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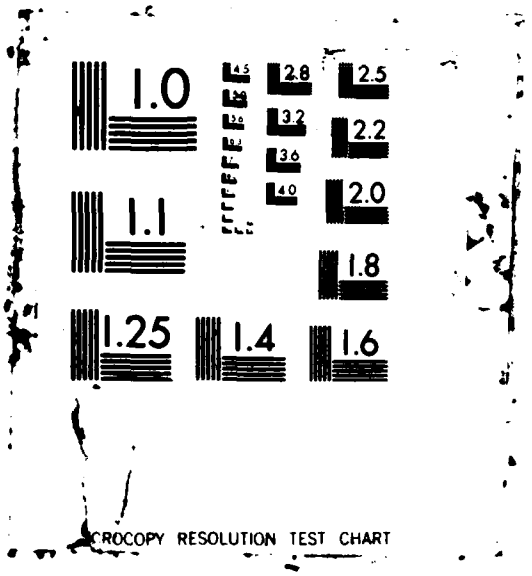
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NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER
Bethesda, Md. 20084

AD-A179 177

A GUIDE TO THE INTERFACING OF NASTRAN WITH A LOCKHEED INTEGRATOR

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and
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COMPUTATION, MATHEMATICS, AND LOGISTICS DEPARTMENT
TECHNICAL MEMORANDUM

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OVERVIEW

These notes describe how to use software written at DTNSRDC to interface a NASTRAN transient analysis with an integrator written by Lockheed Palo Alto Research Laboratory. This integrator is part of the Underwater Shock Analysis (USA) code. Execution on a CDC computer is assumed for both NASTRAN and the integrator. The version of NASTRAN used may be NASA's level 16 or 17 or MSC/NASTRAN.

The Lockheed integrator is intended to be executed in place of the NASTRAN integrator (functional module TRD). Thus, the general computational approach performs the following five steps:

Step 1: Initiate a standard checkpointed NASTRAN transient analysis run (rigid format #9). Exit from NASTRAN prior to the execution of its integrator TRD, and store on file the structural stiffness matrix (KDD), the diagonal mass matrix (MDIAG), and a correspondence table (ASET) which relates the internal DOF (associated with the matrices KDD and MDIAG) to the external grid point and component numbers (assigned by the user).

Step 2: Convert the NASTRAN data blocks KDD, MDIAG, and ASET to a format readable by the Lockheed data manager.

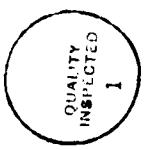
Step 3: Execute the Lockheed integration routines, which compute and store the time history of the solution.

Step 4: Convert the Lockheed solution to a format readable by NASTRAN.

Step 5: Restart the NASTRAN run at the point where it left off in Step 1 and continue on to a normal conclusion. The Lockheed solution replaces that normally generated by NASTRAN.

The following sections describe in detail how to perform Steps 1, 2, 4, and 5 above. Step 3 is described in Lockheed documentation.

Revisions to the preceding version of these notes are indicated with a vertical line in the right margin.



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STEP 1

The structure is modeled with NASTRAN finite elements using any mesh and element selection the analyst desires. The only restrictions are that the mass matrix must be diagonal and the stiffness matrix must be symmetric, in order to be handled by the Lockheed integrator. The first restriction means that only lumped, rather than consistent, mass matrices can be used. Also, only massless degrees of freedom (DØF) may be removed from the problem by static condensation since otherwise nonzero off-diagonal terms would appear in the condensed mass matrix. The second restriction prevents the modeling of contained fluid using a pressure formulation (i.e., a formulation which models compressible fluid and uses pressure as the fundamental fluid unknown). Also, the treatment of the internal/external correspondence table (ASET) requires that no NASTRAN extra points (EPOINT's) appear in the deck. However, for direct (rather than modal) analysis, this imposes no restriction, since scalar points (SPOINT's), if needed, serve the same function. It is unlikely, however, that either SPOINT's or EPOINT's would ever be used.

For fluid-structure interaction problems, no external fluid is modeled, since its effects are built into the Lockheed integrator and computed using the doubly asymptotic approximation (DAA).

