A Program for Calculating Load Coefficient Matrices Utilizing the Force Summation Method, L218 (LOADS)
Volume II: Supplemental System Design and Maintenance Document

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1.0 SUMMARY

The program L218 (LOADS) is structured as five overlays, one main overlay and four primary overlays. Input into the program is made via cards and magnetic files (tapes or disks). Output from the program consists of printed results and magnetic files containing load coefficient matrices for use in either L219 (EQMOD) or L221 (TEV156).

Although L218 (LOADS) serves as a module of the DYLOFLEX system, it can be operated as a stand alone program. Subroutines used by L218 include routines embedded in the program code and routines obtained from the standard FORTRAN and the DYLOFLEX libraries.
2.0 INTRODUCTION

The computer program L218 (LOADS) was developed for use as either a standalone program or as a module of a program system called DYLOFLEX (see fig. 1) developed for NASA under contract NAS1-13918 (ref. 1). Because of the DYLOFLEX contract requirements defined in reference 2, a program was needed to calculate dynamic load coefficient matrices for use as sensors in active control analyses and/or for use in calculating design loads.

The objective of this volume is to aid those persons who will maintain and/or modify the program in the future. To meet this objective, the following items are defined:

- Program design and structure
- Overlay purpose and description
- Input, output and internal data base descriptions
- Extent of checkout
EXTERNALLY DEVELOPED STRUCTURAL DATA

INTERP - (L215)
INTERPOLATE MODAL DATA

MOTAP

SATAP

FLEXSTAB.CPS
STEADY STATE
AERODYNAMICS

SDDATA
GDTPAE
SDINDEX

DUBFLX - (L216)
DOUBLET LATTICE
AERODYNAMICS

NGETP
NAETP

LOADS - (L218)
LOAD EQUATIONS

NPTAP/PTAP
AVDTAP
LTAP

EOMLOD
EOM - (L217)
EQUATIONS OF
MOTION COEF

EOMTAP

EQMOD - (L219)
EQUATIONS MODIFIER

EOLOD
EQEOM

TEV156 - (L221)
FREQ RESPONSE
AND RANDOM
HARMONIC ANAL.

NEWTE
PLOT

IRTAPE

PLTRES
PLOT

TEV126 - (L226)
TIME HISTORY
SOLUTION

LINEAR SYSTEM
ANALYSIS
TIME HISTORY
QR

TAPE 99
PLOT

TAP
PLOT

Figure 1. – Dyloflex Flow Chart
3.0 PROGRAM DESIGN AND STRUCTURE

The program is structured as a system of five overlays (fig. 2):

- Main overlay (L218,0,0) L218vc
- Primary overlay (L218,1,0) RGEN
- Primary overlay (L218,2,0) AVD
- Primary overlay (L218,3,0) NPLDS/PLDS
- Primary overlay (L218,4,0) VBMT

The main overlay L218vc controls reading of general data cards by the primary overlay (1,0) RGEN, and calls the proper primary overlay to perform the execution requested. The main overlay does not read input cards.

The (1,0) primary overlay RGEN reads the general input data and the module cards ($AVD, $NPLDS, $PLDS, or $VBMT), which selects the primary overlay for execution.

The (2,0) primary overlay AVD reads the AVD card and tape input data, performs the AVD calculations, and writes the AVDTAP output tape.

The (3,0) primary overlay NPLDS/PLDS reads the NPLDS (or PLDS) card and tape input data, performs the NPLDS (or PLDS) calculations, and writes the NPTAP (or PTAP) output tape.

The (4,0) primary overlay VBMT reads the VBMT card and tape input data, performs the VBMT calculation, and writes the LTAP output tape.

Although L218 serves as a module of the DYLOFLEX system, it can be operated as a standalone program. When the program is run by itself, it becomes the user's responsibility to generate input data in the format required by L218; see figure 3 for the external file requirements and volume I of this document for the file contents and formats.

This program requires subroutines that are not part of the L218 code. Some routines are automatically obtained from the standard FORTRAN library when the program is loaded. Others, however, are stored in the DYLOFLEX alternate subroutine library, which must be declared at the time of loading. Subsequent sections describe each overlay separately and contain tables displaying the routines called and the library in which they are located. All subroutines are single entry point routines.

This volume describes the program in a macro sense. A more detailed discussion appears in the comments contained in the program source code. Each routine contains a preface describing the routine's purpose, author, analytical steps, modification history, input data, output data, glossary of variables, and list of other routines called. Embedded within the executable code are comments labeling each section and explaining logical branches.
Figure 2. — Overlay Structure of L218 (LOADS)
Figure 3. – Input/Output of L218 Overlays
3.1 OVERLAY (218,0,0) – L218vc

The main overlay of L218 is itself named L218vc where v is a letter indicating the program version and c is an integer number indicating the correction number that applies to the v version.

**Purpose of L218vc**

Overlay L218vc directs the execution of the primary overlays and aids communication between primary overlays via labeled common blocks.

**Analytical Steps of L218vc**

Overlay L218vc performs its task in the following steps:

1. Overlay (L218,1,0), RGEN, is called to read general input and/or a keyword card $AVD, $NPLDS, $PLDS, or $VBMT.

2. L218 determines the next overlay to call.
   a. If the keyword is $AVD, jump to step 3.
   b. If the keyword is $NPLDS, jump to step 4.
   c. If the keyword is $PLDS, jump to step 4.
   d. If the keyword is $VBMT, jump to step 5.
   e. If the keyword is $QUIT, jump to step 6.

3. Overlay (L218,2,0) is called to read input data and perform calculations for AVD (acceleration, velocity, displacement). When finished, program control returns to step 1.

4. Overlay (L218,3,0) is called to read input data and perform calculations for NPLDS/PLDS (net panel loads or panel loads). When finished, program control returns to step 1.

5. Overlay (L218,4,0) is called to read input data and perform calculations for VBMT (shears, bending moments, and torsions). When finished, program control returns to step 1.


The macro flow chart of this overlay is shown in figure 4. The subroutines called are displayed in table 1.

