

*Bell*

SATURN V OPERATING SYSTEM REDESIGN  
TO  
INCREASE SYSTEM RELIABILITY

ECP-1828 REVIEW

January 24, 1969



## REVIEW OUTLINE

- ° DESIGN INTENT
- ° AS-504 SYSTEM PERIPHERAL DEVICES
- ° ECP-1828 SYSTEM PERIPHERAL DEVICES
- ° CORE AND DRUM LAY-OUT
- ° MLC LOADING AND INITIALIZATION
- ° REMOTE DDAS/COUNT CLOCK AND EST REFERENCE
- ° COMPUTED EST IN THE MLC
- ° DISCRETE PROCESSING
- ° DISCRETE AND SYSTEM LOGGING
- ° IOCS
- ° SYSTEM MESSAGE ROUTINE/REMOTE DISPLAY/REMOTE PRINT
- ° DATA LINK AND REMOTE CORE-TO-CORE
- ° MLC IDLE LOOP/FUNCTION EXECUTOR
- ° RECOVERY
- ° LCC UTILITIES



## SATURN V OPERATING SYSTEM REDESIGN

### TO INCREASE SYSTEM RELIABILITY

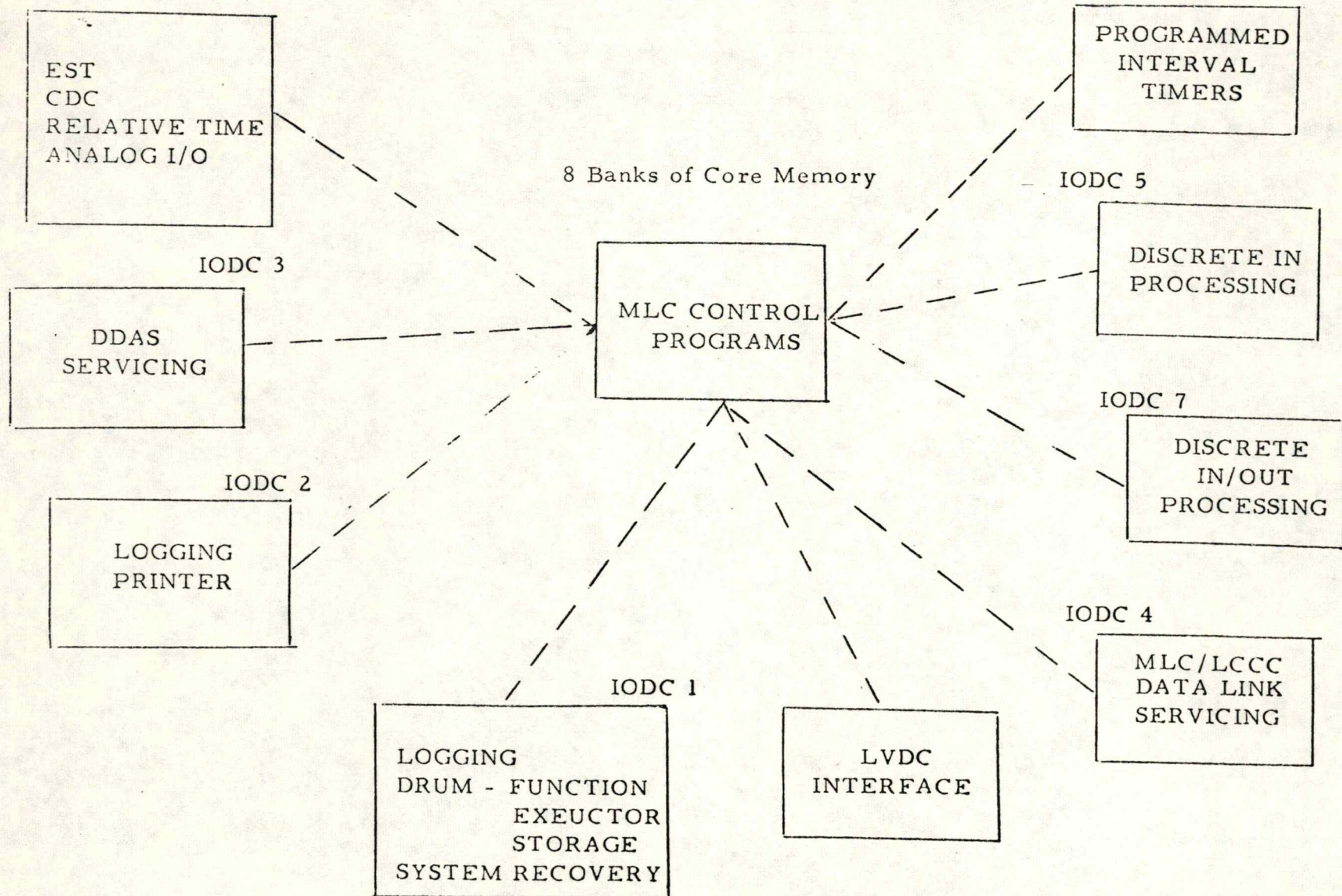
As presently designed, a peripheral hardware failure in the Mobile Launch Computer may result in a delay or possibly a cancellation of launch of a Saturn V vehicle.

The proposed Operating System will require a minimum of peripheral hardware in the remote computer; therefore, the total reliability of the system will be increased. It is designed to be I/O device independent and capable of supporting vehicle checkout with the printer, the card reader, all tape handlers, the Count Clock System, the Relative Timers, and the DDAS IODC inoperative. It will support vehicle checkout and major test support with the drum inoperative. The design intent is to minimize launch critical peripheral equipment in the Mobile Launch Computer to: the MLC/LCCC Data Link, the Discrete Output Equipment, the RCA-110A/LVDC Interface and four banks of core memory.



