Massachusetts Institute of Technology
C. S. Draper Laboratory
Cambridge, Massachusetts

LUMINARY Memo #220

To: Distribution

From: C. W. Schulenberg

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Subject: Erasable Memory Program for LUMINARY Rev. 210 to Provide Backup for DSKY Keys

Summary

The erasable memory program discussed in this memo was developed in order to provide a reasonable workaround technique in the case of a DSKY failure in which any one of the keys, exclusive of the PROCEED/STANDBY key, are failed "open", i.e., activation of the key does not trigger a KEYRUPT interrupt in the LGC. The program was designed to be operative at all times during a mission, with certain qualifications that are discussed later, and is unaffected by software restarts such as V37, BAILOUTs, POODOOs, etc. In addition, except at certain well-defined times, the program will continue operation through a hardware restart. A fresh start, however, will always require reactivation of the program. Reloading of the program should never be necessary.

General Design

The erasable program resides entirely within Executive storage, namely, Core set 8 and Vac area 5. In order to prevent itself from being altered, the program, when activated, continually reserves these areas to keep the Executive from making these storage locations available for job processing. The program itself is called every 20 ms by the Downlink routine once it is activated and it is this device that endows the program with protection from software restarts. Aside from using the Downlink routine to get on-the-air every 20 ms, and thus increasing the duration of the interrupt, this program in no way interferes with the operation of Downlink. At the current time the Engine Gimbal Enable switch is being used to signal the erasable program that a keystroke should be entered via a job call to CHARIN. A dedicated erasable is used

in the program to hold the particular keycode that is being backed-up and each time that the Engine Gimbal Enable switch is switched from the ON to the OFF position, a single keystroke will be induced. Hardware restart protection is afforded by using Group 1, whenever it is available, to schedule a task to redirect the Downlink routine. When the program is in operation it increments REDOCTR by 100 every 20 ms. Since REDOCTR is on all downlists this is a good mechanism for monitoring operation of the program. In addition the data that REDOCTR normally imparts can still be extracted (unless the number of hardware restarts exceeds 99 in any two second interval).

Loading, Activation, and Etc.

Note: The following uplinked keystroke sequences should be performed when the CPU is relatively inactive. This is due to the slight risk involved with writing into Executive storage areas.

Load 1

```
                V 71 E
                  15 E
                 300 E
                35000 E
                54003 E
                41436 E
                60720 E
                10000 E
                 731 E
                 310 E
                40025 E
                55052 E
                 731 E
                77776 E
          V1 N1 E 313 E        Insure that core set 8 is available
            if R1 = 77777,     before loading into it (see note above)
                V 33 E
```

Load 2

```
                V 71 E
                  14 E
                 660 E
                   E
                44744 E
                54313 E
                34746 E
                54660 E
                34734 E
                   6 E
                2032 E
                56727 E
                10000 E
          V1 N1 E 660 E        Insure that Vac area 5 is available
           If R1 = 00660,      before loading into it (see note above)
                V 33 E
```

Load 3

```
V 71 E
  14 E
 672 E
 674 E
 713 E
10727 E
 713 E
34346 E
 5063 E
 2057 E
60101 E
30730 E
 710 E
 V 33 E
```

Load 4

```
 V 71 E
   14 E
  710 E
74337 E
50064 E
54154 E
10752 E
  300 E
 5355 E
47011 E
    1 E
  723 E
10100 E
 V 33 E
```

Load 5

```
 V 71 E
   14 E
  722 E
  731 E
30726 E
54335 E
 5263 E
  661 E
  400 E
   KK E
34770 E
26320 E
 3532 E
 V 33 E
```

Keycode to be backed up*

*KK:

01 = "1"	20 = "0"
02 = "2"	21 = "VERB"
03 = "3"	22 = "ERROR RESET"
04 = "4"	31 = "KEY RELEASE"
05 = "5"	32 = "+"
06 = "6"	33 = "-"
07 = "7"	34 = "ENTER"
10 = "8"	36 = "CLEAR"
11 = "9"	37 = "NOUN"

To activate: V 21 N 1 E 335 E 661 E

To monitor for operation: V 11 N 1 E 320 E
(examine REDOCTR)

To alter keycode: V 21 N 1 E 730 E KK E

To deactivate: V 21 N 1 E 335 E 3532 E
then select some program via V37 to disengage hardware restart protection.

