R. Larson

Joint NASA/MIT Development Plan Meeting #24
Held on 26 March 1968

1. Sundance

Reassignments of personnel increased the level 5 effort so that completion is now scheduled for 7/2/68.

NASA stated they will delay making flight ropes as long as the schedule permits.

Some Problems

1) Mode II attitude error display is not provided.
2) Rate command attitude hold during P40 & P42 is not provided.
3 CSM docked delta V monitor threshold is being checked.
4) Short (less than 6 seconds) DPS burns are inaccurate. (do not account for engine on delay)
5) Ullage (x - translation) is sustained for more than .5 seconds after engine on signal is sent (P & I spec.)
6) Attitude error needles peg at about 2^{o} rather than the anticipated 16 7/8 ^{o} or the crew desired 5^{o}.
   Action: G. Cherry/W. Stameris - MIT directed to generate PCN and necessary ICD documentation for 5^{o}.
7) Minimum range at which P20 operates accurately is not yet known.
8) Orbital integration cannot integrate backwards for more than one orbit.
9) CSM - docked rate command attitude hold works but not as efficiently as it could.

On the Trim Gimbal Fail light problem NASA to issue ECP to GAEC and a PCR to MIT.

Level 4 test status still indicates 4/9 FACI.

NASA (T. Gibson) delivered FACI requirements in rough form.

ACTION - MIT (G. Cherry) comments in 1 week. (4/2/68).

2. Luminary

(a) Execution time in P64 is a problem. MIT is reducing the DAP execution time to gain 4%. Additional relief can be realized if a specification change on the altitude and altitude rate analog tape meter drives from 3 cycles/sec. to 2 cycles/sec. can be made.
MIT ACTION (G. Cherry) - Submit PCN and necessary ICD changes.

(b) MSC (K. Cox) ACTION - PCR on rate command/attitude hold similar to that provided on Colossus.

(c) MSC - DPS needs $\pm$ 8% at 57% throttle vs present specified 50%. Luminary GSOP Chapter 5 specifies 55 to 63%. MSC direction at present is to follow GSOP.

(d) MSC - GAEC wants 15% vs present 10% on DPS start. This change and others in the P40 area should be reviewed by MSC as a group. MIT is to await direction.

3. Colossus

The latest development plan was reviewed. FACI moved to 7/17 by PCR actions. All level 4 tests will be started by 4/10.

Specific programs in the assembly can be utilized by the AMS however, it will be May probably before many sequences of level 4 are satisfactory.

4. Digital Autopilots

Documentation

Sundisk - GSOP chapter 3 and verification test results issued.

Colossus - Basically an updated Sundisk will be published 4/5 (7 copies to MSC for approval prior to full distribution). A revision is planned for release at FACI.

Sundance - Technical problems on the DAP required delay of documents - now scheduled for 4/17.

Data Requests

MIT - R59, R61 and R63 outstanding and data needed.

NASA (K. Cox) stated that data on R63 promised in 4-6 weeks. In addition a TWX action item on the severity of the LM manual throttle regime (17 Nov. 1967) is outstanding.

A design solution to the LM instability has been found and will be incorporated in the next Sundance assembly. The "gains" will be moved to pad loaded erasable at this time.

5. Downlink

A presentation (attachment C) was made on the requirements and interfaces of downlink at MIT.

To improve internal communications and the level of detail required in GSOP Chapter 2 the form (attachment D) has been developed. Milestones and individual deadlines for completion of these forms remains to be completed.

6. Simflight

After a presentation on MIT's Simflight, MSC suggested a meeting in the next couple of months to review the G&N test program.

ACTION MSC - Establish date for a G&N test program review meeting.

7. Status of IBM 360-75s

(a) 3/29 - Second 2314 for "A" machine to be shipped.

(b) 4/8 - MVT ready for production work.

(c) 4/26 - MH-1800 to be removed.

(d) 5/3 - IBM 360-75 "B" machine ship date.

(e) 5/6 - "B" machine arrives.

8. Mission Verification - Sundisk

The detailed data requirements, scheduled tests, and interface of the outputs were reviewed. Pertinent milestones and requirements will be incorporated into the development plans. A list of the verification tests planned is included as (attachment E).