AS-504

MLC SYSTEM PERIPHERAL DEVICES



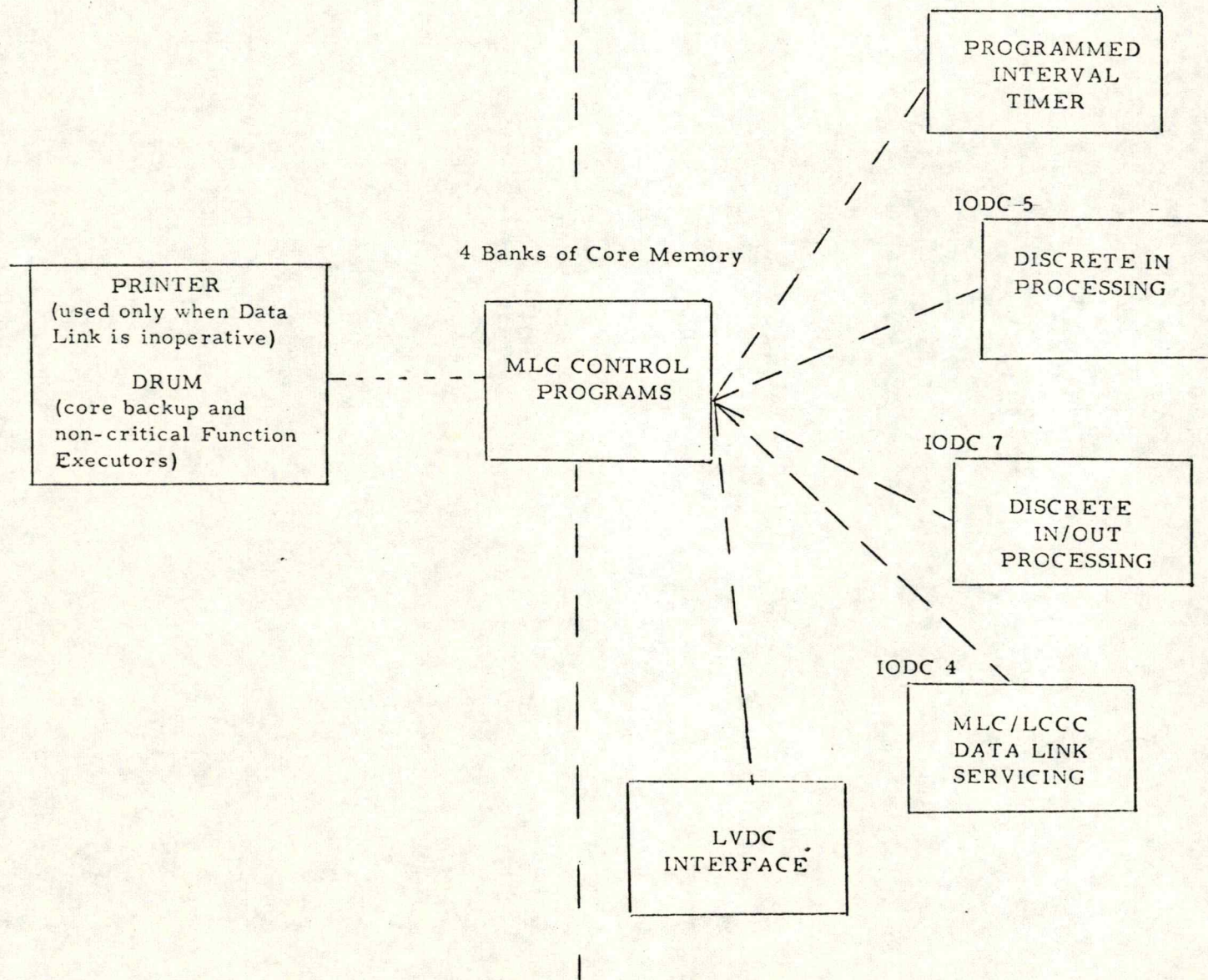


ECP-1828

MLC SYSTEM PERIPHERAL DEVICES

NOT REQUIRED FOR SYSTEM OPERATION

REQUIRED FOR SYSTEM OPERATION





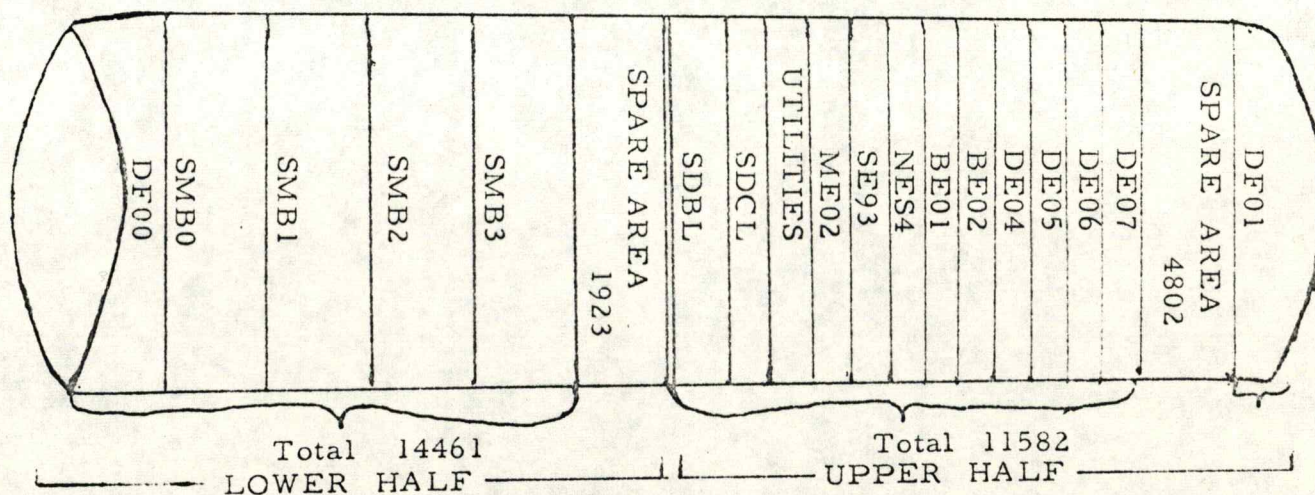
MOBILE LAUNCHER  
SYSTEM REQUIREMENTS

AS-504	ECP-1828
<ul style="list-style-type: none"><li>◦ Data Link</li><li>◦ Discrete I/O Equipment</li><li>◦ LVDC Interface</li><li>◦ 8 Banks Memory</li><li>◦ Count Clock</li><li>◦ Analog Input/Output</li><li>◦ Printer</li><li>◦ Programmed Interval Timers</li><li>◦ Drum<ul style="list-style-type: none"><li>◦ Opsys Loading</li><li>◦ System Messages</li><li>◦ Function Executor Storage</li></ul></li><li>◦ DDAS</li><li>◦ Relative Time Clock</li><li>◦ EST Clock</li><li>◦ Tapes<ul style="list-style-type: none"><li>◦ Opsys Loading</li><li>◦ Logging (two tapes)</li><li>◦ Diagnostic Tape</li></ul></li></ul>	<ul style="list-style-type: none"><li>◦ Data Link</li><li>◦ Discrete I/O Equipment</li><li>◦ LVDC Interface</li><li>◦ 4 Banks Memory</li><li>◦ Programmed Interval Timers</li><li>◦ Printer (used only if Data Link is inoperative)</li><li>◦ Drum</li><li>◦ Analog Input</li><li>◦ Diagnostic Tapes (Not required or supported by Operating System)</li></ul>



# CORE AND DRUM LAY-OUT

		Total Area in use	Total Area available	
0	Tables and Constants Interrupt Processor Utility Conversion Routines System Error Recovery Data Link/Remote Core-to-Core MLC Analog I/O	3971	122	4
1	Discrete Executive Time Sync Routine LVDC Interface	3908	185	5
2	Manual Dump Routine Utility Executive System Logging (SLOG) System I/O Control (IOCS) Remote DDAS System Message/Remote Print and Display Function Executor Control Drum IVAR Search	3609	484	6
3	FE50 GE01 GE16 CE00 ME01	1818	230	7
	Drum Function Executor Buffer	2045		





## MLC LOADING AND INITIALIZATION

- Loaded via LCC Test Program (NT95)
  - Sense Switch 2 Option to stack NT95 during initial load of LCC computer.
  - Debugging Features :
    - Patches Loaded at LCC by Test Program
    - Test Function Executors Loaded at LCC
- Loaded from Drum Backup
  - Bootstrap loader will provide a checksum.
- Discrete Initialization Program (NT98)
  - Current program is modified to load subsystem assignments from the System Master Tape.