**I/O Devices of L218vc**

There is no I/O performed in the (0,0) overlay. It is all performed in the primary overlays.
Figure 4. — Macro Flow Chart of Overlay (L218,0,0) L218 vc
Table 1. — Routines Called by L218vc

<table>
<thead>
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<th>Overlay (L218, 0, 0)</th>
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<td>OVERLAY (L218, 1, 0)</td>
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<td>AVD</td>
<td>OVERLAY (L218, 2, 0)</td>
</tr>
<tr>
<td>NPLDS</td>
<td>OVERLAY (L218, 3, 0)</td>
</tr>
<tr>
<td>VSMT</td>
<td>OVERLAY (L218, 4, 0)</td>
</tr>
</tbody>
</table>
3.2 PRIMARY OVERLAY (L218,1,0) – RGEN

Purpose of RGEN

The L218 (LOADS) program's first primary overlay is named RGEN. RGEN reads general input data from cards and may write a J-MATRIX and a MASS MATRIX tape. Upon reading a keyword defining the LOADS module to be executed, control is returned to L218vc.

Analytical Steps of RGEN

RGEN performs its task in the following steps:

1. If this is not the first call to RGEN, jump to step 4.

2. The header matrix array (IQLTAP) is initialized. The subroutine PRGBEG is called to place the program header on the printed output.

3. A data card is read. It must begin with $LOAD to assure that the card input file is correctly positioned. If it does not contain $LOAD the fatal error counter is incremented and the program tries to process additional cards; however, module execution will not occur.

4. A program directive card is read, printed, interpreted, and acted upon according to the following conditions:
   a. If the keyword is $TITLE, begin step 4 again.
   b. If the keyword is $GEN, jump to step 5.
   c. If the keyword is $AVD, $NPLDS, $PLDS, or $VBMT, jump to step 11.
   d. If the keyword is $END, jump to step 4.
   e. If the keyword is $QUIT, jump to step 11.

5. A general input directive card is read, printed, interpreted, and acted upon as follows:
   a. If the keyword is JMAT, jump to step 6.
   b. If the keyword is MASS, jump to step 7.
   c. If the keyword is TRAN, jump to step 8.
   d. If the keyword is MAXSUR, jump to step 9.
   e. If the keyword is AVDTAP, EOMLOD, JTAPE, LTAPE, MASSTP, NPTAP, IPTAP, or SATAP, jump to step 10.
   f. If the keyword is $----, jump to step 4a.
6. Subroutine RGEN2 is called. This subroutine reads the J-matrix data and writes it on JTAPE. Program control returns to step 5.

7. Subroutine RGEN1 is called. This subroutine reads the MASS matrix data and writes it on MASSTP. Program control returns to step 5.

8. The transformation order is set. Program control returns to step 5.

9. The maximum number of surfaces is set. Program control returns to step 5.

10. The appropriate tape name is changed. Program control returns to step 5.

11. The appropriate keyword code is set. If the keyword was not $QUIT, jump to step 13. If it was a $QUIT card, jump to step 12.

12. Copy the final general output from IOUT to IUTFIL. Call PRGEND to place the program termination message on the printed output.

13. Return control to (L218,0,0).

The intended order of card input for RGEN is: $LOAD card, $TITLE card, $GEN card, all GEN input for this execution run, $module card.

The macro flow chart of this overlay is shown in figure 5. The subroutines called are displayed in table 2.

I/O Devices of RGEN

RGEN reads general loads card input and may write the J-matrix (JTAPE) and mass matrix (MASSTP) magnetic files.

3.3 PRIMARY OVERLAY (L218,2,0) – AVD

Purpose of AVD

The L218 (LOADS) program's second primary overlay is named AVD (acceleration, velocity, and displacement). AVD processes modal deflections ($\phi$), modal slopes ($\phi_\theta$), and geometry data (BS, BBL, WL, $\theta_x$, $\theta_y$, $\theta_z$) to generate the appropriate coefficient matrices required by L221 (TEV156) to calculate loads. The loads consist of translational and/or angular accelerations, velocities, and displacements at selected points on the structure. The axis system may be either reference or local (that system defined by the angular data ($\theta_x$, $\theta_y$, $\theta_z$) in the geometry input, or by ($\theta_x$, $\theta_y$, $\theta_z$) from card input. The resultant loads matrices are written on tape (AVDTAP).

Analytical Steps of AVD

AVD performs its task in the following steps:

1. It initialize FETS for disk storage files MERGE 1, MERGE 2, and MERGE 3.

2. The subroutine RAVD is called to read the AVD card input.

3. If matrices were card input, jump to step 9.

4. The subroutine DISK is called to read geometry, modes, and SA array from (SATAP).
Figure 5. – Macro Flow Chart of Overlay (L218, 1,0) RGEN
Table 2. – Routines Called by RGEN

OVERLAY (L218, 1, C)
PROGRAM RGEN

FE'TACD +
FETDEL +
NAMFIL +
PRGBEG +
PRGEND +
RGEN1 WRTETP +
RGEN2 WRTETP +

+ indicates a routine in the DYLOFLEX alternate subroutine library
All others are local to L218 (LOADS).
5. If interpolation is required, jump to step 8.

6. If transformation (rotation) is not required, jump to step 9.

7. The subroutine ROTATE is called to perform the required axis transformation (rotation); jump to step 9.

8. The subroutine NTERP is called to perform the necessary interpolation.

9. The subroutine MERGE is called to merge the matrices for this surface.

10. If more surfaces are to be processed, jump to step 2.

11. The subroutine AVDTAP is called to write the final tape (AVDTAP).

12. The subroutine RETURNF is called to return all scratch files.

13. Return control to (L218,0,0).

The macro flow chart of this overlay is shown in figure 6. The subroutines called are displayed in table 3.

I/O Devices of AVD

AVD reads card input. Geometry, mode shapes, slopes, and SA arrays are read from SATAP, which is normally written by the DYLOFLEX interpolation program L215 (INTERP), described in reference 3.

Regular and general print options control the printed output.

The coefficient matrices are written on the final output tape (AVDTAP) in a format acceptable to L219 (EQMOD) and L221 (TEV156) (refs. 4 and 5, respectively).

3.3.1 AVD PROGRAMMING SPECIFICATIONS

AVD Modal Data Interpolation Methods

When the interpolation option is selected, axis transformation (rotation) is not allowed. Interpolation is performed in the local axis system to an arbitrary (x,y,z) reference axis coordinate.

There are three interpolation methods available, one method for thin bodies and two methods for slender bodies. Their description is as follows.