9. AS 502 - Mission Flight Support

NASA requested that MIT provide support at Cambridge of either D. Lickly, H. McQuat, or J. Sampson plus a qualified hardware man.

10. Memory Budgets

(a) Fixed memory - Attachment A (handout) shows the present status.

(b) Erasable memory - Presentation by J. Kernan (attachment B).

11. Simulator Configuration Control

D. Hoag presented Apollo Project Memorandum No. 1804 (addendum 6) quoted in part.

> During the development of the digital and hybrid simulators to support the development and verification of a given flight computer program the simulator design will use the best model data available up to the point of simulator configuration control. This point will occur shortly before or at FACI at the end of level 4 testing. An edition of Section 6 GSOP will be issued at this time to reflect the frozen configuration of each of the simulators.
>
> New revelant data, such as new models of the spacecraft, arriving after configuration control will be examined by a committee made up of MSC/FSB and the appropriate MIT/IL Mission Development Divisions.

It it is decided by the above committee that the new data are not essential to the accurate verification of the mission program, the new data will not be incorporated into the simulators.

If it is decided that the new data are essential to the accurate verification of the mission program, a PCR (ref. APM 1804, Addendum 5) is generated with the estimate of schedule impact on the date of the release for program rope manufacture at the Customer Acceptance Readiness Review for the program. Action by the Software Control Board will either deny the suggested change of the simulators or accept the incorporation of the new data with the corresponding schedule effect.

12. At the next joint meeting MIT is to present plans for future versions of Colossus and Luminary.

R. C. Millard

RCM/km

ATTENDEES

NASA/MSC

C. Kraft
K. Cox
J. Stokes
J. Williams
T. Gibson
W. Ankney

GAEC

C. Tillman

BELLCOM

G. Heffron
D. Hoag
R. Millard
J. Vittek
P. Peck
M. Johnston
P. Felleman
W. Widnall
W. Marscher
E. Copps
W. Stameris
D. Dolan
A. Kosmala
K. Greene
B. Sokkappa
I. Johnson
A. Laats
R. Ragan
L. Larson
G. Cherry
J. Kernan
R. Battin
F. Martin
N. Sears
J. Dahlen
S. Copps
D. Lickly
J. Henize
L. Drane
J. Nevins
J. S. Miller
R. Larson

cc: Attendees

R. Scholten
G. Levine
J. Saponaro
J. Sutherland
R. Morth
C. Schulenberg
A. Engle
M. Hamilton
R. Beckham, FS 5
R. Wieser
W. Kupfer
F. Little
R. White

Attachment A

FIXED MEMORY WORDS

3/25/68
PEP

	BLACK FRIDAY 8/29/67	3/25/68	Δ	NOTES (G = GONE)
LUMINARY				
UTILITY + SERVICE	14303	13012	(1291)	THRUPT (200) SCHECK (600) DOWNLINK (200) G LUNSURFC/C (200) G
AUTOPILOT + MANEUVER	5181	4363	(818)	AUTOPILOT (1000) FINDCDUW 200
BASIC MATH	3967	4080	113	
TARGETING	2072	649	(1423)	TPI SEARCH (300) G PRED LNDG TIME (200) G PRED LAUNCH TIME (700) TO MISS CONTROL DESCENT ORBIT INS G (100)
NAVIGATION	1531	1477	(54)	
POWERED GUIDANCE	1988	2814	826	SERVICER 300 ASCENT GUID 500
ALINEMENT	649	652	3	
MISSION CONTROL	3019	4610	1591	PRED LAUNCH TIME 450 ASCENT GUID 150 PRETHRUST 400 LUNAR SURFACE ALINE 300 P60's + P70's 500 LNDG ANAL DSPLA MCN 500
MISCELLANEOUS	1025	2048	1023	
TOTAL	33735	33705	(30)	
PAD	3129	3159	30	
COLOSSUS				
UTILITY + SERVICE	12724	12269	(455)	S CHECK (650) SYS TST 250 DOWNLINK (150)
AUTOPILOT + MANEUVER	5498	6662	164	
BASIC MATH	4081	4172	91	
TARGETING	1422	353	(1069)	RET TO EARTH (900) PRED LND TIME (200) G
NAVIGATION	2406	1479	(927)	LUN ORB NAVIG (750) R23 (200)
POWERED GUIDANCE	2233	2182	(51)	
ALINEMENT	862	947	85	
MISSION CONTROL	4231	6664	2433	ORBITAL NAV 1000 RET TO EARTH 1000 CISL MIDCRS NAV 500
MISCELLANEOUS	984	1318	334	
TOTAL	34441	35046	605	
PAD	2423	1818	(605)	

