

Massachusetts Institute of Technology
Charles Stark Draper Laboratory
Cambridge, Massachusetts

COLOSSUS Memo #293 / LUMINARY Memo # 174 / SKYLAB Memo #???

TO: Distribution
FROM: William M. Robertson
DATE: October 9, 1970
SUBJECT: Summary of Program Change Requests Involving Astrodynamic
Coordinate Systems, Ephemerides and Orientations, etc.

The following list summarizes the approved, disapproved and withdrawn PCR's for Apollo 14, 15, 16, 17 and Skylab which involve coordinate systems, ephemeris and orientation subroutines, etc. Some comments are given concerning what is being accomplished by the PCR's.

APOLLO 14 (COLOSSUS 2E and LUMINARY 1D)

Approved PCR's

*986.1 and 986.2: Update Fixed Constants for 1970-1971 Ephemeris Year (Originator: J. M. Reber)

Disapproved or Withdrawn PCR's

*293.1 and 293.2: Update Fixed Constants for 1970-1971 Ephemeris Year (Originator: MSC)

Remarks

Apollo 14 is being flown with the 1970-1971 Nearest Besselian Year Coordinate System (also known as the 1971.0 system). This is in accord with the long-standing tradition of choosing the flight year's Basic Reference Coordinate System to be the coordinate system associated with the Nearest Besselian Year during which the flight takes place.

APOLLO 15, 16, and 17

COLOSSUS

Approved PCR's (See Approval Notes at end of memo)

*1082.1: Update Fixed Constants for 1971-1972 Ephemeris Year

Disapproved or Withdrawn PCR's

None

LUMINARY

Approved PCR's (See Approval Notes at end of memo)

*1082.2: Update Fixed Constants for 1971-1972 Ephemeris Year

*1093 : Eliminate 481 day limitation on TEPHEM in Lunar-Solar Ephemerides.

Disapproved or Withdrawn PCR's

*323: "Improvements to Ephemerides" - Incorporate extra term proposed by TRW in the Lunar-Solar Ephemerides.

Remarks

Apollo 15, 16, 17 are being flown with the 1971-1972 Nearest Besse-
lian Year Coordinate System (also known as the 1972.0 system). Since
these flights are scheduled in July 1971, January 1972, and June 1972, the
choice of the 1972.0 system is in accord with the traditional method of
establishing the coordinate system. But what happens if any of these flights
slip past June 30, 1972 (the end of the 1971-1972 NBY), now that the Soft-
ware Control Board has decided there should be almost no changes in the
ropes after Apollo 15? In case of such a slip, the ropes (and the RTCC)
will continue to use the 1972.0 system, thus breaking tradition. That the
ropes are mathematically capable of doing this was shown for the PIOS
routine in SGA Memo #10-70 and for the Lunar-Solar Ephemerides Routine
in 23S Memos #70-60, 70-66, and 70-68. One coding limitation exists in
LUMINARY for the Apollo 14 (and previous) LM rope, which would have
prevented the Apollo 15 (and subsequent) LM rope from flying after late

November 1972, but MIT/DL was directed to eliminate this limitation and it is being done by PCR 1093. When 1082.1, 1082.2 and 1093 have been incorporated, the ropes will be able to fly without fixed-memory changes in the astrodynamic area anytime up to mid-February 1974. The NASA/RTCC and the MIT/DL Digital Simulator are preparing for the possible break with the traditional coordinate system choice.

SKYLAB

Approved PCR's (See Approval Notes at end of memo)

- * SLO33: Use 1950.0 Fixed Coordinate System. (Full implementation details given in 23A SKYLAB Memo #3-70 by Robertson). Briefly: 1) Modify PIOS to use full 3 x 3 Precession-Nutation matrix stored in erasable, 2) Equivalence UNITW to third row of this matrix, 3) Delete AXO, AYO, 4) Move AZO from fixed to erasable, and 5) Modify Coasting Integration to use true north rather than (0, 0, 1) in computing oblateness acceleration.
- * SL404: Transfer LUMINARY Lunar-Solar Ephemerides Routine to Skylab Guidance Computer, putting 11 of its 22 "constants" into part of the erasable freed by deleting the COLOSSUS version of this routine. (This PCR replaces SLO23 and SL401; the former put all constants in fixed, the latter put them all in erasable). The actual values of the 11 fixed constants are to be specified in another PCR.
- * SL402: Eliminate 481 day limitation on TEPHEM in the (former LUMINARY) Lunar-Solar Ephemerides Routine. (Strictly speaking, this is superfluous as it is now being done for the Apollo 15 rope by PCR 1093, and hence will already be in Skylab.)
- * SLO34: "Improvements to Ephemerides" - Incorporate extra term proposed by TRW in the Lunar-Solar Ephemerides. (This increases the number of constants from 19 to 22).
- * SL???: Incorporate Star Position data in 1950.0 coordinate system, but with stars proper-motioned to January 1973. Also incorporate the eleven fixed constants for the (former LUMINARY) Lunar-Solar Ephemerides Routine. (To be written by M. Reber).

Disapproved PCR's

- * SLO23: Transfer LUMINARY Lunar-Solar Ephemerides Routine to Skylab Guidance Computer, leaving all "constants" in fixed memory. Delete COLOSSUS version of this routine. (Replaced by SL404).

- * SL401: Transfer LUMINARY Lunar-Solar Ephemerides Routine to Skylab Guidance Computer, putting all "constants" in erasable memory. Delete COLOSSUS version of this routine. (Replaced by SL404).

Remarks

Because of a strong NASA/MSC desire, Skylab will use a 1950.0 coordinate system. There are pros and cons to this, but two of the bigger pros are that it does not change every year as the NBY system has, and that JPL uses this system. Some minor changes are being made in the (former LUMINARY) Lunar-Solar Ephemerides Routine. Its accuracy is being improved (over a one year span) by adding an extra term proposed by TRW to its formulation, and its most quickly changing astrodynamic "constants" are being put in erasable to give NASA the flexibility to change or not to change them as they desire. (These constants are currently held fixed for a year in mainline Apollo, but a considerable improvement in the moon's angular accuracy may be achieved by changing them for each mission.)

NOTES ON THE APPROVAL OF SOME OF THE "APPROVED PCR's"

*1082.1: Approved in its entirety by the Software Control Board on September 30, 1970.

*1082.2: The first page (and only the first page) of this PCR was approved by the Software Control Board on 30 September 1970. This action was taken in order to indicate the SCB's intent to incorporate the 1972.0 coordinate system, but not necessarily to agree at the meeting to the "constants" proposed by the PCR. Actually this was due to a question solely over the Lunar-Solar Ephemerides Routine constants, (namely whether to use the "480 day" ones listed in the PCR or a "960 day" set). The question was later resolved by R. White and W. Robertson in favor

of the 480-day set originally proposed, and pages 2 thru 13 of the PCR have been re-submitted to MSC as MIT's detailed implementation.

*1093: The Software Control Board on 30 September 1970 directed MIT/DL to prepare this PCR. Hence, while it is not officially signed as of the date of this memo, verbal approval may be considered to have been given.

*SLO33, SL404, SL402, SLO34 and SL???: Complete agreement has been obtained on these PCR's between the astrodynamic and RTCC branches of MSC (R. Savely, B. Cockrell, E. Schiesser) and MIT/DL. A special meeting was held at MSC just after the Software Control Board Meeting of 30 September 1970, and verbal approval was given to these PCR's by J. Williams.