1. Interpolation of Thin Bodies (INTER=1): Where $\phi_x = \phi_y = \phi_{yz} = 0$, $\phi_z$, $\phi_{\theta x}$, and $\phi_{\theta y}$ are obtained by calling AINTG, a subroutine in the DYLOFLEX library, with the appropriate SA array and multiplying the results by -1 to retain the proper sign convention of the modes.
ENTRY
  Initialize FETS
  Read AVD card input
  Obtain geometry, modes, and SA from disk
  Perform interpolation
  Perform axis rotation
  Return scratch files
  END

Figure 6. – Macro Flow Chart of Overlay (L218,2,0) AVD
Table 3. — Routines Called by AVD

OVERLAY (L218, 2, 0)

PROGRAM AVD

AVCTAP

\{ FETDEL +
  \FETADD +
  \WRTETP +
\}

DISK

\{ DISK1 DISK5 READTP +
  DISK2 DISK5 READTP +
  DISK5 READTP +
\}

FETADD +

MERGE

Mmerge1

NTEFP

\{ NTERP1 AINTG +
  NTERP5
  NTERP6
\}

RAVD

\{ RAVD1
  RAVD2
  RAVD3
\}

\{ RAVD1A
  RAVD6
  RAVD6
  KOMSTR +
  RAVD5B
  RAVE5B
  RAVD6
\}

* Indicates a routine in the DYLOFLEX alternate subroutine library.
Table 3. – (Concluded)

\[
\text{RAVD} \begin{cases} \\
\text{RAVD4} \\
\text{RAVD5} \\
\text{RAVD5A} \\
\text{RAVD6} \\
\text{READTP+} \\
\end{cases} 
\begin{cases} \\
\text{RAVD5B} \\
\text{RAVD5A} \\
\text{RAVD5E} \\
\end{cases} 
\text{RCTATE} \quad \text{ROTATEE1}
\]
2. Interpolation of Slender Bodies (INTER=2). This linear interpolation method between points is suitable for elastic axes that are straight and, preferably, parallel to the reference axis. To interpolate to a point \( x \), given two structural node points \( I \) and \( I+1 \) and their coordinate locations (BS, BBL, WL):

\[
\begin{align*}
\text{A} & = (x - \text{BS}_I)/(\text{BS}_{I+1} - \text{BS}_I) \\
\phi_{x_x} & = \phi_{x_I} \\
\phi_{y_x} & = A \left( \phi_{y_{I+1}} - \phi_{y_I} \right) + \phi_{y_I} + LTT \phi_{\theta_{x_x}} \\
\phi_{z_x} & = A \left( \phi_{z_{I+1}} - \phi_{z_I} \right) + \phi_{z_I} + LT \phi_{\theta_{x_x}} \\
\phi_{\theta_{x_x}} & = A \left( \phi_{\theta_{x_{I+1}}} - \phi_{\theta_{x_I}} \right) + \phi_{\theta_{x_I}} \\
\phi_{\theta_{y_x}} & = A \left( \phi_{\theta_{y_{I+1}}} - \phi_{\theta_{y_I}} \right) + \phi_{\theta_{y_I}} \\
\phi_{\theta_{z_x}} & = A \left( \phi_{\theta_{z_{I+1}}} - \phi_{\theta_{z_I}} \right) + \phi_{\theta_{z_I}}
\end{align*}
\]

where:

\[
\begin{align*}
LT & = \text{BBL}_X - \text{BBL}_I \\
LTT & = \text{WL}_X - \text{WL}_I
\end{align*}
\]

To interpolate to a point \( x \), given only one structural node point \( I \) and its coordinate locations (BS, BBL, WL):

\[
\begin{align*}
\phi_{x_x} & = \phi_{x_I} \\
\phi_{y_x} & = \phi_{y_I} - LB \phi_{\theta_{z_I}} + LTT \phi_{\theta_{x_x}} \\
\phi_{z_x} & = \phi_{z_I} + LB \phi_{\theta_{y_I}} + LT \phi_{\theta_{x_x}}
\end{align*}
\]
where:

\[ LB = BS_X \cdot BS_I \]

\[ LT = BBL_X - BBL_I \]

\[ LTT = WI_X - WL_I \]

3. Interpolation of Slender Bodies (INTER=4). A linear interpolation method that interpolates to a node using rigid links attached to a reference node. To interpolate to a point \( x \) using only one structural reference node \( I \):

\[
\begin{align*}
\phi_{x_X} &= \phi_{x_I} \\
\phi_{y_X} &= \phi_{y_I} - LB \cdot \phi_{z_I} + LTT \cdot \phi_{x_I} \\
\phi_{z_X} &= \phi_{z_I} + LB \cdot \phi_{y_I} + LT \cdot \phi_{x_I} \\
\phi_{x_x} &= \phi_{x_I} \\
\phi_{y_x} &= \phi_{y_I} \\
\phi_{z_x} &= \phi_{z_I}
\end{align*}
\]

where \( I, LB, LTT, \) and \( LT \) are card input using the relationship defined in method 2.
Transformation of Axis

To transform the modal data from the local axis to the inertia (or arbitrary) axis requires that each mode $\phi_x$, $\phi_y$, $\phi_z$, $\phi_{\theta_x}$, $\phi_{\theta_y}$, and $\phi_{\theta_z}$ at each node for the surface be transformed to the axis defined by $\theta_x$, $\theta_y$, $\theta_z$ as follows:

$$
\begin{bmatrix}
\phi_x \\
\phi_y \\
\phi_z \\
\end{bmatrix}
= T
\begin{bmatrix}
\phi_x \\
\phi_y \\
\phi_z \\
\end{bmatrix}
$$

local axis

and

$$
\begin{bmatrix}
\phi_{\theta_x} \\
\phi_{\theta_y} \\
\phi_{\theta_z} \\
\end{bmatrix}
= T
\begin{bmatrix}
\phi_{\theta_x} \\
\phi_{\theta_y} \\
\phi_{\theta_z} \\
\end{bmatrix}
$$

local axis

where T is the Euler transformation matrix for $\theta_x$, $\theta_y$, $\theta_z$ (see vol. I, sec. 5).

Note: All $\phi$'s must be present; they are assumed zero if null.

Selection of Modes

In general, $\phi_x$, $\phi_y$, $\phi_z$, $\phi_{\theta_x}$, $\phi_{\theta_y}$ and $\phi_{\theta_z}$ are available, but for a normal case only some will be selected. Keywords will be input to select the required modes and final $M_1$, $M_2$, and $M_3$ matrices.

For the acceleration matrix ($M_3$), either translation ($\phi_x$, $\phi_y$, $\phi_z$) and/or rotation ($\phi_{\theta_x}$, $\phi_{\theta_y}$, $\phi_{\theta_z}$) may be required. Furthermore, any combination of $\phi_x$, $\phi_y$, and $\phi_z$ may be required (similarly for $\phi_{\theta_x}$, $\phi_{\theta_y}$ and $\phi_{\theta_z}$). The same is also true for the $M_2$ and $M_1$ matrix.