WHAT IS ERASABLE USED FOR

- COMPUTATIONAL VARIABLES
- LOGIC & CONTROL VARIABLES
- CONSTANTS NOT DEFINABLE AT MANUFACTURING TIME

WHAT IS THE PROBLEM

- NOT SUFFICIENT ERASABLE REGISTERS FOR UNIQUE ASSIGNMENT TO COVER ALL REQUIREMENTS

HOW ARE REQUIREMENTS SATISFIED

- TIME-SHARING

ERASABLE MEMORY ASSIGNMENTS

- PERMANENT (UNSHARABLE)
- TEMPORARY (SHARABLE)

TYPES OF PERMANENT ASSIGNMENT

- MISSION-VITAL VARIABLES
  - e.g. STATE VECTORS
    TIME
- CONTROL VARIABLES
  - e.g. PHASE REGISTERS
    WAITLIST
    EXECUTIVE
    INTERRUPT ROUTINES
- TIME-DEPENDENT CONSTANTS
  - e.g. AXO
    AYO
    MOON-SUN POLYNOMIALS
- CONSTANT NOT DEFINABLE AT MANUFACTURING TIME
  - e.g. EMS ALTITUDE
    INERTIAL COMPENSATION PARAMETERS
    BOOST POLYNOMIALS

TIME-SHARING METHODS

- DYNAMIC ASSIGNMENT BY EXECUTIVE (PUSH-DOWN LIST STRUCTURE)

