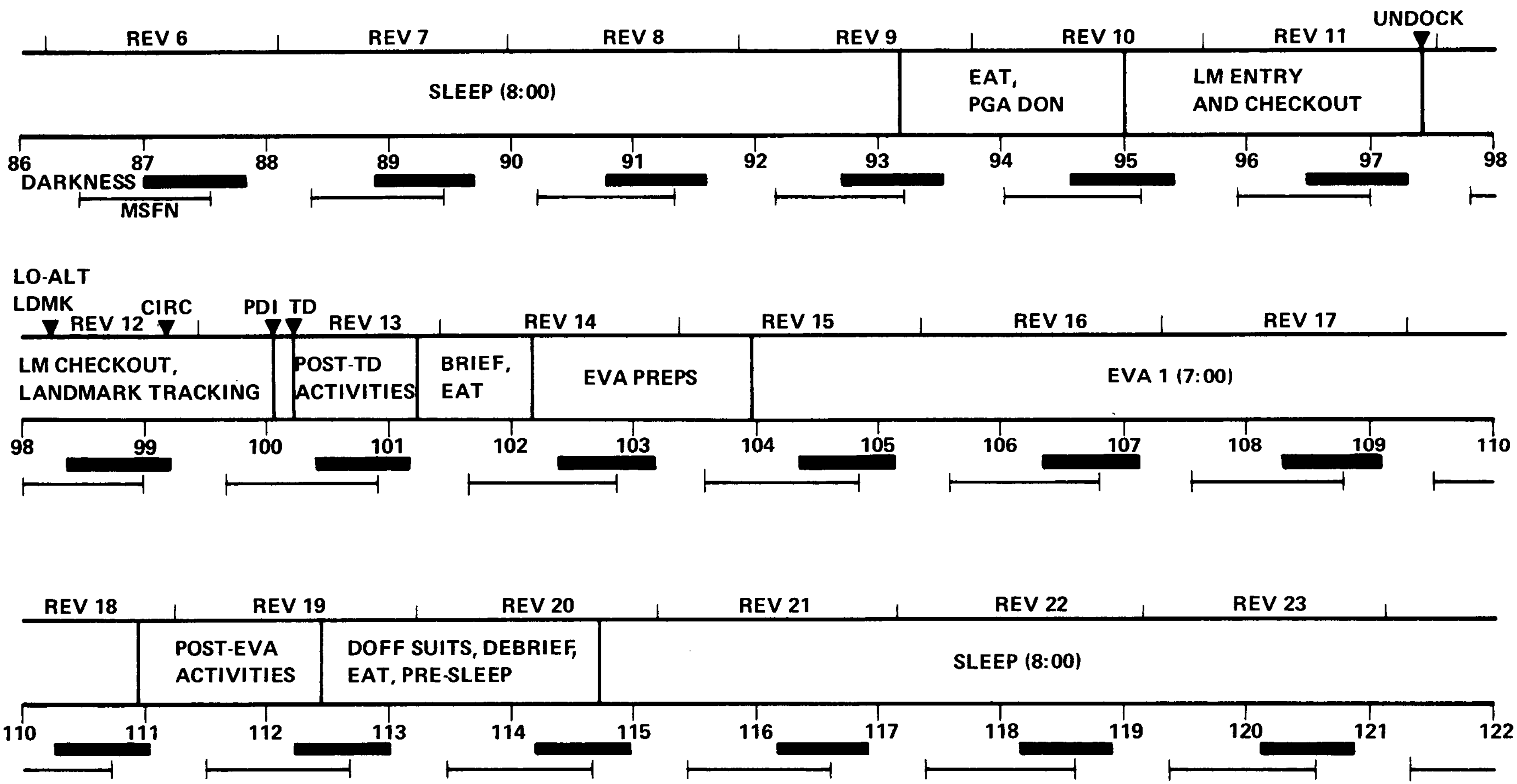


FIGURE 6 - CANDIDATE APOLLO 16 TOUCHDOWN-DAY TIMELINE

only way to keep the touchdown day short enough to avoid excessive crew fatigue. Several timeline options are available for the sleep-first case and are shown in Figure 7:

Option 1. DOI trim and touchdown on the same day; LOI and DOI on the previous day,

Option 2. DOI and touchdown on the same day; LOI on the previous day,

Option 3. LOI, DOI, and touchdown on the same day; MCC4 and SIM door jettison on the previous day,

Option 4. MCC4, LOI, DOI, and touchdown all on the same day.