Although all loads are computed in the Lockheed integrator, the NASTRAN deck should contain one dummy load specification at one DOF in order for NASTRAN to set several flags correctly during execution. The bulk data cards TLOAD1 or TLOAD2 can be used for this. This load, however, will not be used, since the integration is not being performed in NASTRAN. For the same reason, a TSTEP selection must also be made.

For levels 16 or 17, the following DMAP alter should be inserted into the executive control deck:

```
ALTER 72
CHKPNT ASET $
ALTER 152
DIAGØNAL MDD/MDIAG $
ØUTPUT2 MDIAG,ASET,KDD,,//C,N,0/C,N,11 $
JUMP FINIS $
ENDALTER
```

In the above sequence, DMAP statement 148 is the checkpoint following GKAD, the functional module in which the matrices of interest (KDD and MDD)

are created. (Thus, in MSC/NASTRAN the numbers 72 and 148 above should be changed to 53 and 129, respectively.) The functional module DIAGØNAL is a utility which strips off the diagonal from a matrix. The module ØUTPUT2 is a utility which creates a file called UT1 containing the diagonal mass matrix MDIAG, the symmetric stiffness matrix KDD, and the internal/external correspondence table ASET. ASET is the name given to the fourth output block from module GP4.

The ordering of the three data blocks on ØUTPUT2 was selected to agree with that expected by the Lockheed integrator (Step 3). NASTRAN (levels 16 or 17) requires UT1 to be a physical disk file rather than tape. If desired, it can be rewound and copied to tape following the NASTRAN execution.

The NASTRAN run must be checkpointed so that it can be restarted later in Step 5. Because of the potentially large size of NPTP (the checkpoint file) and UT1 (the ØUTPUT2 file), it may be desirable at DTNSRDC to store these files on a private disk pack rather than on tape in order to improve I/Ø reliability. Thus, following the NASTRAN execution, these two files should be catalogued on a private disk pack if they are not on tape. In any case, the following NASTRAN card should be inserted ahead of the ID card:

```
NASTRAN CØNFIG=6,FILES=(NPTP,ØPTP,PLT2)
```

This tells NASTRAN that the CP time is expressed in CDC 6400-equivalent units and that the files indicated may be on disk rather than on tape. At a CDC data center, the CØNFIG specification is 0 for a 6600 and 14 for a 7600.

In the executive control deck, DIAG 22 should be turned on in order to generate the ASET data block. For the same reason, the following bulk data card is also required:

```
PARAM SUBID 1
```

where SUBID is the name given to the 12th parameter in functional module GP4.

This NASTRAN run generates a set of punched cards (the checkpoint dictionary) which should be saved for later restart in Step 5. If desired, the checkpoint dictionary can be stored on disk (permanent file PFNAME6) rather than punched.

Thus, a typical deck setup at DTNSRDC for Step 1 is the following:

```
XXXX,CM160000,P2,TYYY.  NAME/LØCATIØN
CHARGE,XXXX,ZZZZZZZZZZ.
MAP,ØFF.
PAUSE.  JØB REQUIRES DISK PACK QQQQQQ
MØUNT,VSN=QQQQQQ,SN=PPPPPPP.
LIMIT,13000.
ATTACH,NASTRAN.
REQUEST,PUN,*PF.
REQUEST,NPTP,*PF,SN=PPPPPPP.
REQUEST,UT1,*PF,SN=PPPPPPP.
ATTACH,BANDIT,ID=CAEE.
RFL,120000.
BANDIT.
RØUTE,PUNCH,DC=PU,TID=C.
BEGIN,NASTRAN,NASTRAN,160000,TAPE8,,PUN.
CATALØG,NPTP,PFNAME1,ID=XXXX.
CATALØG,UT1,PFNAME2,ID=XXXX.
CATALØG,PUN,PFNAME6,ID=XXXX.
AUDIT,ID=XXXX.
AUDIT,SN=PPPPPPP.
EXIT.
DMP,340000.
CATALØG,NPTP,PFNAME1,ID=XXXX.
CATALØG,UT1,PFNAME2,ID=XXXX.
CATALØG,PUN,PFNAME6,ID=XXXX.
7/8/9  EØR
NASTRAN CØNFIG=6,FILES=(NPTP,ØPTP,PLT2)
$SEQUENCE  YES
$CONFIG  6
$GRID  n (upper bound on number of grid points)
  .
  .
ENDDATA
6/7/8/9  EØF
```

See Appendix B for a discussion of private pack usage.