- BLOCK SHARING (OVERLAYING) BY PROGRAMS OR ROUTINES CONSTRAINED NOT TO RUN SIMULTANEOUSLY
  e.g. DESCENT AND ASCENT

- INTERNAL STALL ROUTINES
  e.g. INSTALL
  ERASTALL
  UPDATE FLAG CONTROL

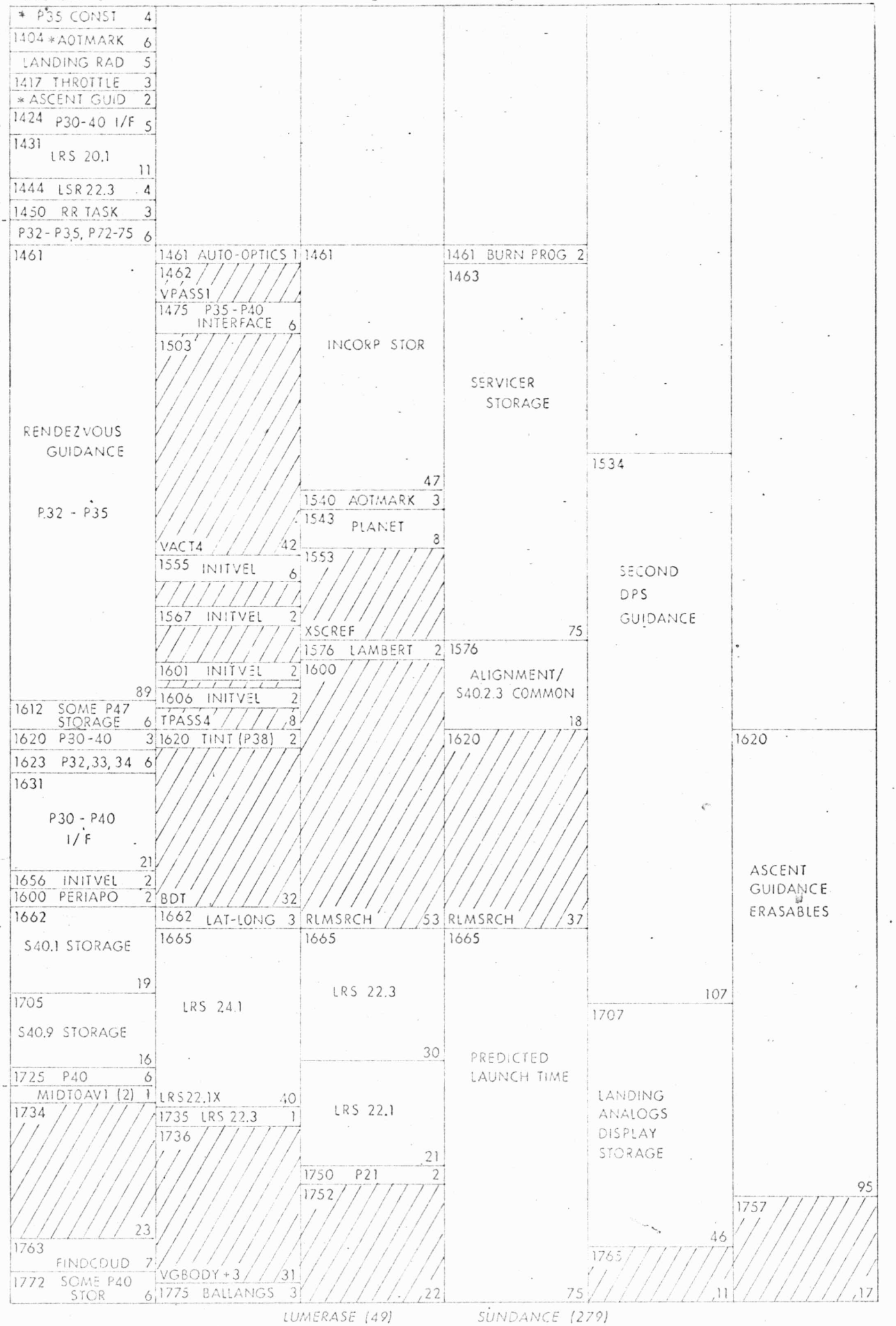
ERASABLE ASSIGNMENT CONTROL

- HIGH LEVEL CONTROL: ERASABLE CONTROL COMMITTEE WITH ONE PERMANENT SECRETARY PER ASSEMBLY.
- ERASABLE REQUEST CONTROL: FORMS
- PICTORIAL VISIBILITY: ERASABLE BANK MAPS
- RUN-TIME MONITORING: TEMPCHK, ETC.
- ASSEMBLY-TIME MONITORING: GAP

VARIOUS OBSERVATIONS

- TIME-SHARING PURSUED ONLY TO POINT WHERE ALL AVAILABLE REQUIREMENTS MET.
- FURTHER TIME-SHARING TO OPEN UP MORE PERMANENT STORAGE IS POSSIBLE, BUT THE SCHEDULE PENALTY IS HIGH.
- PERMANENT STORAGE REQUIREMENTS MUST BE SPELLED OUT IN THE SPECIFICATION (GSOP) AT START OF PROGRAMMING.
- SUMMARY OF CURRENT SUNDANCE (280)

TOTAL ERASABLES		2000 cells
PERMANENT		1373 cells (68.6%)
UNASSIGNED	E0	0 cells
	E1	0 cells
	E2	0 cells
	E3	1 cells
	E4	12 cells
	E5	0 cells
	E6	5 cells
	E7	0 cells
TOTAL		21 cells



LUMERASE (49) SUNDANCE (279)

DOWNLINK LISTS

- EACH LIST TRANSMITTED DURING ANY ONE OF A PARTICULAR SET OF PROGRAMS.
- EACH LIST CONTAINS 100 PAIRS OF REGISTERS AND IS TRANSMITTED CONTINUOUSLY WITH A CYCLE TIME OF 2 SECONDS.

DOWNLINK WORDS

- NORMALLY FOUND IN PROGRAM. SPECIAL PROGRAMMING REQUIREMENTS FOR DOWNLINK ONLY IN A FEW EXCEPTIONAL CASES.
- SOME ERASABLE MEMORY LOCATIONS MUST BE MADE ADJACENT.