As an example, if an $M_3$ translational matrix for $x$, $y$, $z$ is required, then $M_{3x}$, $M_{3y}$, $M_{3z}$ will be selected. If the $M_3$ rotational matrix for $Z$ is required, then $M_{3z}$ (rotational) will be selected.
Merging of Matrices

Matrices for a given surface are merged in the order x, y, z translational, x, y, z rotational. Any matrix that is null is omitted. If all of the matrices $\bar{M}_3$ were nonzero for surface IS, $\bar{M}_3$ for surface IS would merge as:

$$\begin{bmatrix}
\bar{M}_{3x} \\
\bar{M}_{3y} \\
\bar{M}_{3z} \\
\bar{M}_{3x} \\
\bar{M}_{3y} \\
\bar{M}_{3z}
\end{bmatrix}$$

and similarly for $\bar{M}_2$ and $\bar{M}_1$. This is further illustrated by the following examples:

Assume the number of modes is three and that nodes 1 and 4 are selected from $\phi_x, \phi_y, \phi_x'$, $\phi_y', \phi_z$ for translational and rotational acceleration mode shapes, respectively.
Then the merged matrix would appear as:

$$
\begin{bmatrix}
\phi_{x11} & \phi_{x12} & \phi_{x13} \\
\phi_{x41} & \phi_{x42} & \phi_{x43} \\
\phi_{y11} & \phi_{y12} & \phi_{y13} \\
\phi_{y41} & \phi_{y42} & \phi_{y43} \\
\phi_{z11} & \phi_{z12} & \phi_{z13} \\
\phi_{z41} & \phi_{z42} & \phi_{z43} \\
\phi_{\theta x11} & \phi_{\theta x12} & \phi_{\theta x13} \\
\phi_{\theta x41} & \phi_{\theta x42} & \phi_{\theta x43} \\
\phi_{\theta y11} & \phi_{\theta y12} & \phi_{\theta y13} \\
\phi_{\theta y41} & \phi_{\theta y42} & \phi_{\theta y43} \\
\phi_{\theta z11} & \phi_{\theta z12} & \phi_{\theta z13} \\
\phi_{\theta z41} & \phi_{\theta z42} & \phi_{\theta z43}
\end{bmatrix}
$$

If nodes 1 and 4 are selected from $\phi_y$ and $\phi_z$ for translational velocity only, $\bar{M}_2$ would merge as:

$$
\begin{bmatrix}
\bar{M}_{3x} \\
\bar{M}_{3y} \\
\bar{M}_{3z}
\end{bmatrix}
= 
\begin{bmatrix}
\phi_{y11} & \phi_{y12} & \phi_{y13} \\
\phi_{y41} & \phi_{y42} & \phi_{y43} \\
\phi_{z11} & \phi_{z12} & \phi_{z13} \\
\phi_{z41} & \phi_{z42} & \phi_{z43}
\end{bmatrix}
$$
AVD's Final Output Tape

After all surfaces have been processed and the matrices merged, the final tape will contain the merged matrices $[\bar{M}_1]$, $[\bar{M}_2]$, and $[\bar{M}_3]$. The maximum size of $[\bar{M}_1]$ is (100 x 70), similarly for $[\bar{M}_2]$ and $[\bar{M}_3]$.

To illustrate the format for final output, consider a load set of one surface with all matrices required (no zero matrices). Then:

$[\bar{M}_1] = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ M_{1x} \\ M_{1y} \\ M_{1z} \end{bmatrix}$

$[\bar{M}_2] = \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ M_{2x} \\ M_{2y} \\ M_{2z} \end{bmatrix}$

$[\bar{M}_3] = \begin{bmatrix} \bar{M}_{3x} \\ \bar{M}_{3y} \\ \bar{M}_{3z} \\ \bar{M}_{3x} \\ \bar{M}_{3y} \\ \bar{M}_{3z} \end{bmatrix}$
These matrices would be written on the tape as:

\[
\begin{bmatrix}
\text{Header} \\
\bar{M}_1 \\
\bar{M}_2 \\
\bar{M}_3 \\
\text{EOF} \\
\bullet \\
\bullet \\
\text{EOF}
\end{bmatrix}
\]

\text{Load set number 1}

\text{Load set number 2}

The physical size of the matrices \(\bar{M}_1\), \(\bar{M}_2\), and \(\bar{M}_3\) are equal and are appropriately loaded with zero rows as follows.

In general there may be several surfaces in a load set. Then:

\[
\begin{bmatrix}
0 \\
0 \\
\bar{M}_{1\text{surface 1}} \\
0 \\
0 \\
\bar{M}_{1\text{surface 2}} \\
\cdot \\
\cdot \\
\text{etc}
\end{bmatrix}
\]

\[
\begin{bmatrix}
0 \\
0 \\
\bar{M}_{2\text{surface 1}} \\
0 \\
0 \\
\bar{M}_{2\text{surface 2}} \\
\cdot \\
\cdot \\
\text{etc}
\end{bmatrix}
\]

\[
\begin{bmatrix}
\bar{M}_{3\text{surface 1}} \\
0 \\
0 \\
\bar{M}_{3\text{surface 2}} \\
0 \\
0 \\
\cdot \\
\cdot \\
\text{etc}
\end{bmatrix}
\]

where zero rows are added as required.
3.4 PRIMARY OVERLAY (L218,3,0) - NPLDS/PLDS

Purpose of NPLDS/PLDS

The L218 (LOADS) third primary overlay, NPLDS/PLDS, reads the specific card input data for net panel loads or panel loads. A net panel loads run will result in loads matrices written on tape NPTAP. A panel loads run will result in loads matrices written on tape PTAP.

Analytical Steps of NPLDS/PLDS

NPLDS/PLDS performs its task in the following steps:

1. It initializes FETS for disk storage.
2. The subroutine OPENMS is called to initialize a random access file, MERGB.
3. The subroutine NPLDA is called to read card input data.
4. The subroutine NPLDB is called to calculate $M_3$ and/or read geometry for this surface (PLDS reads geometry but does not calculate $M_3$).
5. The subroutine NPLDD is called to calculate $M_4$, $M_5$, and $\Phi$ for all frequencies.
6. If more surfaces are to be processed, jump to step 3.
7. The subroutine NPLDH is called to merge the matrices and write the final output tape NPTAP or PTAP.
8. The overlay closes all FETS and returns scratch files.
9. Return control to (L218,0,0).

The macro flow chart of this overlay is shown in figure 7. The subroutines called are displayed in table 4.