For large data decks, the building of the deck using the CDC utility UPDATE is recommended, since it avoids the handling of large card decks. The resequencing of the grid points by BANDIT is recommended since the execution time of the Lockheed integrator is sequence-dependent.

STEP 2

The conversion of the three data blocks created in Step 1 to the format of the Lockheed data manager is accomplished with a FORTRAN program called NASSKY. NASSKY requires the following two inputs:

1. a single punched data card (with the format A10, A2, 4X, 3I8) containing the following variables:

SKYNAM = 12-character permanent file ID and name to be catalogued by NASSKY (for the file to be later read by the Lockheed integrator), e.g., XXXX*PFNAME3

IØPT = NASTRAN version flag (1 for levels 16 or 17, 2 for MSC/NASTRAN)

IPRT = print flag for debugging (0 for normal printout and 1 for extensive printout)

IBLØCK = block size (= 6720, say), not to exceed dimension in program (6720)

2. the file (containing KDD, MDIAG, and ASET) created by NASTRAN in Step 1, which is attached here as TAPE2.

The output from NASSKY is a file containing MDIAG, ASET, and KDD, in that order, written in the format of the Lockheed data manager and stored on the permanent file PFNAME3 given on the data card above.

Thus, a typical deck setup at DTNSRDC for Step 2 is the following:

```
XXXX,CM150000,P2,TYYY.  NAME/LØCATIØN
CHARGE,XXXX,ZZZZZZZZZZ.
PAUSE.  JØB REQUIRES DISK PACK QQQQQQ
MØUNT,VSN=QQQQQQ,SN=PPPPPPP.
MAP,ØFF.
LIMIT,13000.
ATTACH,NASSKY,ID=CAEE,MR=1.
ATTACH,TAPE2,PFNAME2,ID=XXXX,MR=1,SN=PPPPPPP.
ATTACH,SKULIB,ID=CAEE,MR=1.
LIBRARY,SKULIB.
SETNAME,PPPPPPP.
FILE,TAPE2,BT=C,RT=S.   } delete for level 17
LDSET,FILES=TAPE2.      }
NASSKY.
SETNAME.
AUDIT,ID=XXXX.
AUDIT,SN=PPPPPPP.
7/8/9  EØR
       data card
6/7/8/9  EØF
```

In the above sequence, the FILE/LDSET sequence ensures that the TAPE2 file, which was written by a RUN program (NASTRAN level 16) can be read by NASSKY, which is an FTN program. Since level 17 is an FTN program, the FILE and LDSET cards are not used when interfacing with level 17.

STEP 3

The procedures for executing the Lockheed software are described in Lockheed documentation. The response file generated by the integrator in this step is catalogued on a file named PFNAME4. The various files used here can be written on a private pack at DTNSRDC by using the SETNAME control card. See Appendix B.

STEP 4

The conversion of the Lockheed solution to a format readable by NASTRAN is accomplished by a FORTRAN program called XUDVT. This program requires the following input data cards:

Card 1: the 12-character name of the permanent file PFNAME4 containing the solution vectors from Step 3, punched starting in card column 1, e.g., XXXX*PFNAME4

Card 2: a data card (with the format 5I8, 10A4) containing the five variables NS, NF, M1, IØPT, NPRES, and a 40-character descriptive title, where

NS = number of structural DØF,

NF = number of fluid DOF passed by the Lockheed integrator,

M1 = number of integration time steps plus one,

IØPT = NASTRAN flag (1 for level 16 or 17, and 2 for MSC/NASTRAN), and

NPRES= number of fluid pressure DØF's to be output on TAPE3 ($0 \leq NPRES \leq NF$).

Cards 3, 4, ···: the fluid DØF's to be output from this step. These cards are present only if $0 < NPRES < NF$. The fluid DØF's must be entered free-field on one or more cards. These positive integers may be delimited by any non-numeric characters. The program will sort the list and eliminate zero or duplicate entries.

The outputs from the XUDVT program are a file (written on TAPE2) containing the solution vectors in a format readable by NASTRAN, and a file (TAPE3) containing the fluid pressures requested by the user. TAPE3 consists of one record of NPRES+1 unformatted words at each of M1 output time values, where the first word is the time value, and words 2 through NPRES+1 are the pressures.