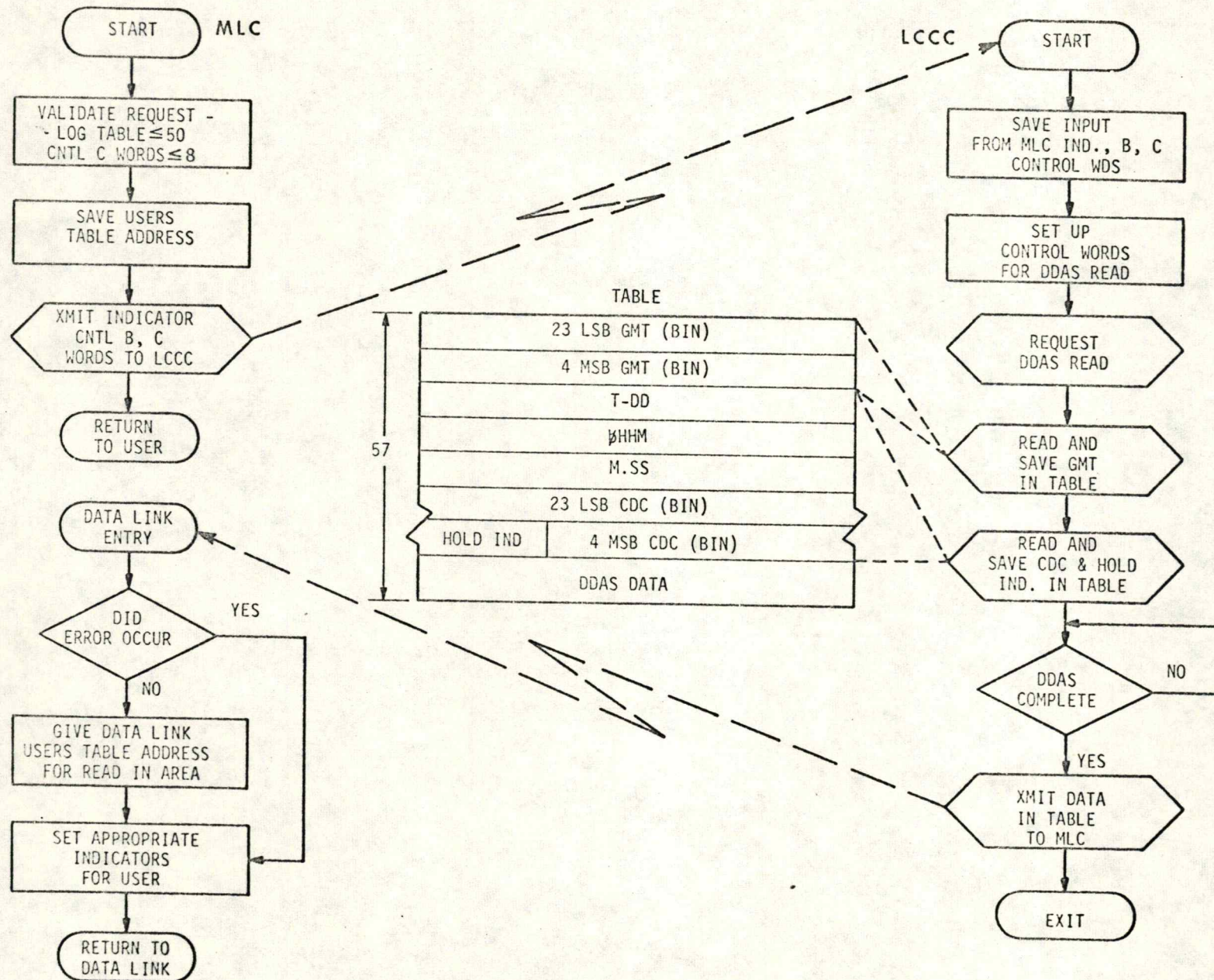


## REMOTE DDAS/COUNT CLOCK AND EST REFERENCE

- DDAS readings are supplied by the Operating System from the LCC computer.
- The Operating System provides, as part of the data read, the EST and Count Clock value and Count Clock status at the time of the DDAS reading in the LCC computer.
- The Operating System provides a special entry to Remote DDAS Read to read time values only.
- Restrictions On Use
  - DDAS Modes Single Scan Sequential Transfer and Log Mode Terminate on 1/2 Full will be supported.
  - Control A, B, and C words must be contiguous in core memory.
  - Maximum of 8 Control C words allowed (allows for 100% expansion of largest - BE02).
  - Maximum of 50 DDAS Data Words allowed (BE02 requires 24).



# REMOTE DDAS



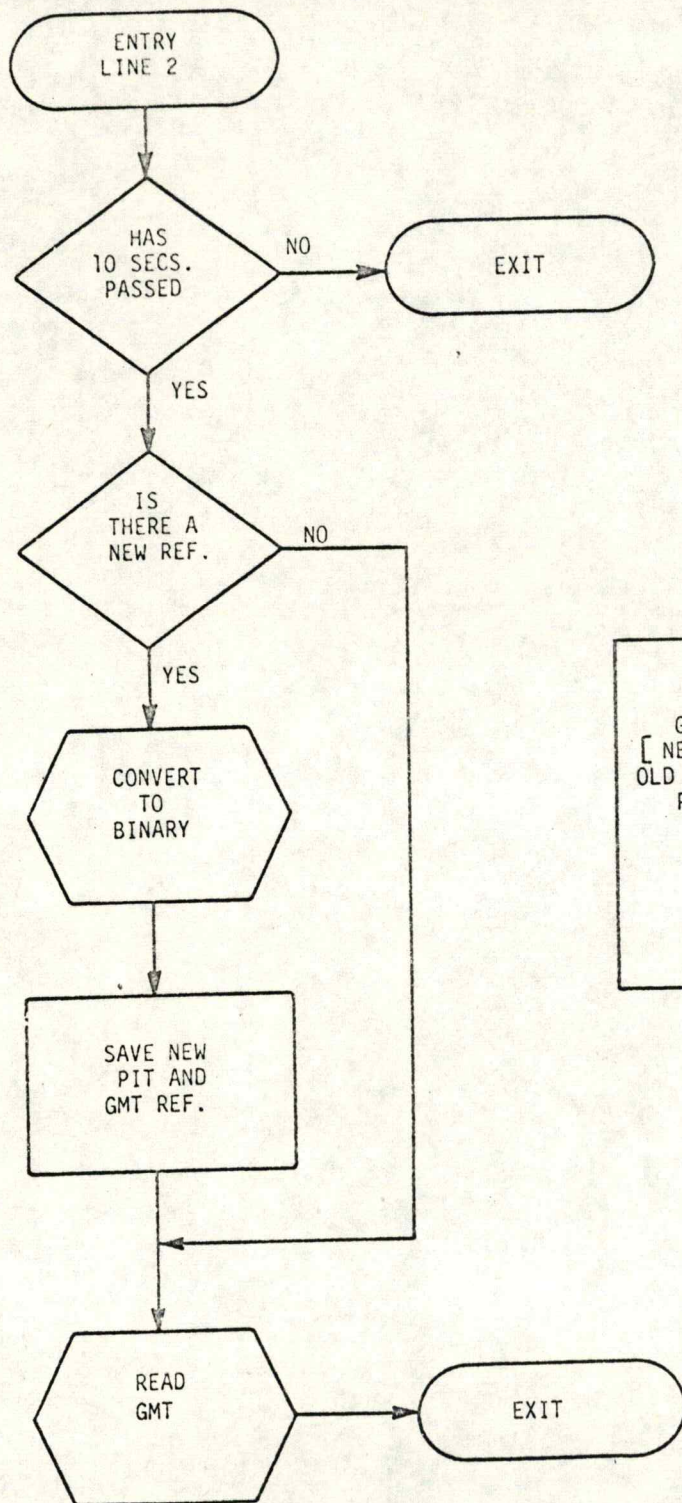


## COMPUTED EST IN MLC

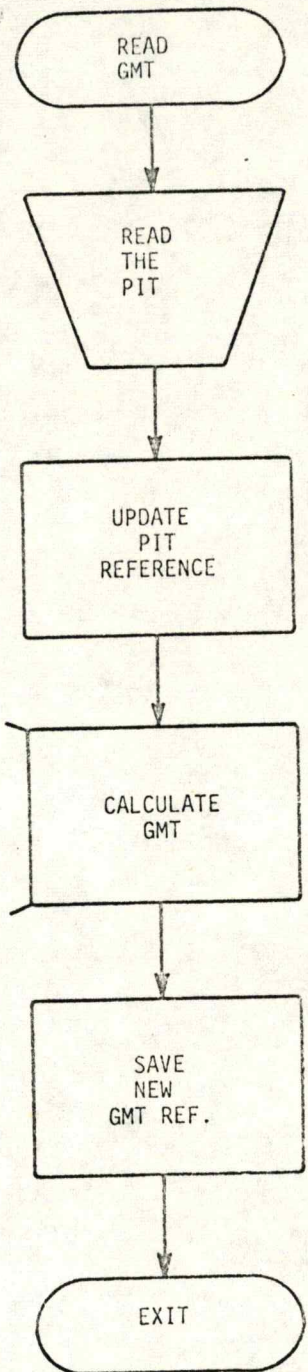
- ° GMT is required by the:
  - ° LVDC Interface Routine
  - ° MDO Logging Routine
  - ° FE50 Accelerometer Monitor
- ° GMT will be established in the MLC every 10 seconds if there is any LDI to MDO activity.
- ° GMT will be computed and updated on each request.
- ° Accuracy of computed GMT can only be altered by Line 7 or Line 8 activity. The Line 7 and Line 8 routines will suppress EST update.
- ° Accuracy of PIT is 0.005%.
- ° Estimated average MLC overhead per second is 0.36 milliseconds.
- ° Estimated average LCC overhead per discrete change buffer transmission is 0.9 milliseconds.