I/O Devices of NPLDS

NPLDS reads card input. Geometry and modal data is read from tape (SATAP) as provided by L215 (INTERP) (ref. 3). Equations of motion data is read from tape (EOMLOD) as provided by L217 (EOM) (ref. 6). Mass matrix data is read from tape (MASSTP) as provided by (L218,1,0), RGEN.

Note: Both SATAP and EOMLOD are required for either NPLDS or PLDS.

Regular and general print options control the printed output. For net panel loads, the loads matrices are written on tape (NPTAP) in a format acceptable to L219 (EQMOD) (ref. 4) and L221 (TEV156) (ref. 5).

For panel loads, the loads matrices are written on tape PTAP in a format acceptable to L219 (EQMOD) and L221 (TEV156).
Figure 7. — Macro Flow Chart of Overlay (L218,3,0) NPLDS/PLDS

Note: For the PLDS case, NPLDB does not calculate the $M_3$ matrix, but does get the geometry in the reference axis.
Table 4. — Routines Called by NPLDS/PLDS

OVERLAY (L218, 3, 0)
PROGRAM NPLDS/PLDS

<table>
<thead>
<tr>
<th>NPLDA</th>
<th>NPLDB</th>
</tr>
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<tbody>
<tr>
<td>NPLDA1</td>
<td>NPLDB1</td>
</tr>
<tr>
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<td>NPLDA2</td>
</tr>
<tr>
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<td></td>
</tr>
<tr>
<td></td>
<td>NPLDA6</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>READTP+</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NPLDA6</td>
</tr>
<tr>
<td></td>
<td>WRITMS*</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

FETADD+
FETDEL+

* Indicates a routine in the DYLOFLEX alternate subroutine library.
* Indicates a routine in the FORTRAN subroutine library.
Table 4. — (Concluded)

<table>
<thead>
<tr>
<th>NPLDD</th>
<th>{NPLDD1</th>
<th>READTP+</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NPLDD2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>NPLDD4</td>
<td>{NPLDD1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>NPLDD2</td>
</tr>
<tr>
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<td></td>
<td>NPLDD3</td>
</tr>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>WRTMS*</td>
</tr>
<tr>
<td>NPLCH</td>
<td>{FETDEL+</td>
<td>READMS*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NPLDH1</td>
<td>READMS*</td>
</tr>
<tr>
<td></td>
<td>WRTETP+</td>
<td></td>
</tr>
<tr>
<td>OFENMS*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RETUPNF</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.4.1 NPLDS/PLDS PROGRAMMING SPECIFICATIONS

NPLDS (net panel loads) uses the modal deflection $\phi_z$ with the mass matrix to obtain the inertia forces ($\bar{M}_3$ matrix) on each subsurface. It also uses the aerodynamic force matrices generated in the Equations of Motion program from which selected nodes are extracted to form the $\bar{M}_4$, $\bar{M}_5$, and $\bar{\phi}$ matrices. The resulting matrices are in the local axis only. PLDS is identical to NPLDS except that the $[\bar{M}_3]$ matrix is omitted. The following information is useful in understanding the program generation of the required matrices.

For each requested surface and selected nodes:

1. Calculate $[\bar{M}_3]$ and write it on NPTAP.

2. Form $[\bar{M}_4]$, $[\bar{M}_5]$, and $[\bar{\phi}]$ for all frequencies (k) and write them on NPTAP (also on PTAP if requested).

To calculate $\bar{M}_3$:

1. Read the mass matrix.

2. Read scalars for $[\bar{M}_3]$.

3. Read $\phi_z$ from disk (also geometry).

4. Read nodes to be used.

5. Calculate:

$$\bar{M}_3 = \text{SCALR1} \begin{bmatrix} m_1\phi_{z_{11}} & \cdots & m_1\phi_{z_{1n}} \\ \vdots & \ddots & \vdots \\ m_1\phi_{z_{n1}} & \cdots & m_1\phi_{z_{nn}} \end{bmatrix}$$

There is no contribution from $\phi_x$ and $\phi_y$. $\bar{M}_3$ is in the local axis only.

To calculate $[\bar{M}_4]$, $[\bar{M}_5]$, and $[\bar{\phi}]$:

1. Read nodes.

2. Read $F_{PL}(\dot{q})$, $F_{PL}(\ddot{q})$, $F_{PL}(\dot{\alpha}_g)$ from the EOM tape.


29
4. If the structural and aero node points are identical:

\[
\begin{bmatrix}
F_{PL_{11}} & \cdots & F_{PL_{1n}} \\
\vdots & \ddots & \vdots \\
F_{PL_{l1}} & \cdots & F_{PL_{ln}}
\end{bmatrix}
\]

\[
[M_4] = \text{SCALR2}
\]

\[
[M_5] = \text{SCALR2}
\]

\[
[M_\phi] = \text{SCALR3}
\]

where \( g \) = number of gust zones.

5. If the structural and node points are not identical, there are two options available in NPLDS for interpolating the aerodynamic forces from the aerodynamic nodes to the structural nodes.

Option 1: (OPT1)

Required data is as follows:

1. Card input of the force weighting matrix \([P]\) (weighting matrix of aerodynamic forces from aerodynamic nodes to structural nodes).

2. \( F_{PL}(\dot{q}), F_{PL}(\ddot{q}), F_{PL}(\dot{\alpha}_g) \), read from the EOM tape

The program calculates:

\[
[M_4] = \text{SCALR2} \ [P] \ [F_{PL}(\dot{q})]
\]

\[
[M_5] = \text{SCALR2} \ [P] \ [F_{PL}(\ddot{q})]
\]

\[
[M_\phi] = \text{SCALR3} \ [P] \ [F_{PL}(\dot{\alpha}_g)]
\]
where the size of:

\[ [P] \]

is the number structural loads by the number of aerodynamic panels

\[ [F_{PL}(\dot{q})] \]

is the number aerodynamic panels by the number of modes

\[ [F_{PL}(\ddot{q})] \]

is the number aerodynamic panels by the number of modes

\[ [F_{PL}(\dddot{\alpha}_g)] \]

is the number aerodynamic panels by the number of gust penetration panels

Limitations:

Number of structural loads \( s \) \( \leq \) structural nodes \( s \leq 100 \)

Number of aero panels \( s \) \( \leq 100 \) \( \leq \) number structural node

Number of modes \( c \leq 70 \)

Number of gust penetration panels \( s \leq 35 \)

Number of structural nodes \( s \leq 100 \)

Option 2: (OPT2)

Required data is as follows:

1. Read card input structural areas corresponding to structural nodes: \([a_s]\).
2. Read structural \((X, Y, Z)_S\) coordinates from INTERP.
3. Read local aero \((X, Y)_L\) coordinates from EOM.
4. Read local aero areas \([A]_L = \begin{bmatrix} A_1 \\ \vdots \\ A_j \end{bmatrix}\) from EOM.
5. Read \(F_{PL}(\dot{q}), F_{PL}(\ddot{q}), F_{PL}(\dddot{\alpha}_g)\) from EOM.