At DTNSRDC, both TAPE1 and TAPE2 are large enough so that they should be on tape or private disk pack rather than standard permanent file.

Thus, a typical deck setup at DTNSRDC for Step 4 is the following:

```
XXXX,CM70000,P2,TYYY.  NAME/LØCATIØN
CHARGE,XXXX,ZZZZZZZZZZ.
PAUSE.  JØB REQUIRES DISK PACK QQQQQQ
MØUNT,VSN=QQQQQQ,SN=PPPPPPP.
MAP,ØFF.
ATTACH,XUDVT,ID=CAEE,MR=1.
ATTACH,SKULIB,ID=CAEE,MR=1.
LIBRARY,SKULIB.
REQUEST,TAPE2,*PF,SN=PPPPPPP.
REQUEST,TAPE3,*PF,SN=PPPPPPP.
SETNAME,PPPPPPP.
FILE,TAPE2,BT=C,RT=S.   } delete for level 17
LDSET,FILES=TAPE2.      }
XUDVT.
SETNAME.
CATALØG,TAPE2,PFNAME5,ID=XXXX.
CATALØG,TAPE3,PFNAME7,ID=XXXX.
AUDIT,ID=XXXX.
AUDIT,SN=PPPPPPP.
7/8/9     EØR
          data cards
6/7/8/9   EØF
```

The FILE/LDSET sequence above ensures that the TAPE2 file, which is being written by an FTN program (XUDVT), can be read by NASTRAN level 16, which is a RUN program. As in Step 2, the FILE and LDSET cards are not used when interfacing with level 17.

The Lockheed file (TAPE1) containing the solution consists of three vectors for each time value: the displacement and velocity vectors for the structural DØF, and the total pressure vector for the fluid DØF. The number of time values exceeds by unity the number of time steps, since the first solution written is for zero time.

The NASTRAN file created by XUDVT (TAPE2) also consists of three vectors per time value (the displacement, velocity, and acceleration vectors for the structural DØF) to be consistent with the matrix UDVT which is normally output from NASTRAN's integrator TRD. The format in which TAPE2 is written is that of NASTRAN's I/Ø utility INPUTT2 for levels 16 or 17 and INPUTT4 for MSC/NASTRAN.

Program XUDVT passes the Lockheed displacements and velocities directly to NASTRAN without change. The accelerations are computed from the velocities using the backward finite difference formula

$$a_n = (v_n - v_{n-1})/(t_n - t_{n-1})$$

where v_n is the velocity vector at the n^{th} time step. This allows an

arbitrary number of time step size changes during the integration. The acceleration at time t=0 is zero.

STEP 5

This step is a NASTRAN restart from the run of Step 1. The principal inputs needed for this run are:

1. the checkpoint dictionary (a set of punched cards) from Step 1. This is inserted into the NASTRAN executive control deck.
2. the checkpoint tape (or disk file) from Step 1. This is attached here as ØPTP.
3. the NASTRAN executive and case control decks from Step 1.
4. the output file generated in Step 4, attached here as UT1. At execution time, UT1 must be on disk.

For NASTRAN levels 16 or 17, the rigid format alter used in Step 1 is replaced here with

```
ALTER 165, 166
INPUTT2    /UDVT,,,,/C,N,0/C,N,11 $
ENDALTER
```

On MSC/NASTRAN, the alter to be used here is

```
ALTER 139, 139
INPUTT4  /UDVT,,,,/C,N,0/C,N,11 $
ENDALTER
```

This alter directs NASTRAN to replace the integration module TRD with the utility INPUTT2 or INPUTT4 which reads the file UT1 generated in Step 4. Also, in the executive control deck, DIAG 22 should be replaced by DIAG 8, which triggers the diagnostic printout of matrix trailers.

The case control deck used here need not be the same as that used in Step 1. For example, it is important that the TSTEP selection made here match precisely that which was used in the Lockheed integrator. If necessary, a new TSTEP bulk data card can be added to the bulk data deck. Also, a dummy DLOAD selection must be made in Case Control. Except for this possible change (the TSTEP card), the bulk data deck entered here would probably be otherwise null.

The analyst may request in this step any output display normally available from NASTRAN for transient problems.