# MLC GMT



$$\text{GMT REF.} + [\text{NEW PIT REF.} - \text{OLD PIT REF.}] = \text{PRESENT GMT READING}$$





# LDI DISCRETE PROCESSING

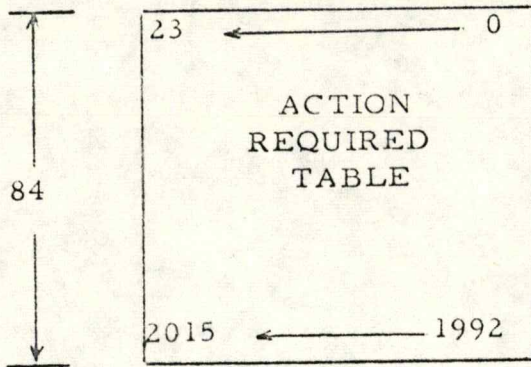
3A

Switch Type	Error Checking	Advantages
TYPE I		
<p><u>LDI</u> = <u>MDO</u></p> <p><u>LDI</u> 000-479      MDO 000-479</p> <p>Complex switch action only</p>	<p>Log &amp; History</p> <p>More than 7 Bypass Groups</p>	<p>Faster processing</p> <p>Action table not required</p>
TYPE IIA		
<p><u>LDI</u> = <u>MDO</u></p> <p><u>LDI</u> = <u>MDO</u></p> <p><u>LDI</u> 480-695      MDO 480-695</p> <p>Complex switch action only</p> <p><i>Complex ON → AUTO MDO OFF</i></p> <p><i>Simple ON → AUTO MDO ON</i></p>	<p>Log &amp; History</p> <p>Side by Side</p>	<p>Faster processing</p> <p>Action table not required</p> <p>Increased hardware error checking</p>
TYPE IIB		
<p>LDI 0696-0863</p> <p><u>LDI</u> Issue SS Function and/or Inhibit</p> <p><u>LDI</u> Issue SS Function and/or Inhibit</p> <p><u>LDI</u> Issue SS Function or Inhibit</p>	<p>Log &amp; History</p> <p>More than 7</p>	<p>Minimum action table required</p>
TYPE IIC		
<p>LDI 0864 0959, 0984-1103</p> <p><u>LDI</u> No Action</p>	<p>Log &amp; History</p>	<p>No action table required</p> <p>Fast processing</p>
TYPE IID		
<p>LDI 0960-0983</p> <p><u>LDI</u> Subroutine</p>	<p>Log &amp; History</p>	<p>No action table required</p> <p>Faster processing</p>
TYPE III		
<p>LDI (even) } MDO <math>\left[ \frac{\text{LDI even}}{2} \right] + 504</math></p> <p>LDI (odd) }</p> <p>LDI 1104-3023      MDO 1056-2015</p> <p>Complex or simple switch action</p>	<p>Log &amp; History</p> <p>Side by Side</p>	<p>Faster processing</p> <p>Increased hardware error checking</p> <p>Only an 80 word action table</p>
MDI DISCRETE PROCESSING		
MDI = LDO	Log & History	84 word action required table



# DISCRETE ACTION TABLES

MLC



LCCC

TYPE IIB.  $863 \geq \text{LDI} \geq 696$

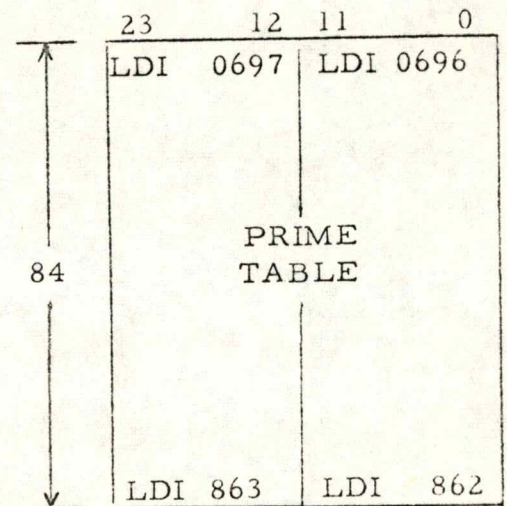
## PRIME TABLE WORD FORMATS

11	10	9	7	6	0
INHIBIT CODE		STAGE CODE		SWITCH SEL. CHANNEL #	

Inhibit Code: 00 for Inhibit SWSEL Chan  
 10 for No Inhibit  
 11 for Inhibit SWSEL Counteracting Chan

Stage Code: 001 for IU  
 010 for S-II  
 011 for S-4B  
 100 for S-IC

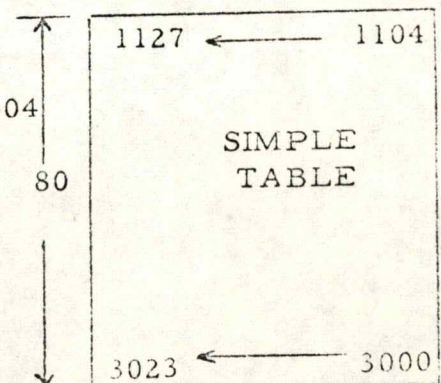
\* Spare SWSEL LDI is coded 7777



TYPE III.  $3023 \geq \text{LDI} \geq 1104$

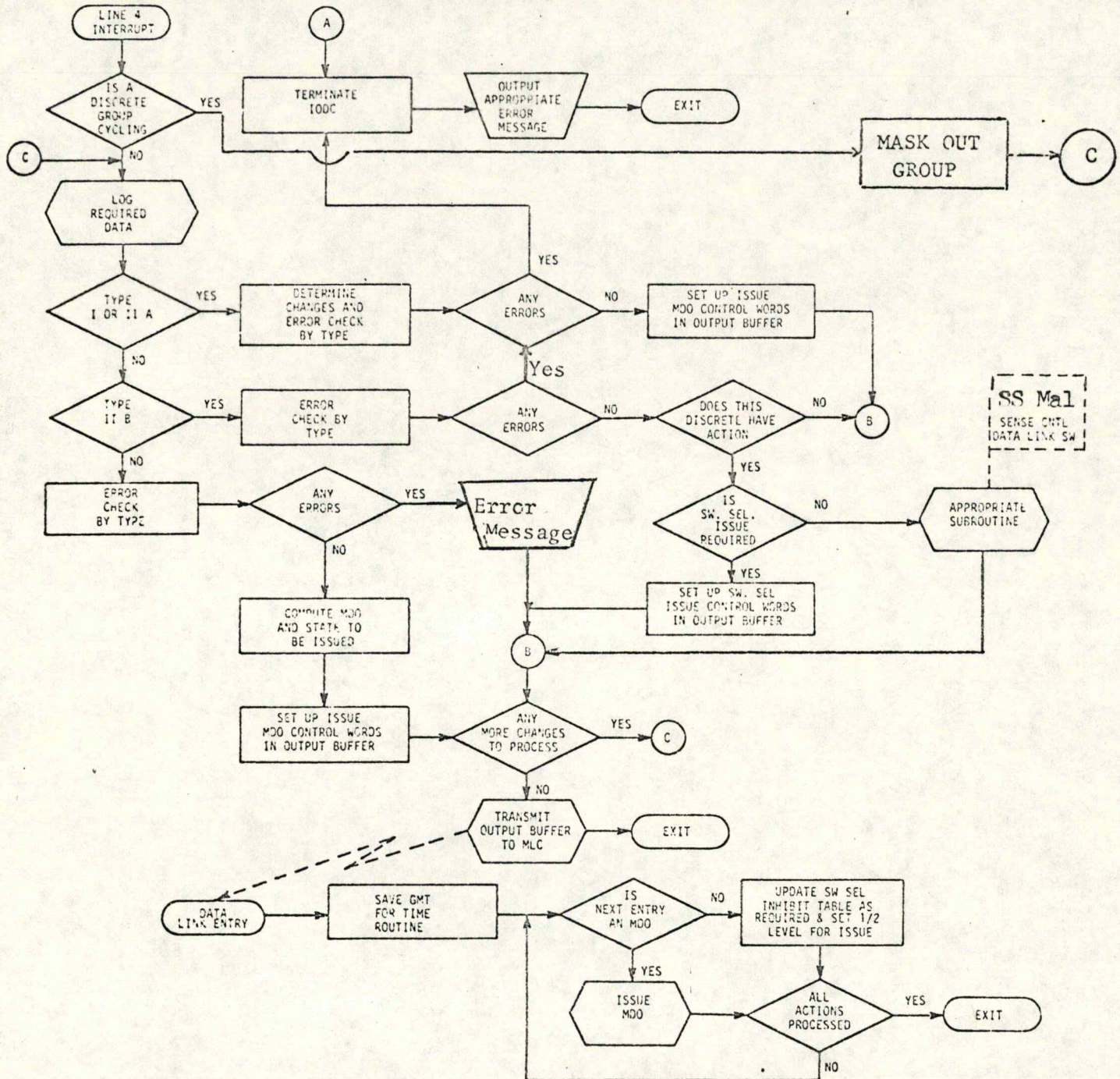
$$\text{MDO} = \left\lfloor \frac{\text{LDI (EVEN)}}{2} \right\rfloor + 504$$