Program operations are as follows:

1. Calculate:

\[
[P]_L = \begin{bmatrix}
F_{PL_{11}}/A_1 & \cdots & F_{PL_{1n}}/A_1 \\
\vdots & \ddots & \vdots \\
F_{PL_{i1}}/A_i & \cdots & F_{PL_{in}}/A_i \\
\end{bmatrix}_{q, \dot{q}, \dddot{\alpha}_g}
\]
where:
\[
F_{in} = F_{PL}(\dot{q}), F_{PL}(\ddot{q}), F_{PL}(\dot{\alpha}_g)
\]

\[[P]_L = \text{matrices of aerodynamic pressures at aerodynamic nodes for } \dot{q}, \ddot{q}, \text{ and } \dot{\alpha}_g.\]

2. Call PLATEI using \([P]_L\) and \((X,Y)_L\).

3. Get SA from INTERP, extract transformation.

4. Insert transformation in SA array from step 2.

5. Call AINTG using \((X,Y,Z)\) to interpolate \([p]_S\) (aerodynamic pressures on structural areas).

6. Calculate aerodynamic force at structural nodes due to \(\dot{q}, \ddot{q}, \text{ and } \dot{\alpha}_g\) as

\[
[F_{PL}(\dot{q})]_S, [F_{PL}(\ddot{q})]_S, [F_{PL}(\dot{\alpha}_g)]_S = \begin{bmatrix} a_1 \\ \vdots \\ a_j \end{bmatrix} [p]_S
\]

where \([p]_S\) is the aerodynamic pressure due to \(\dot{q}, \ddot{q}, \text{ and } \dot{\alpha}_g\).

7. Then:

\[
[M_4] = \text{SCALR2} [F_{PL}(\dot{q})]_S
\]

Similarly

\[
[M_5] = \text{SCALR2} [F_{PL}(\ddot{q})]_S
\]

\[
[\vec{\phi}] = \text{SCALR3} [F_{PL}(\dot{\alpha}_g)]_S
\]

*Warning: This option is only valid over regions where \(\frac{dp}{dx}\) and \(\frac{dp}{dy}\) are equal or approximately equal to constants.
**NPTAP and/or PTAP Final Output/LOAD-SET**

A LOAD-SET is a result of processing all surfaces requested following the $\text{NPLDS}$ card, but before the next $\$\text{ card.}

Note: The final output of PLDS is identical to that for NPLDS described above except that $\overline{M}_3$ matrix is omitted.

\[
\begin{align*}
\text{[Header]} & \quad \text{[\overline{M}_3]} \\
\text{[\overline{M}_4]} & \quad \text{k=1} \\
\text{[\overline{M}_5]} & \quad \text{\{Load set 1\}} \\
\{\overline{\phi}\} & \quad \text{\{\{\text{where:}\} \quad [\overline{M}_3] = \begin{bmatrix} \cdot & \cdot \\ \cdot & \cdot \\ \cdot & \cdot \end{bmatrix}} \\
\text{[\overline{M}_6]} & \quad \text{k=2} \\
\{\overline{\phi}\} & \quad \text{\{\{\text{Surface IS}\} \quad [\overline{M}_4] = \begin{bmatrix} \cdot & \cdot \\ \cdot & \cdot \\ \cdot & \cdot \end{bmatrix}} \\
\text{EOF} & \quad \text{\{\{\text{Surface IS}\} \quad [\overline{M}_6] = \begin{bmatrix} \cdot & \cdot \\ \cdot & \cdot \\ \cdot & \cdot \end{bmatrix}} \\
\text{[Header]} & \quad \text{[\overline{M}_4]} \\
\text{[\overline{M}_5]} & \quad \text{k=1} \\
\text{\{Load set 2\}} \\
\{\overline{\phi}\} & \quad \text{\{\begin{align*}
\text{Similarly for } [\overline{M}_5] \text{ and } [\overline{\phi}] \\
\text{and for all values of } k
\end{align*}} \\
\text{Maximum size of} & \quad [\overline{M}_3] = [\overline{M}_4] = [\overline{M}_5] \text{ is } 100 \times 70 \\
[\overline{\phi}] & \quad \text{is } 100 \times (2)(35)
\end{align*}
\]
3.5 PRIMARY OVERLAY (L218,4,0) – VBMT

Purpose of VBMT

The L218 (LOADS) fourth primary overlay is named VBMT. VBMT reads the specific card input data to calculate shears, bending moments, and torsions and writes the load matrices on the magnetic file LTAP.

Analytical Steps of VBMT

VBMT performs its task in the following steps:

1. VBMT initialize FETS for disk storage.
2. The subroutine VBMTA is called to check all data for this load-set.
3. The subroutine OPENMS is called to initialize a random access file.
4. The subroutine VBMTA is called to read data for one load for this surface.
5. The subroutine VBMTC is called to calculate $\overline{M}_3$ for this load.
6. The subroutine VBMTD is called to calculate $\overline{M}_4$, $\overline{M}_5$, and $\overline{\phi}$ for this load.
7. If more loads or surfaces are to be processed, jump to step 4.
8. The subroutine VBMTF is called to merge the matrices and write the final tape LTAP.
9. If another load-set is to be read, jump to step 2.
10. Close all FETS and return scratch files.
11. Return control to (L218,0,0).

The macro flow chart of this overlay is shown in figure 8. The subroutines called are displayed in table 5.

I/O Devices of VBMT

VBMT reads card input. Geometry and modal data is read from tape SATAP as provided by L215 (INTERP) (ref. 3). Equations of Motion data is read from tape EOMLOD as provided by L217 (EOM) (ref. 6). J-matrix data is read from tape JTAPE as provided by (L218,1,0), RGEN.

Note: J-matrix data on JTAPE can also be used by NPLDS, since the mass matrix is the first record of each file.