Program Code

Location	Tag	Code		Octal
		Core Set 8		
300	MPAC + 84D	CA	EBANK3	35000
301	MPAC + 85D	TS	EBANK	54003
302	MPAC + 86D	CS	PHSNAME1	41436
303	MPAC + 87D	AD	TSKECADR	60720
304	MPAC + 88D	CCS	A	10000
305	MPAC + 89D	TC	COMMEXIT	00731
306	MPAC + 90D	TC	+2	00310
307	MODE + 84D	TC	COMMEXIT	00731
310	LOC + 84D	CS	TIME1	40025
311	BANKSET + 84D	TS	TBASE1	55052
312	PUSHLOC + 84D	TC	COMMEXIT	00731
313	PRIORITY + 84D			77776
		Vac Area 5		
660	VAC5USE			00000
661	"Entry Point"	CS	BIT1	44744
662		TS	PRIORITY + 84D	54313
663		CA	ZERO	34746
664		TS	VAC5USE	54660
665		CA	BIT9	34734
666		EXTEND		00006
667		RAND	CHAN32	02032
670		XCH	MULTFLAG	56727
671		CCS	A	10000
672		TC	+2	00674
673		TC	CHKPHASE	00713
674		CCS	MULTFLAG	10727

```
675                     TC      CHKPHASE        00713
676                     CA      PRIO30          34346
677                     TC      NOVAC           05063
700                     2CADR   CHARIN          02057
701                                             60101
702                     CA      KEYBKUP         30730
703                     TC      AFTGOLOC        00710
704     GOLOC -1
705     GOLOC           These four cells are used by the
706     GOLOC +1        RESTARTS routine
707     GOLOC +2
710     AFTGOLOC        MASK    LOW5            74337
711                     INDEX   LOCCTR          50064
712                     TS      MPAC            54154
713     CHKPHASE        CCS     PHASE1          10752
714                     TC      MPAC + 84D      00300
715                     TC      PHASCHNG        05355
716                     OCT     47011           47011
717                     OCT     1               00001
720     TSKECADR        OCT     723             00723
721                     OCT     10100           10100
722                     TC      COMMEXIT        00731
723                     CA      EPROGAD         30726
724                     TS      DNTMGOTO        54335
725                     TC      TASKOVER        05263
726     EPROGAD         OCT     661             00661
727     MULTFLAG        OCT     400             00400
730     KEYBKUP         OCT     KK              000KK
731     COMMEXIT        CA      1SEC            34770
732                     ADS     REDOCTR         26320
733                     TC      DNPHASE2        03532
```

Further Comments

1. Once the program is activated by directing the DNTMGOTO cell to point to location 661, operation will continue unless terminated by a Fresh Start or a hardware restart occurring at a time when group 1 is being used by other programs. Group 1 will be unavailable during the time that ullage has been scheduled prior to a burn (ULLGTASK) and, in descent, when antenna repositioning is in progress (REREPOS). If operation has been halted as evidenced by REDOCTR not incrementing in multiples of 100, the program can be reactivated by uplinking V 21 N 1 E 335 E 661 E.

2. This erasable program must not be activated while an erasable dump is in progress as a result of selection of V74. Nor should V74 be selected while the program is in operation since this will deactivate it by causing the DNTMGOTO cell to be altered.

3. This erasable program is designed to operate at all times, but since it steals resources from the Executive routine the likelihood of 31201 and 3202BAILOUTs (no Vac areas and no Core sets, respectively) is increased. In particular, too much demand upon the LGC during Rendezvous may produce an occasional 31201BAILOUT. This would most likely occur if an extended verb were exercised during a period of high CPU activity. The BAILOUT, however, would clean out the extended verb and the erasable program would continue operation.

4. This erasable program will issue one and only one keystroke each time the Engine Gimbal Enable switch is switched from ON to OFF. Since the sample rate is 50 times per second, the switch can be toggled from ON to OFF to ON as fast as desired.

5. The increase in CPU activity as a result of operation of this program will be at least 26.325 milliseconds per second (a 2.6325 % slice of the CPU time). Slightly more time will be required each time that a keystroke is supplied or a new PHASCHNG call is required.

6. Since all Core sets and Vac areas are made available at the time of a hardware restart, there is an extremely small chance that Core set 8 and/or Vac area 5 might be reallocated to some active job before the task in restart group 1 is able to reactivate the erasable program. At the present time it is felt that this is a vanishingly small possibility, although the consequences could be considerable if it did occur.

Action Items

1. This erasable program needs substantially more testing with intermittent hardware restarts and especially at peak activity periods such as are encountered in Descent and Rendezvous.

2. A study should be made of the hardware effects of intermittent activations of the Engine Gimbal Enable switch. If this might cause problems in the hardware, other toggle-type switches that set LGC channel inbits could be examined as substitutes. Intermittent activations of this switch will have no repercussions in the LGC software aside from the possibility that the digital autopilot will desist from driving the engine gimbals for a two second period following each such activation during a burn employing the DPS engine. The odds of this happening are small if the switch is immediately switched back to the ON position, and in any event the consequences are minor.

3. A survey should be made to determine if REDOCTR should be incremented by 100_{10} or some other number. This might be significant if the ground displays of REDOCTR are octal instead of decimal.

4. Attention should be given to the question of to what extent, if at all, the operation of this erasable program increases the likelihood of losing downrupts.