EVEN	ODD	
LDI	LDI	MDO
1	0	1
0	1	0



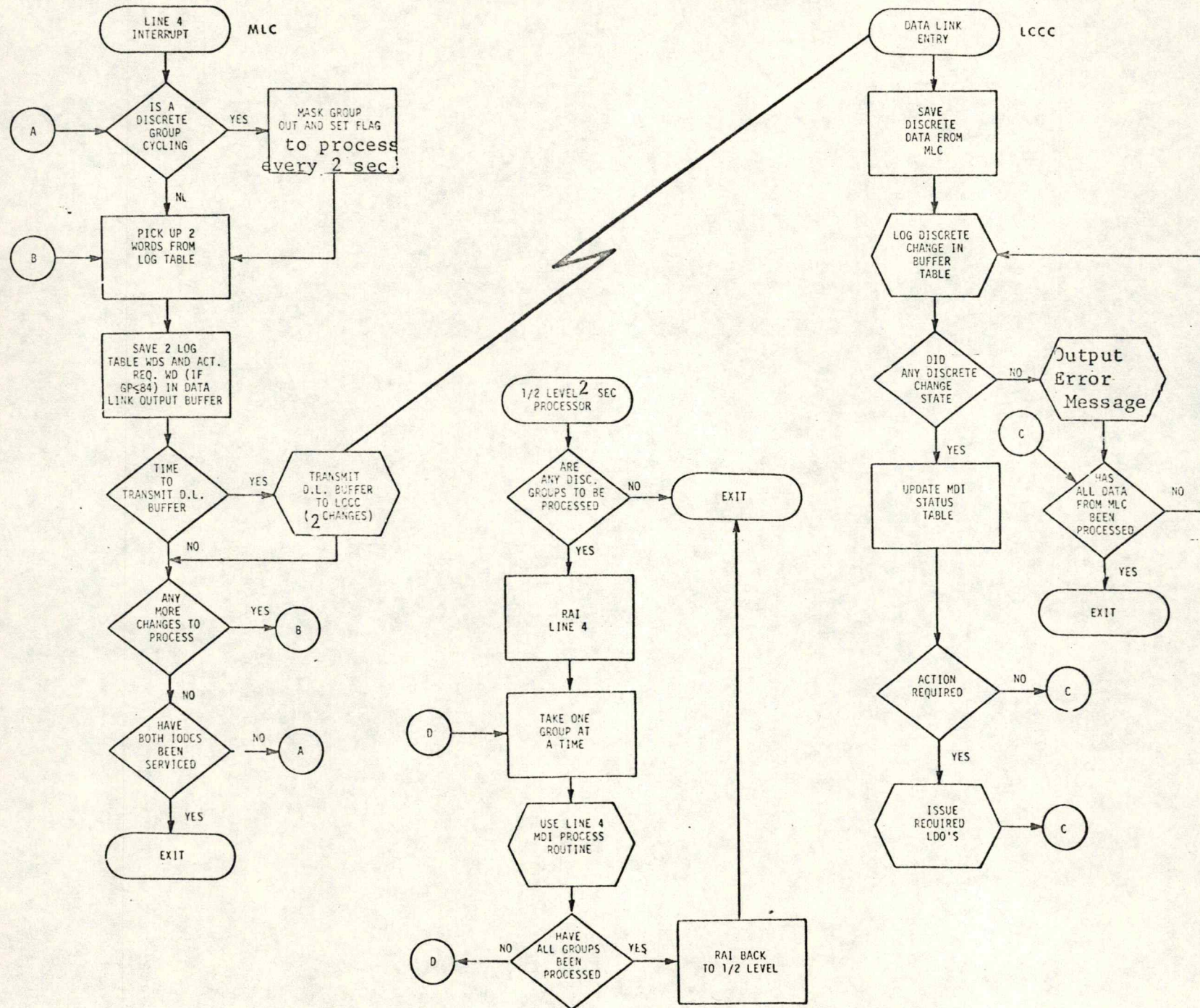


# LDI PROCESSING



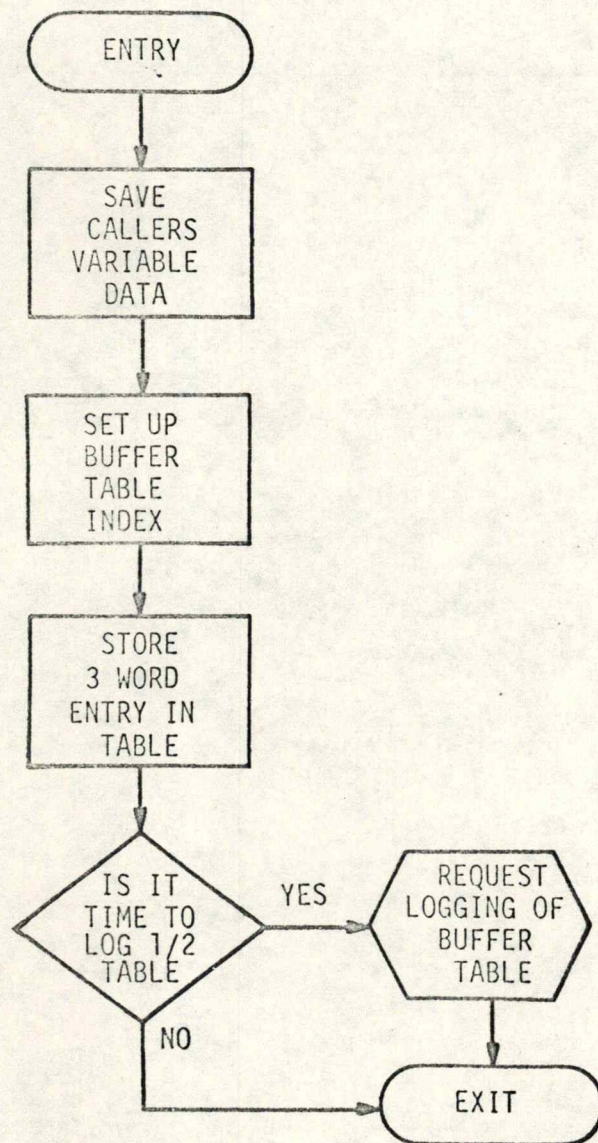


# MDI PROCESSING





# DI/LDO LOGGING



Note 1	Note 2	4MSB GMT (Gray)	LDO IND	Complement LDO Group #	} LDO CHANGE ENTRY
23 LSB GMT (Gray)					
LDO Group Status					
LDI MDI	Note 3	Note 4	IODC IND	DI IND	} LDI/MDI CHANGE ENTRY
DI Group Status					
DI Group #	18 Bits Relative Time				

Note 1 - Bit set if change was caused by DI

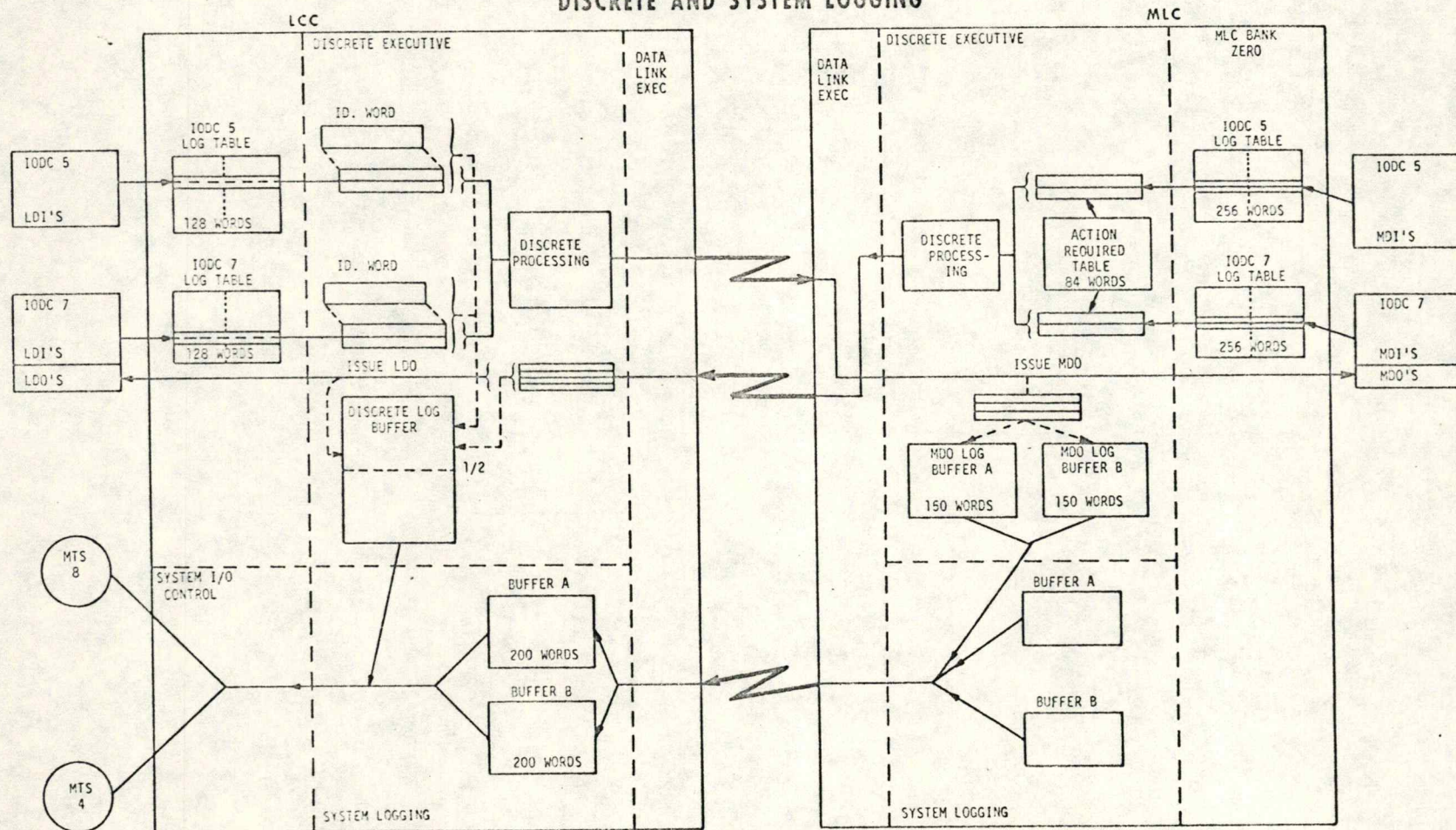
Note 2 - Bit set if change occurred when system was in IDLE Mode, not set if system was in GO Mode.