Regular and general print options control the printed output. Loads matrices are written on tape LTAP in a format acceptable to L219 (EQMOD) (ref. 4) and L221 (TEV156) (ref. 5).
Figure 8. — Macro Flow Chart of Overlay (L218,4,0) VBMT
Table 5. — Routines Called by VBMT

OVERLAY (L218,4,0)

PROGRAM VBMT

RETN

VBMTA

\{ VBMTA1

VBMTA2 VBMTA3 \{ LTOGT* \{ REACTP*

VEMTC

\{ VEMTC1 READTP*

VBMTC2 \{ VBMTC3 VBMTC4

READMS* WRITMS*

* Indicates a routine in the DYLOFLEX alternate subroutine library.
* Indicates a routine in the FORTRAN subroutine library.
Table 5. – (Concluded)

<table>
<thead>
<tr>
<th>VBMTD</th>
<th>VBMTD1</th>
<th>...READTP*</th>
</tr>
</thead>
<tbody>
<tr>
<td>VBMTD2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VBMTD3</td>
<td>VBMTD1</td>
<td>READTP*</td>
</tr>
<tr>
<td></td>
<td>VBMTD4</td>
<td>READMS*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WRITMS*</td>
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<td></td>
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</tr>
<tr>
<td></td>
<td>VBTC4</td>
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</tr>
<tr>
<td>VBMTF</td>
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<td>VMIF1</td>
<td>READMS*</td>
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</tr>
<tr>
<td>RETURNF*</td>
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</tr>
<tr>
<td>WRTETP*</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.5.1 VBMT PROGRAMMING SPECIFICATIONS

To calculate $\bar{M}_3$ for a given surface number (IS), the inertia forces at the structural nodes and in local axis are:

$$
[F_{xi}]_{\text{local axis}} = [m_i] [\phi_x] - [m_i z_i] [\phi_{\theta_y}] - [m_i y_i] [\phi_{\theta_z}]
$$

$$
[F_{yi}]_{\text{local axis}} = [m_i] [\phi_y] + [m_i z_i] [\phi_{\theta_x}] - [m_i x_i] [\phi_{\theta_z}]
$$

$$
[F_{zi}]_{\text{local axis}} = [m_i] [\phi_z] + [m_i y_i] [\phi_{\theta_x}] + [m_i x_i] [\phi_{\theta_y}]
$$

where $[F_{xi}]$, $[F_{yi}]$, and $[F_{zi}]$ are the matrices of inertia forces in the x, y, and z directions. $\phi_x$, $\phi_y$, $\phi_z$, $\phi_{\theta_x}$, $\phi_{\theta_y}$, and $\phi_{\theta_z}$ are obtained from the INTERP tape (SATAP) and $m_i$, $m_i x_i$, $m_i y_i$, and $m_i z_i$ are obtained from the J-matrix (general card input or tape). These local axis forces are transformed to the inertia axis by:

$$
\begin{bmatrix}
[F_x] \\
[F_y] \\
[F_z]
\end{bmatrix}_{\text{inertia axis}} = SCALS \begin{bmatrix}
[T]
\end{bmatrix} \begin{bmatrix}
[F_x] \\
[F_y] \\
[F_z]
\end{bmatrix}_{\text{local axis}}
$$

where:

$$
[F_x] = \begin{bmatrix}
F_{x11} & \cdots & F_{x1n} \\
\vdots & \ddots & \vdots \\
F_{xin} & \cdots & F_{xin}
\end{bmatrix}
$$

$n = \text{number of modes}$

$i = \text{number of nodes}$

$[F_y]$ and $[F_z]$ are similar to $[F_x]$. $[T]$ = the coordinate transformation matrix using $\theta_x$, $\theta_y$, $\theta_z$ from the geometry data provided by INTERP.

The matrix is formed using the Euler transformation triad $[X]$ $[Y]$ $[Z]$ or some other combination, where $[X]$, $[Y]$, $[Z]$ are the individual axis transformation matrices making up the triad (see sec. 4.0, vol. I).

SCALS = 1.0 or SCALE from card 6.9.3 (sec. 6.3, vol. I) for the specific structural panels.
The forces in the inertia axis are summed at all required nodes to calculate shears at point \(A\) (load station or dummy load station).

\[
\begin{align*}
    v_x_A &= \text{SCALE}_1 \sum_i F_{x_i} + \sum_j \text{SCALE}_D F_{x_D_j} \\
    v_y_A &= \text{SCALE}_1 \sum_i F_{x_i} + \sum_j \text{SCALE}_D F_{x_D_j} \\
    v_z_A &= \text{SCALE}_1 \sum_i F_{x_i} + \sum_j \text{SCALE}_D F_{x_D_j}
\end{align*}
\]

where:

- \(i\) = required structural node numbers.
- \(j\) = required dummy node numbers.

\(\text{SCALE}_1\) is from card set 6.0 (sec. 6.3, vol. 1)

and

\[
\begin{align*}
    F_{x_D_j} &= v_{x_D_j} = \text{SCALE}_1 \sum_i F_{x_i} \\
    F_{y_D_j} &= v_{y_D_j} = \text{SCALE}_1 \sum_i F_{y_i} \\
    F_{z_D_j} &= v_{z_D_j} = \text{SCALE}_1 \sum_i F_{z_i}
\end{align*}
\]

dummy node forces at dummy node \(j\)

Note: If \(\text{SCALE}_D = +2.0\) (see vol. 1, sec. 6.3, card 6.9),

\[
F_{y_D_j} = M_{x_D_j} = M_{z_D_j} = \Delta_y \text{ is set} = 0
\]

If \(\text{SCALE}_D = -2.0\),

\[
F_{x_D_j} = F_{z_D_j} = M_{y_D_j} \text{ is set} = 0
\]

and \(\text{SCALE}_D = | -2.0 |\).
The moments at the structural nodes are obtained by $[J] \phi$ (local axis) as follows:

$[M_{x_i}] = [m_{1x_i}] [\phi_y] + [m_{1y_i}] [\phi_z] + [m_{1x_i}y_i] [\phi_{\theta_x}] + [m_{1x_i}y_i] [\phi_{\theta_y}] - [m_{1x_i}z_i] [\phi_{\theta_z}]$

$[M_{y_i}] = [m_{1x_i}] [\phi_x] + [m_{1y_i}] [\phi_z] + [m_{1x_i}y_i] [\phi_{\theta_x}] + [m_{1y_i}y_i] [\phi_{\theta_y}] + [m_{1y_i}z_i] [\phi_{\theta_z}]$

$[M_{z_i}] = -[m_{1y_i}] [\phi_x] - [m_{1x_i}] [\phi_y] - [m_{1x_i}z_i] [\phi_{\theta_x}] - [m_{1y_i}z_i] [\phi_{\theta_y}] + [m_{1x_i}y_i z_i] [\phi_{\theta_z}]$

These moments are transformed to the inertia axis system by:

$$
\begin{bmatrix}
M_{x_i} \\
M_{y_i} \\
M_{z_i}
\end{bmatrix}
= SCALS \begin{bmatrix} T \end{bmatrix}
\begin{bmatrix}
M_X \\
M_Y \\
M_Z
\end{bmatrix}
$$

The bending moments at point A (load station or dummy load station) are now obtained by summing over all required nodes.