DOWNLINK MILESTONES

- NASA DEFINITION OF DOWNLINK REQUIREMENTS.
- MIT DEFINITION OF DOWNLINK REQUIREMENTS FOR PROGRAM TESTING AND POST-FLIGHT ANALYSIS.
- JOINT MIT/NASA DETERMINATION OF LISTS.
- NASA DETERMINATION OF ORDER (FLIGHT MEMO WITH ORDER AND COORDINATE SYSTEMS).
- FIRST PUBLICATION OF GSOP, SECTION 2 (USED IN LEVEL 3 TESTING).
  - Abbreviated Parameter Description
  - Scaling
  - Coordinate System
  - Time Sharing Between Parameters When A Location On A List Contains More Than One Parameter
  - Flagword Bits, Spares and Garbage Registers Not Defined
  - Programs For Each List
- DEFINITION OF FLAGWORD BITS AND SPARES
  Scheduled Revision to GSOP, Section 2
- FINAL VERSION OF GSOP, SECTION 2 (FACI & 1 MONTH)
  Adds:
  - Expanded definitions of parameters
  - Frequency of calculations
  - Description of garbage registers
  - Description of any garbage quantities which are time-shared with Downlink parameters.
  - Mnemonics

STRUCTURE OF SECTION 2

FIRST PUBLICATION

- DESCRIPTION OF OPERATION OF UPLINK AND DOWNLINK PROGRAMS
- LIST OF PROGRAMS FOR EACH DOWNLINK LIST
- REFERENCE LISTS GIVING ORDER OF PARAMETERS
- PARAMETER LISTS GIVING ORDER, ABBREVIATED DESCRIPTION, SCALING, COORDINATE SYSTEMS AND TIME-SHARING BETWEEN PARAMETERS

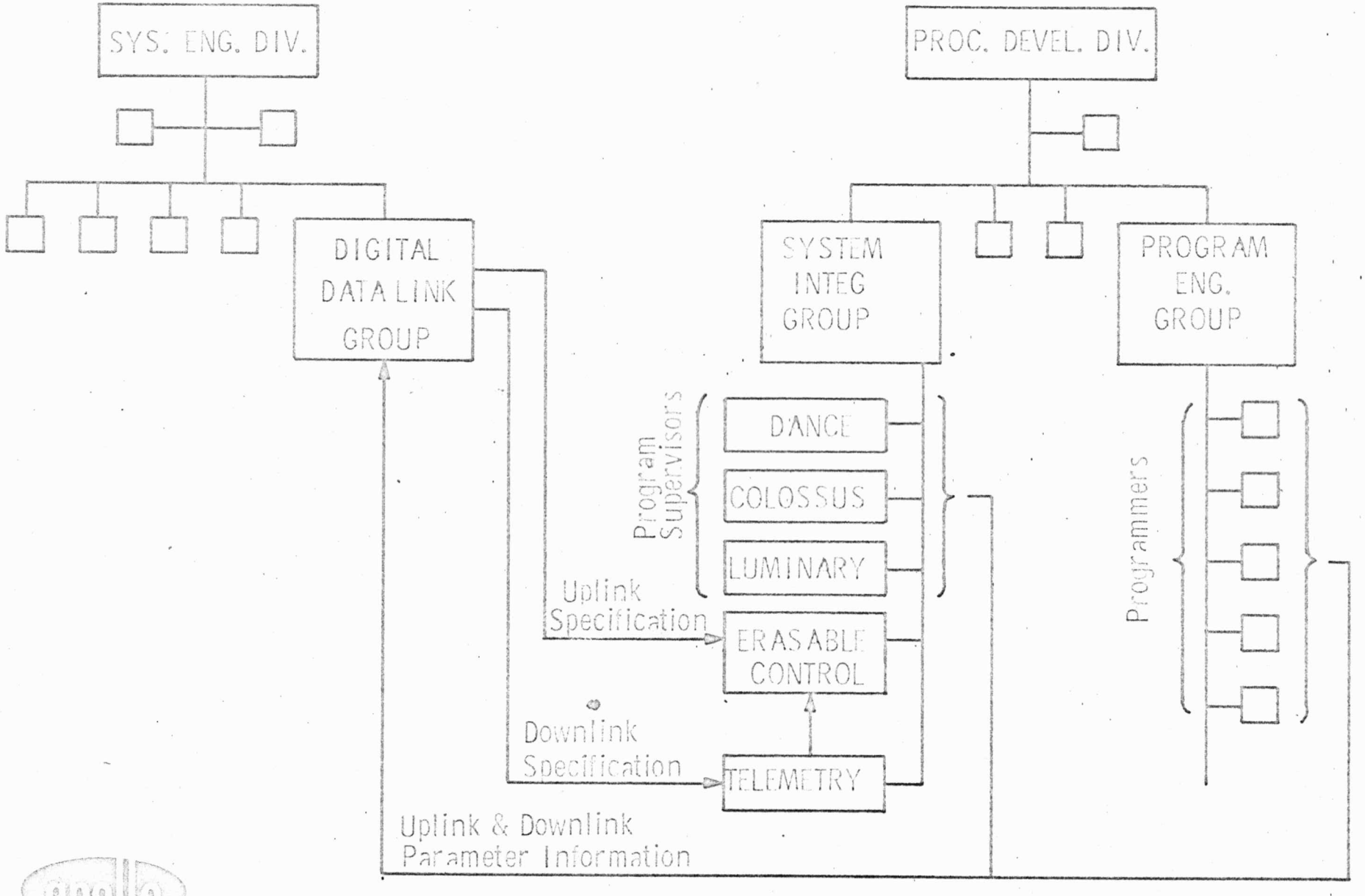
REVISIONS ADD:

- FINAL DEFINITIONS OF UPDATE PARAMETERS, SCALE FACTORS, COORDINATES AND USE OF UPDATE VERBS 71 AND 72
- DEFINITION OF FLAGWORD BITS AND SPARES
- DEFINITION OF UPDATED QUANTITY ADDRESSES

FINAL PUBLICATION ADDS:

- EXPANDED PARAMETER DEFINITIONS, FREQUENCY OF CALCULATION, MNEMONICS, DESCRIPTION OF GARBAGE REGISTERS AND DESCRIPTION OF GARBAGE QUANTITIES WHICH ARE TIME-SHARED WITH DOWNLINK PARAMETERS

DIGITAL DATA LINKS (FLOW OF INFORMATION AND DIRECTION)



Attachment D

Programmer _____ Program _____

Parameter _____

Mnemonic _____

DEFINITION OF PARAMETER. Describe in detail what it is and how it is used. What is expected range of values and variation with time?

FREQUENCY OF CALCULATION. When is it calculated and how often?

SCALING. Give scaling and indicate if it ever changes (if so, what flagbits, etc, indicate the change?)

REFERENCES. Where in other sections of the GSOP is there useful information about this parameter?

Attachment E

MISSION VERIFICATION TESTS

MV 1.0	Full Rendezvous (GET 25:45 - 29:50)
MV 1.1	Rendezvous Phase I (GET 26:27 - 27:20)
MV 1.2	Rendezvous Phase IIa (GET 27:22 - 29:50) (Track data from 27:26 on)
MV 1.3	Rendezvous Phase IIb (GET 27:22 - 29:50) (Track data from 28:10 on)
MV 1.4	Rendezvous Phase IIc (GET 27:22 - 29:50) (Track data from 28:30 on)
MV 1.8	TPI Rendezvous (GET 28:10 - 29:50)
MV 2.0	Boost Phase
MV 3.0	3rd SPS Burn (Minimum Impulse Test) (GET 94:36 - 95:40)
MV 4.0	4th SPS Burn (SCS Auto Mode SPS Burn) (GET 119:56 - 121:06)
MV 5.0	5th SPS Burn (MTVC Attitude Control during SPS Burn) (GET 168:12 - 169:27)

MV 6.0	6th SPS Burn (Minimum Impulse Test) (GET 211:46 - 212:44)
MV 7.0	7th SPS Burn (SCS Auto Mode SPS Burn) (GET 216:36 - 217:46)
MV 8.0	SPS Deorbit Burn (GET 256:11 - 259:13)
MV 8.1	SPS Deorbit Burn (short) (GET 258:00 - 259:13)
MV 8.2	CSM - RCS Deorbit Burn (GET 256:11 - 259:13) (GET 256:11 - 261:43)
MV 8.3	CSM - RCS Deorbit Burn (short) (GET 257:40 - 259:13)
MV 8.4	CM - RCS Deorbit Burn (GET 256:11 - 259:13) (GET 256:11 - 261:43)
MV 9.0	Digital Auto Pilot Tests
MV 10.0	Earth Orbital Landmark Tracking Exercise (GET 72:30 - 77:00)
MV 10.1	Star/Lunar Landmark Sighting Exercise
MV 10.2	Star/Lunar Horizon Sighting Exercise