Note 3 - No Log and History

Note 4 - Start of Scans



# DISCRETE AND SYSTEM LOGGING





## IOCS

- ° Supports only DRUM (IODC 1) and Printer (IODC 2)
- ° Routines Simplified
- ° Error Messages Maintained
- ° Error Counters Maintained
- ° Calling Sequence Same as Before

## SYSTEM MESSAGE/REMOTE DISPLAY/REMOTE PRINT

- ° Combining Functions Makes Efficient Use of Buffer Areas in LCC.
- ° All Canned Messages on LCC Drum
- ° If Display Fails, Message is Printed in LCC
- ° If Data Link Fails, Message Number and Variable Data are Printed on the Local Printer
- ° User Complete Bits are Set after Transmission is Complete to the LCC

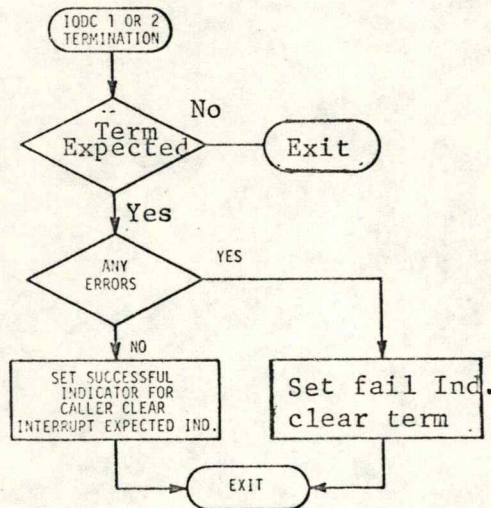
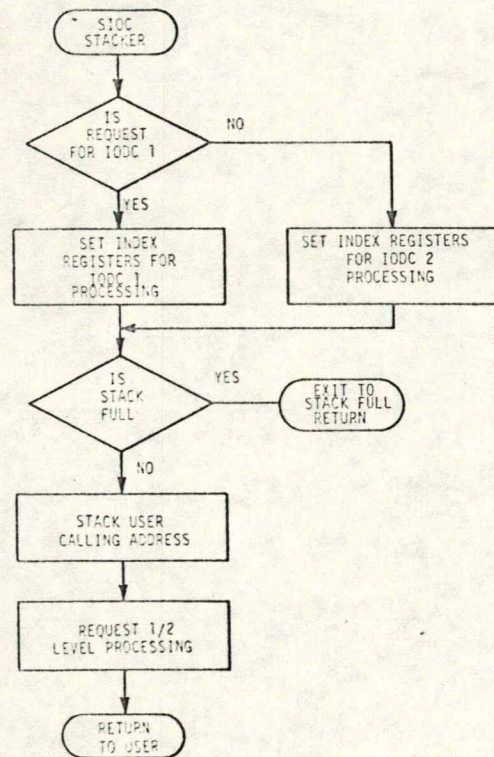
## DATA LINK/REMOTE CORE-TO-CORE

- ° Combining Functions Provides Faster Remote Core-to-Core Operations
- ° Special Functions for EST Update in MLC