Option 1 - DOI Trim and Touchdown on the Same Day

Scheduling a DOI trim maneuver and touchdown on the same day is the philosophy used on Apollo 15. Total crew awake time on touchdown day on Apollo 15 was about 14-1/2 hr. This time included a SEVA on the surface before sleeping. The experience gained on Apollo 15 seems to indicate, however, that surface activities such as SEVA are not a very efficient use of surface stay time, and the SEVA is not scheduled for future missions. Thus, the timeline with DOI trim on touchdown day, as shown in Figure 7, totals 13 hr 15 min of crew awake time, and, with an 8-hr sleep period, the day totals only 21 hr 15 min.

Such a short day is not very appealing especially since sleeping difficulty is anticipated for other reasons. The crew awake time on this day could be increased by moving the preceding sleep period ahead in the total timeline and scheduling further activities prior to DOI trim. The amount by which this sleep period can be moved ahead is constrained by the time of LOI and the required DOI burn. DOI could possibly be moved ahead one rev by eating prior to LOI and by postponing the exercise period and some of the SIM bay and CM photography tasks scheduled between LOI and DOI on Apollo 15. Some of the SIM bay activities scheduled after DOI could possibly also be delayed. These tasks could be picked up on the next day prior to the DOI trim. The addition of these tasks to the touchdown day timeline will also require that a third 1-hr eat period be included. In this way, the touchdown day could possibly be increased by a maximum of about 4 hr without delaying touchdown beyond rev 14. The day would then total 25 hr 15 min with touchdown occurring 14-1/2 hr after wake-up.