Thus, a typical deck setup at DTNSRDC for Step 5 is the following:

```
XXXX,CM160000,P2,TYYY.  NAME/LØCATIØN
CHARGE,XXXX,ZZZZZZZZZZ.
PAUSE.  JØB REQUIRES DISK PACK QQQQQQ
MØUNT,VSN=QQQQQQ,SN=PPPPPPP.
MAP,ØFF.
LIMIT,13000.
ATTACH,NASTRAN.
ATTACH,INSERT,PFNAME6,ID=XXXX,MR=1.
ATTACH,BANDIT,ID=CAEE.
RFL,70000.
BANDIT.
ATTACH,UT1,PFNAME5,ID=XXXX,MR=1,SN=PPPPPPP.
ATTACH,ØPTP,PFNAME1,ID=XXXX,MR=1,SN=PPPPPPP.
BEGIN,NASTRAN,NASTRAN,160000,TAPE8.
AUDIT,ID=XXXX.
AUDIT,SN=PPPPPPP.
EXIT.
DMP,340000.
7/8/9    EØR
NASTRAN  CØNFIG=6,FILES=(NPTP,ØPTP,PLT2)
  .
  .
  .
ENDDATA
6/7/8/9  EØF
```

BANDIT is used here merely as a convenient way to insert the checkpoint dictionary from Step 1 into the deck. To effect this, the following two cards are placed in the NASTRAN executive control deck before CEND:

```
$SEQUENCE  NO
$INSERT
```

Also, if a $SEQUENCE YES card remains in the deck from Step 1, it must be removed here.

APPENDIX A

Compilation of Source Code

The source code for the two programs (NASSKY and XUDVT) executed in Steps 2 and 4, as well as the source for all the Lockheed programs, is contained on a CDC stranger tape (7-track, 800 bpi, even parity, blocked 30 cards per block). The tape consists of nine files, each of which can be used as input to an UPDATE creation run, in the following order:

1. NASSKY - NASTRAN skyliner
2. XUDVT - response file reformatter
3. IOMSYM - I/O manager
4. SKBSYM - skyline block solver
5. SKUSYM - skyline utilities
6. ADMSYM - added mass generator
7. PRESYM - preprocessor
8. INTSYM - integrator
9. POSSYM - postprocessor

The library SKULIB referenced in Steps 2 and 4 can be created from files 3-5.