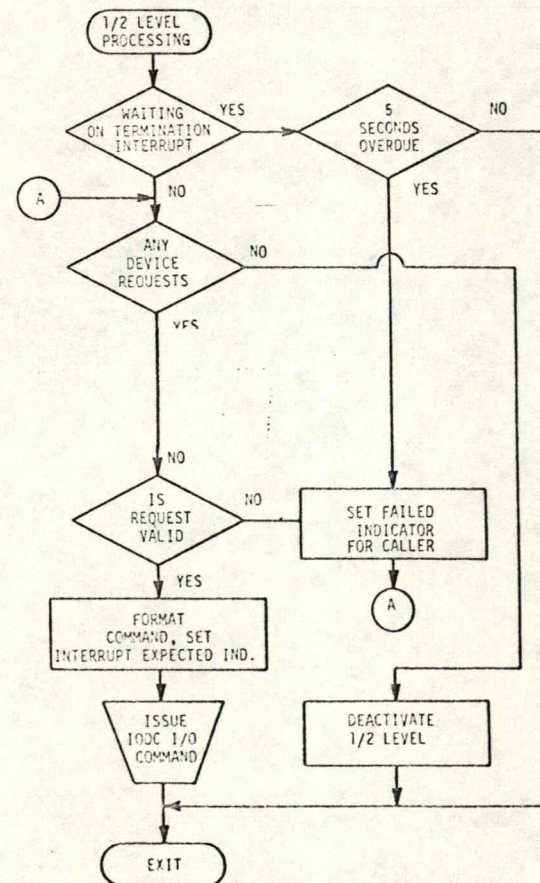


# SYSTEM I/O CONTROL

IODC 1/IODC 2



IODC 1/IODC 2

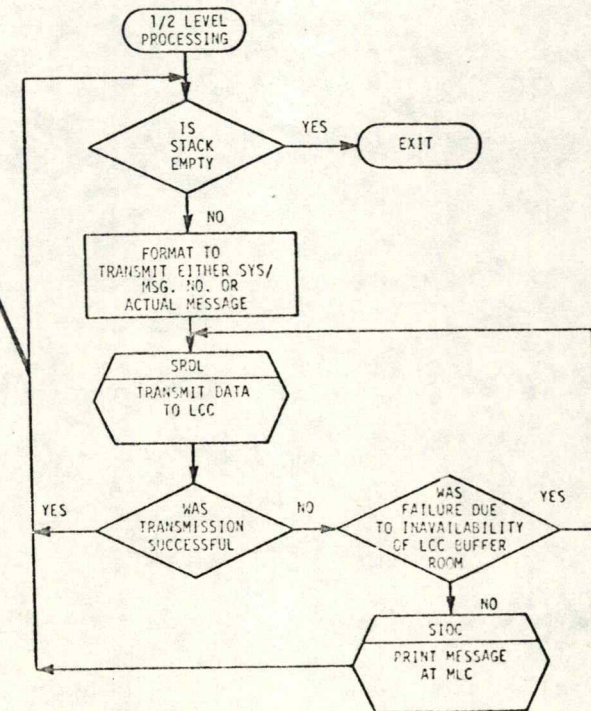
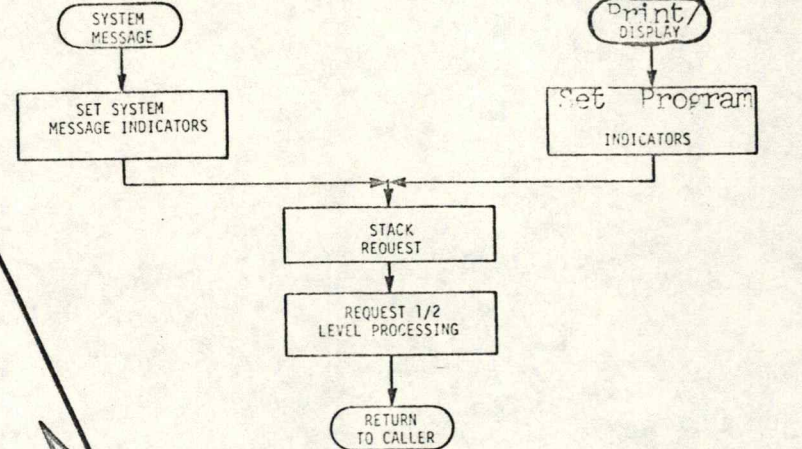
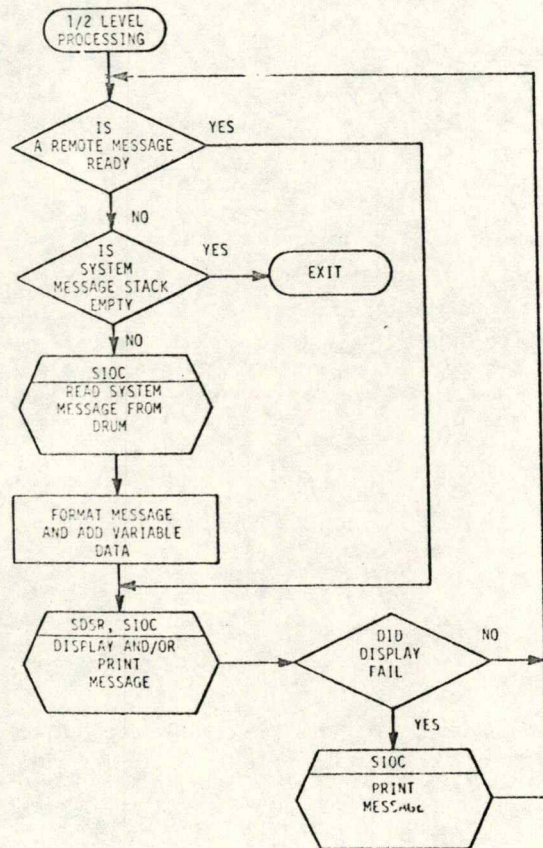
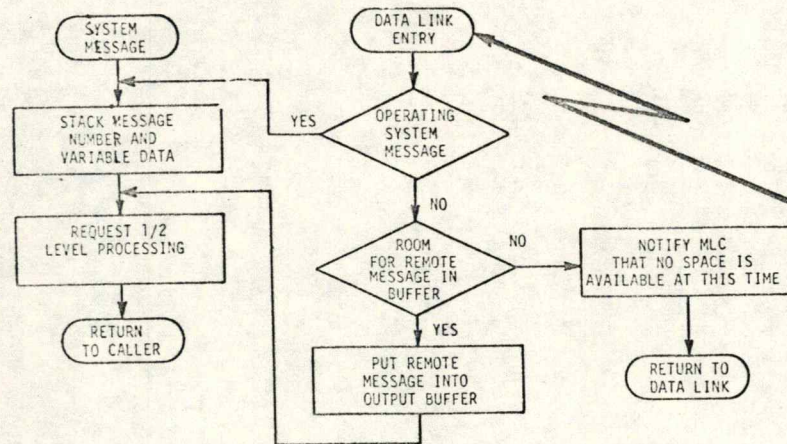




# SYSTEM MESSAGE

LCC

MLC





## MLC IDLE LOOP/FUNCTION EXECUTOR CONTROL

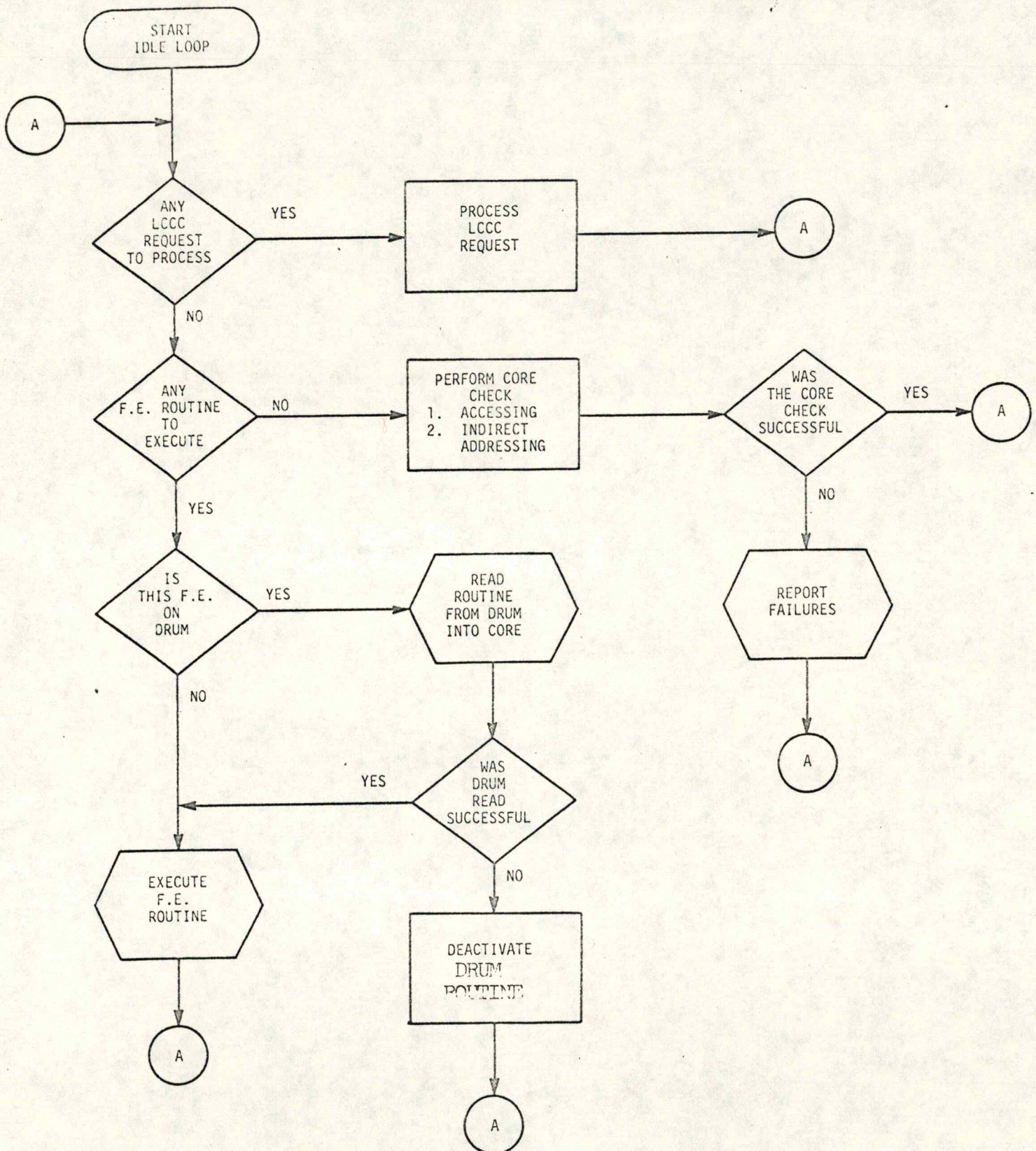
- Current Scheduling of Function Executors Remains
- Addressing Memory Check on each Idle Loop (Banks 0-7)
- Drum Check is made after each Drum Read.
- Should the drum fail, the requested Function Executor on drum will be deactivated.
- A new request for a drum resident Function Executor will activate drum operation.