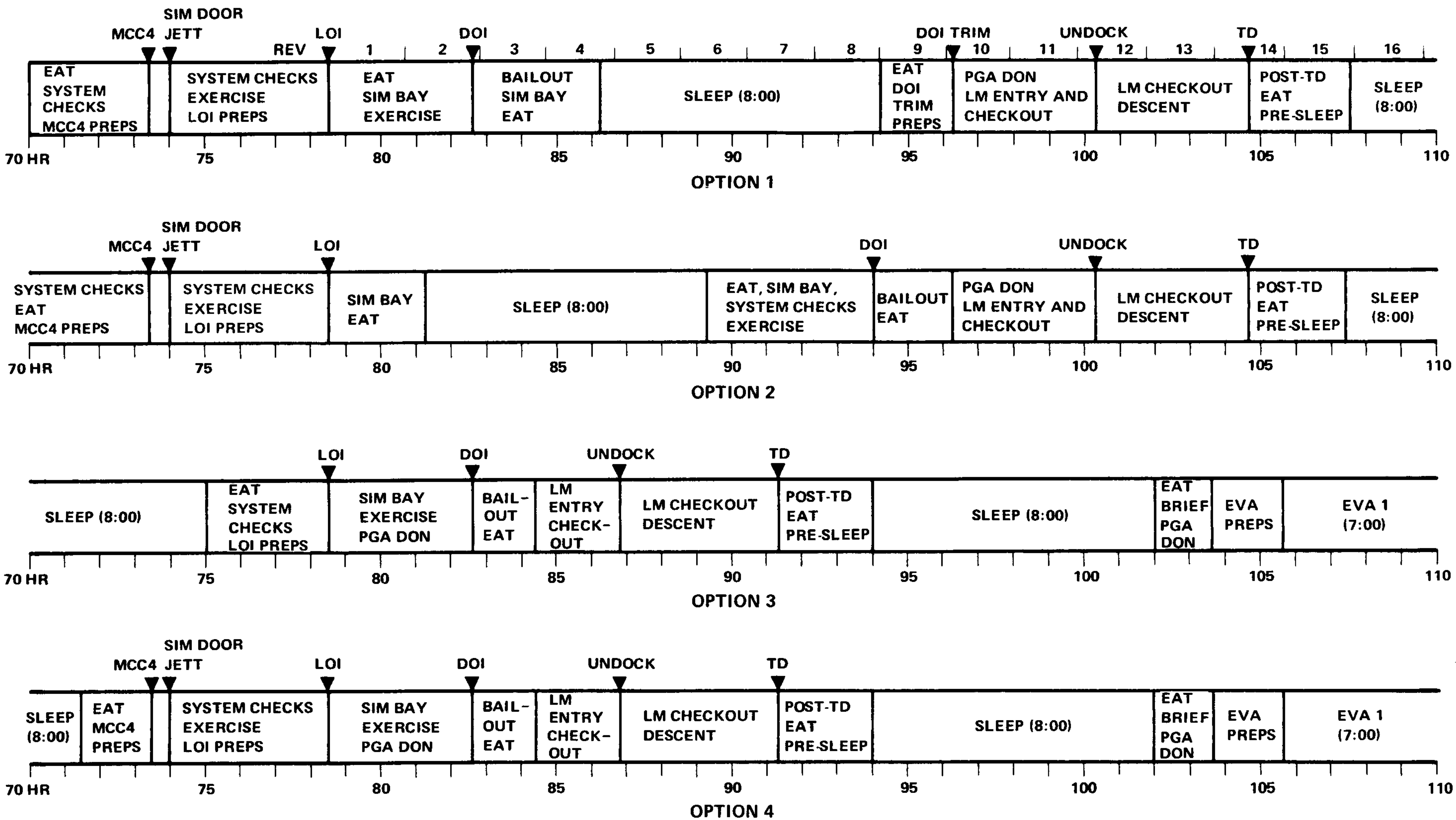


FIGURE 7 - TOUCHDOWN-DAY TIMELINE OPTIONS WITH SLEEP FIRST ON THE LUNAR SURFACE

Option 2 - DOI and Touchdown on the Same Day

The method used to lengthen touchdown day under Option 1 could be extended further by postponing DOI until touchdown day. The sleep period could then be moved up to shortly after LOI, and touchdown day could be lengthened by about 5 hr. DOI would then be performed at the end of rev 8. Doing DOI this close to touchdown makes the DOI trim maneuver unnecessary. The touchdown day would total 26 hr 15 min for this timeline option with touchdown occurring 15-1/2 hr after wake-up. One disadvantage of this option is that the spacecraft stays in the high 60 x 170 nm orbit for 6 revs longer than planned on Apollo 15. This high orbit degrades SIM bay data slightly compared to the 60 x 8 nm orbit achieved after DOI.

Option 3 - LOI, DOI, and Touchdown on the Same Day

Another way to increase the length of touchdown day and thereby make sleeping first on the surface feasible is to perform LM descent earlier in the mission with touchdown occurring toward the end of the LOI work day. To make such a work day possible, MCC4 would have to be performed at the end of the day preceding that of LOI, with LOI occurring shortly after the intervening sleep period. DOI would occur at the end of rev 2 as in the past, and touchdown would be 4-1/2 revs later on rev 7. Such a day would total 27 hr in length with touchdown occuring 16 hr 15 min after wake-up. SIM door jettison could also be included on this day prior to LOI if desired. Including SIM door jettison would add about 30 min to the day assuming that the crew need not be suited. The major disadvantage of this timeline option is that MCC4 would occur 13 to 14 hr before LOI rather than 5 hr before as on past missions. The greater interval allows for larger errors at LOI; however, the errors should not be unacceptable even for a 14-hr interval. This option also impacts the length of the translunar coast days causing them each to be 1 to 2 hr longer than they would be using the Apollo 15 schedule of events. An advantage of this option over Options 1 and 2 is that, because touchdown occurs on rev 7, the GET of EVA 1 is no later than it would be for a normal EVA-first timeline even though a sleep period precedes the EVA on the lunar surface.

Option 4 - MCC4, LOI, DOI, and Touchdown on the Same Day

The fourth timeline option carries Option 3 one step further by including MCC4 along with LOI and touchdown on the same day. MCC4 is scheduled the normal 5 hr before LOI. The work day schedule is similar to that of Apollo 15 with LM checkout, undocking, and touchdown added on the end. Touchdown again would occur on rev 7. The crew is assumed to be unsuited for SIM door jettison. The day totals 30 hr 30 min in duration with touchdown occurring 19 hr 45 min after wake-up. The main disadvantage of this option is that the day becomes somewhat too long, and touchdown does not occur until the crew has been awake almost 20 hr. Again the GET of EVA 1 is no later than for a nominal EVA-first timeline.