Given the tape, the following control cards will create the files at DTNSRDC necessary to execute Steps 2 - 4 of this report:

```
XXXX,CM60000,P2,T400,MT1.  NAME/LØCATIØN
CHARGE,XXXX,ZZZZZZZZZZ.
REQUEST,TAPE,HY,S,VSN=NRLTAP,NØRING.   SLØT i
FILE,TAPE,BT=K,RT=F,MRL=90,RB=30,MBL=2700,CM=YES.
FILE,DISK,BT=C,RT=Z,MRL=80.
CØPYRM,TAPE,DISK,9.
RETURN,TAPE.
REWIND,DISK.
REQUEST,NEWPL,*PF.
UPDATE,I=DISK,F,C,N.
CATALØG,NEWPL,USANASSKYPL,ID=XXXX.
CØPYCF,DISK,DUM.
REQUEST,LGØ,*PF.
FTN,I=CØMPILE,R=2,ØPT=1,PL=500000.
CATALØG,LGØ,NASSKY,ID=XXXX.
UNLØAD,NEWPL,LGØ.
REQUEST,NEWPL,*PF.
UPDATE,I=DISK,F,C,N.
CATALØG,NEWPL,USAXUDVTPL,ID=XXXX.
CØPYCF,DISK,DUM.
```

```
REQUEST,LGØ,*PF.
FTN,I=CØMPILE,R=2,ØPT=1,PL=500000.
CATALØG,LGØ,XUDVT,ID=XXXX.
UNLØAD,NEWPL,LGØ.
REQUEST,NEWPL,*PF.
UPDATE,I=DISK,F,C,N.
CATALØG,NEWPL,USAIØMSYMPL,ID=XXXX.
CØPYCF,DISK,DUM.
FTN,I=CØMPILE,R=2,ØPT=1,S=CPCTEXT,S=PFMTEXT.
UNLØAD,NEWPL.
REQUEST,NEWPL,*PF.
UPDATE,I=DISK,F,C,N.
CATALØG,NEWPL,USASKBSYMPL,ID=XXXX.
CØPYCF,DISK,DUM.
FTN,I=CØMPILE,R=2,ØPT=1.
UNLØAD,NEWPL.
REQUEST,NEWPL,*PF.
UPDATE,I=DISK,F,C,N.
CATALØG,NEWPL,USASKUSYMPL,ID=XXXX.
CØPYCF,DISK,DUM.
FTN,I=CØMPILE,R=2,ØPT=1.
UNLØAD,NEWPL.
REQUEST,SKULIB,*PF.
EDITLIB.
CATALØG,SKULIB,ID=XXXX.
UNLØAD,NEWPL,LGØ.
REQUEST,NEWPL,*PF.
UPDATE,I=DISK,F,C,N.
CATALØG,NEWPL,USAADMSYMPL,ID=XXXX.
CØPYCF,DISK,DUM.
REQUEST,LGØ,*PF.
FTN,I=CØMPILE,R=2,ØPT=1,PL=500000.
CATALØG,LGØ,ADMREL,ID=XXXX.
UNLØAD,NEWPL,LGØ.
REQUEST,NEWPL,*PF.
UPDATE,I=DISK,F,C,N.
CATALØG,NEWPL,USAPRESYMPL,ID=XXXX.
CØPYCF,DISK,DUM.
REQUEST,LGØ,*PF.
FTN,I=CØMPILE,R=2,ØPT=1,PL=500000.
CATALØG,LGØ,PREREL,ID=XXXX.
UNLØAD,NEWPL,LGØ.
REQUEST,NEWPL,*PF.
UPDATE,I=DISK,F,C,N.
CATALØG,NEWPL,USAINTSYMPL,ID=XXXX.
CØPYCF,DISK,DUM.
REQUEST,LGØ,*PF.
FTN,I=CØMPILE,R=2,ØPT=1,PL=500000.
CATALØG,LGØ,INTREL,ID=XXXX.
```

```
UNLØAD,NEWPL,LGØ.
REQUEST,NEWPL,*PF.
UPDATE,I=DISK,F,C,N.
CATALØG,NEWPL,USAPOSSYMPL,ID=XXXX.
CØPYCF,DISK,DUM.
REQUEST,LGØ,*PF.
FTN,I=CØMPILE,R=2,ØPT=1,PL=500000.
CATALØG,LGØ,PØSREL,ID=XXXX.
7/8/9   EØR
LIBRARY(SKULIB,NEW)
ADD(*,LGØ)
FINISH.
ENDRUN.
6/7/8/9  EØF
```

APPENDIX B

The Use of Private Disk Packs at DTNSRDC

The mounting of a private pack (also referred to as a device set) is accomplished with the following two control cards:

```
PAUSE.  JOB REQUIRES DISK PACK QQQQQQ
MOUNT,VSN=QQQQQQ,SN=PPPPPPP.
```

where the visual serial number (VSN) is assigned by the DTNSRDC computer center, and the setname (SN) is selected by the user at the time the pack is first assigned to the user and initialized. The above two control cards may be placed anywhere in the system control cards ahead of where the pack is first used.

Permanent file management on a private pack is similar to that used for standard system permanent files. For most control cards, the only change is the addition of the setname parameter to the parameter list, e.g.,

```
REQUEST,LFN,*PF,SN=PPPPPPP.
CATALØG,LFN,PFNAME,ID=XXXX.
ATTACH,LFN,PFNAME,ID=XXXX,SN=PPPPPPP.
PURGE,LFN.    If LFN already attached
PURGE,LFN,PFNAME,ID=XXXX,SN=PPPPPPP.
```

The pack must be mounted before any of the above control cards can be executed.

The contents of the private pack can be audited with the following control card:

```
AUDIT,SN=PPPPPPP.
```

The capacity of a pack is about 180,000 PRU's.

ATTACH and REQUEST control cards issued by applications programs such as the Lockheed data manager, and hence outside the direct control of the user, can be forced to apply to a private pack by changing the default setname (SN) for which such requests apply:

```
SETNAME,PPPPPPP.
```

To restore the default (SN=SYSSET), use the control card

```
SETNAME.
```

END

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