## RECOVERY

- LCC Same as Present
- MLC Controlled by LCC Test Program (ST90)
  - Data Logged in LCC
  - Same Major Functions as Currently Provided
  - Off-Line Diagnostic Loader Passed Down Data Link if in Slow Diagnostic Mode of Recovery

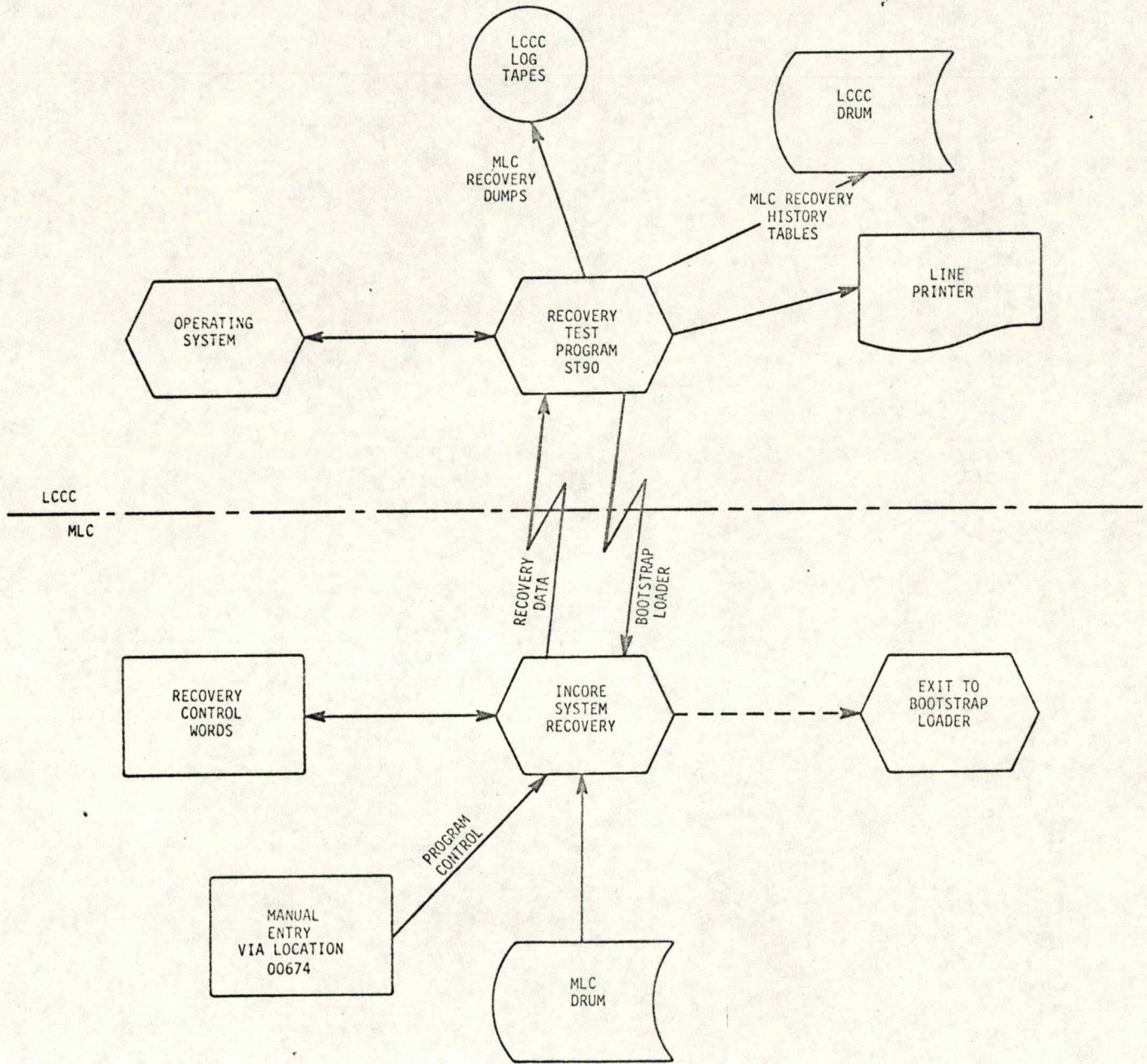


# MLC IDLE LOOP





# RECOVERY



NORMAL  
BOOTSTRAP  
LOADER

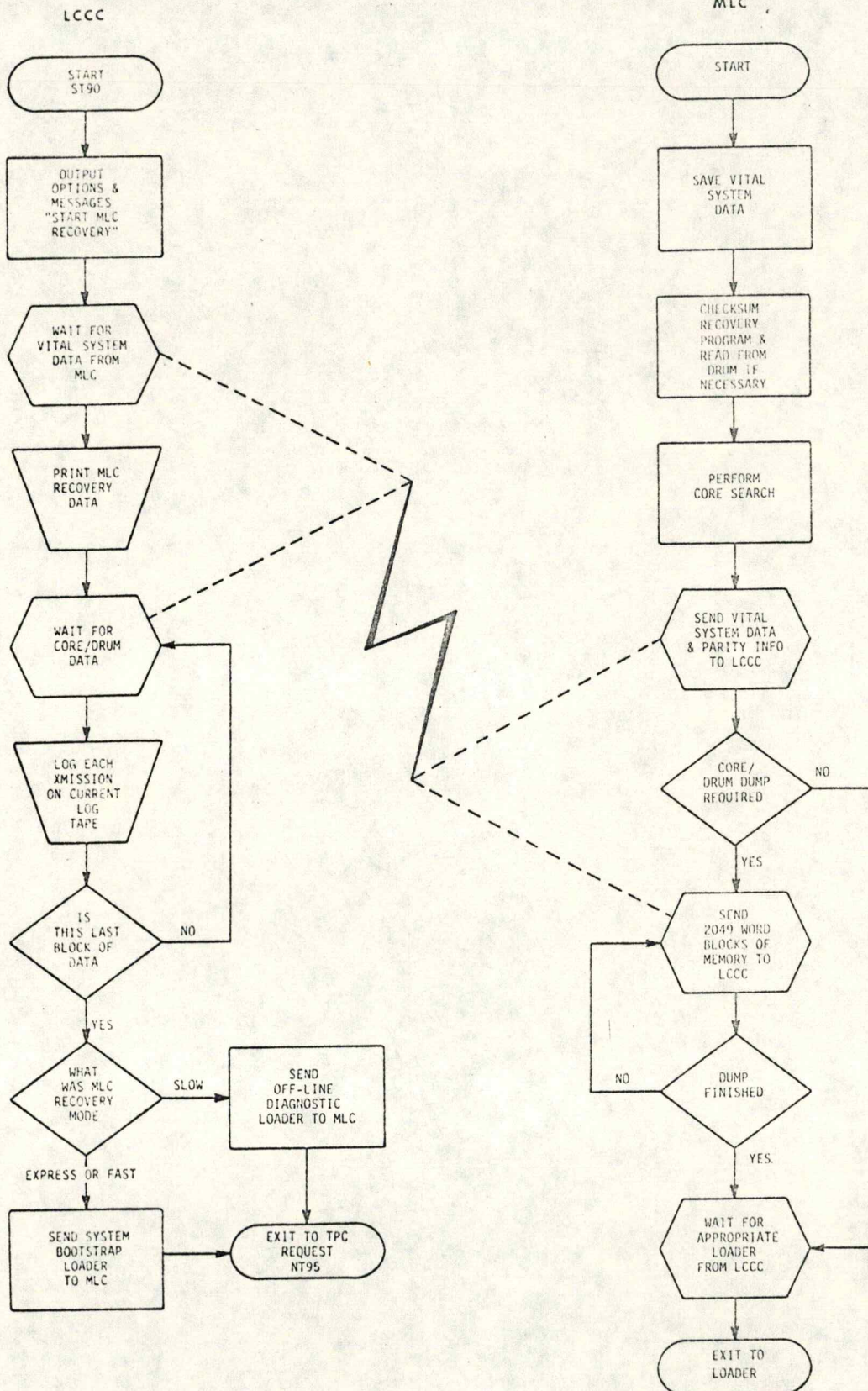
OFF-LINE  
DIAGNOSTIC  
LOADER

IF IN EXPRESS OR FAST DIAGNOSTIC MODE, NORMAL OPERATING SYSTEM SHOULD BE RELOADED -  
 FAST DIAGNOSTIC - DE04 Stacked by NT95  
 DE05 } if it was called  
 DE06 }  
 DE07 by ST90

IF IN SLOW DIAGNOSTIC MODE - OFF-LINE DIAGNOSTIC LOADER will BE GIVEN CONTROL



# RECOVERY





## LCC MAGNETIC TAPE STATION RE-ALLOCATION

- ° A logical MTS may be re-assigned to another IODC via System Utility \$ULTAX-Y  
where: X = IODC  
Y = MTS Number
- ° All subsequent commands will be routed via System I/O Control to new IODC.
- ° Initial MTS Assignment  
MTS 1-5 IODC 1  
MTS 6-9 IODC 2
- ° Utility to provide current status  
\$ULTA  
Table of current assignments will be displayed.

## MLC UTILITY EXECUTIVE

- ° Each Utility Routine is stored on Drum
- ° Console keyboard print requests are printed on the LCC line printer.
- ° Manual core print is printed on local printer.

## MLC ANALOG READ ROUTINE

- ° Reads MLC DC Analog Test Point
- ° Called from LCC or MLC
- ° Cannot be called by DMON