SUMMARY

Performing the first lunar surface EVA as soon as possible after touchdown is highly desirable. Rearrangement of the Apollo 15 timeline to provide for the EVA immediately after touchdown results in a total crew-awake time on touchdown day of nearly 25 hr for a full 7-hr EVA. A day of this length could result in excessive crew fatigue. In order to avoid such fatigue, a limit of 18 hr has been put on the total time scheduled from wake-up to cabin repress after EVA 1.

The length of the crew work period on touchdown day can be reduced to an acceptable value in the following ways:

1. shorten EVA 1,
2. shorten the time awake before EVA 1,
3. lengthen the time awake before touchdown and sleep before EVA 1.

Shortening EVA 1 is undesirable on Apollo 16 because of the resulting loss of lunar surface exploration time. If the Apollo 17 mission should allow for four EVA's, a short first EVA might be acceptable.

Time awake prior to EVA 1 can be reduced for Apollo 16 relative to Apollo 15 in these ways:

Eliminate DOI trim	1:12 hr/min
Eat and don PGA's in parallel	:20
Omit high-altitude landmark tracking	1:36
Omit two post-touchdown P57's	:15
Fly with PLSS's charged with H_2O	:13
Total time saved	3:36

The current timeline drawn up at MSC for Apollo 16 has incorporated all of the above changes except the parallel eating and PGA donning. Incorporating these changes into the timeline will allow for a full 7-hr EVA to be scheduled immediately after touchdown without risking excessive crew fatigue.

If Apollo 17 should be constrained to three EVA's and should require a planned DOI trim and/or high-altitude landmark tracking, a timeline with a longer touchdown day and a sleep period on the surface before EVA 1 might be the only way to maintain full 7-hr EVA periods while still avoiding crew fatigue. Several options for providing such a timeline are available.

K. P. Klaasen

2013-KPK-pjr

K. P. Klaasen

REFERENCES

1. "Apollo 15 Preliminary Flight Plan," Manned Spacecraft Center, April 20, 1971.

2. "Apollo 14 Preliminary Flight Plan," Manned Spacecraft Center, September 23, 1970.

3. "Final Apollo 13 Flight Plan," Manned Spacecraft Center, March 16, 1970.

4. "Final Apollo 12 Flight Plan," Manned Spacecraft Center, October 15, 1969.

5. "Final Apollo 11 Flight Plan," Manned Spacecraft Center, July 1, 1969.

6. "Apollo Operations Handbook, Lunar Module, Volume II - Operational Procedures," Grumman Document LMA790-3-LM10 and Subsequent, September 1, 1970.

Subject: Acceptable Crew Work/Rest Cycles for the Lunar Touchdown Day on Apollo Missions - Case 310

From: K. P. Klaasen

DISTRIBUTION LIST

NASA Headquarters
D. A. Beattie/MAL
G. F. Esenwein/MAL
J. K. Holcomb/MAO
C. M. Lee/MA
A. S. Lyman/MR
W. T. O'Bryant/MAL
R. B. Sheridan/MAO
W. E. Stoney/MAE

Manned Spacecraft Center
S. Blackmer/PD
E. A. Cernan/CB
R. E. Evans/CB
S. Gardner/CG5
G. D. Griffin/FC
T. W. Holloway/CF6
C. R. Huss/FM
G. S. Lunney/FC
E. Pippert/CG5
H. H. Schmitt/CB
J. R. Sevier/PD4
P. C. Shaffer/FC5
R. G. Zedekar/CG3

Bellcomm, Inc.
R. A. Bass
A. P. Boysen, Jr.
J. O. Cappellari, Jr.
F. El-Baz
J. W. Head
W. G. Heffron
N. W. Hinners
M. Liwshitz
K. E. Martersteck
J. Z. Menard
P. E. Reynolds

Bellcomm, Inc. (Cont.)
R. L. Wagner
All Members Dept. 2013
Central Files
Dept. 1024 File
Library

Abstract Only to

Bellcomm, Inc.
J. P. Downs
D. R. Hagner
I. M. Ross
J. W. Timko
M. P. Wilson