$M_{XA} = SCALE1 \sum_i (\Delta y_i F_{z_i} + \Delta z_i F_{y_i} + M_{x_i}) + \sum J M_{Xj}$

$M_{YA} = SCALE1 \sum_i (\Delta x_i F_{z_i} - \Delta z_i F_{x_i} + M_{y_i}) + \sum J M_{Yj}$

$M_{ZA} = SCALE1 \sum_i (-\Delta y_i F_{x_i} - \Delta x_i F_{y_i} + M_{z_i}) + \sum J M_{Zj}$

where:

$\Delta x_i = BS_i - BS_A$

$\Delta y_i = BBL_i - BBL_A$

$\Delta z_i = WL_i - WL_A$

$MS_j = SCALED_j (\Delta y_{Dj} F_{zDj} + \Delta z_{Dj} F_{yDj} + M_{xDj})$

$MY_j = SCALED_j (\Delta x_{Dj} F_{zDj} - \Delta z_{Dj} F_{xDj} + M_{yDj})$

$MZ_j = SCALED_j (-\Delta y_{Dj} F_{xDj} - \Delta x_{Dj} F_{yDj} + M_{zDj})$

$\Delta x_{Dj} = BSD_j - BS_A$

$\Delta y_{Dj} = BBL_{Dj} - BBL_A$

$\Delta z_{Dj} = WL_{Dj} - WL_A$

$D_j$ is the $j^{th}$ dummy node
Note: See the previous note on SCALED₁.

The dummy node forces and moments at each dummy load station are saved for future use.

For load stations, the shears and moments are now transformed to the requested orientation. The angles $\theta_x$, $\theta_y$, and $\theta_z$ used to calculate $[T^{-1}]$ for the transformation are obtained from card input (see card 6.7, sec. 6.3, vol. I).

\[
\begin{bmatrix}
V_x \\
V_y \\
V_z
\end{bmatrix}_{\text{Point A, requested axis}} = [T^{-1}]
\begin{bmatrix}
V_x \\
V_y \\
V_z
\end{bmatrix}_{\text{Point A, inertia axis}}
\]

and:

\[
\begin{bmatrix}
M_x \\
M_y \\
M_z
\end{bmatrix}_A = [T^{-1}]
\begin{bmatrix}
M_x \\
M_y \\
M_z
\end{bmatrix}_A, \text{ inertia axis}
\]

Thus, we have $\overline{M}_3$ at point A:

\[
[\overline{M}_3] =
\begin{bmatrix}
V_x \\
V_y \\
V_z \\
M_x \\
M_y \\
M_z
\end{bmatrix}
= 
\begin{bmatrix}
V_{x_1} & \cdots & V_{x_n} \\
. & \cdots & . \\
. & \cdots & . \\
. & \cdots & . \\
M_{z_1} & \cdots & M_{z_n}
\end{bmatrix}
\]
For a surface with two load points (A and B), and with all components ($V_x$, $V_y$, $V_z$, $M_x$, $M_y$, and $M_z$), the structure of $[\bar{M}_3]$ as placed on LTAP would be:

$$[\bar{M}_3] = \begin{bmatrix}
V_{x_A} \\
V_{x_B} \\
V_{y_A} \\
V_{y_B} \\
V_{z_A} \\
V_{z_B} \\
M_{x_A} \\
M_{x_B} \\
M_{y_A} \\
M_{y_B} \\
M_{z_A} \\
M_{z_B}
\end{bmatrix}$$

If one or more component is missing, the matrix would close up; also, each surface is treated separately and is merged onto the preceding surface.

To calculate $[\bar{M}_4]$, $[\bar{M}_5]$, and $\{\bar{\phi}\}$, obtain the aero force coefficient matrices $F_{PL}(\dot{q})$, $F_{PL}(\ddot{q})$, $F_{PL}(\dot{w})$ from the Equations of Motion tape and transform the forces into the matrix axis system. Then:

$$\begin{bmatrix}
F_{x_1}(\dot{q},\ddot{q},\dot{w}) \\
F_{y_1}(\dot{q},\ddot{q},\dot{w}) \\
F_{z_1}(\dot{q},\ddot{q},\dot{w})
\end{bmatrix} = \text{SCALAI} \begin{bmatrix}
T_1
\end{bmatrix} [F_{PL}(\dot{q},\ddot{q},\dot{w})]_{local\ axis}$$

where $\{T_1\}$ is the transpose of the third row of $[T]$ with $\theta_2 = 0$, or:

$$F_{x_1}(\dot{q},\ddot{q},\dot{w}) = \text{SCALAI} T(3,1) F_{PL}(\dot{q},\ddot{q},\dot{w})$$
$$F_{y_1}(\dot{q},\ddot{q},\dot{w}) = - \text{SCALAI} T(3,2) F_{PL}(\dot{q},\ddot{q},\dot{w})$$
$$F_{z_1}(\dot{q},\ddot{q},\dot{w}) = \text{SCALAI} T(3,3) F_{PL}(\dot{q},\ddot{q},\dot{w})$$

$\text{SCALAI} = 1.0$ or SCALE from card 6.93 (section 6.3, volume 1) for the specific aerodynamic panels.
The aero forces in the inertia axis are summed at all required nodes to calculate shears at point A (load station or dummy load station, inertia axis):

\[
\begin{align*}
V_{xA} &= \text{SCALE} \sum_i F_{xi} + \sum_j \text{SCALE} \cdot F_{xj} \\
V_{yA} &= \text{SCALE} \sum_i F_{yi} + \sum_j \text{SCALE} \cdot F_{yj} \\
V_{zA} &= \text{SCALE} \sum_i F_{zi} + \sum_j \text{SCALE} \cdot F_{zj}
\end{align*}
\]

where:

\[i = \text{required aerodynamic node numbers}\]
\[j = \text{required dummy node numbers}\]

\[
\text{SCALE} = \text{SCALE2 for } M_4 \text{ and } M_5 = \text{SCALE3 for } \Phi
\]

and

\[
\begin{align*}
F_{xj} &= V_{xj} = \text{SCALE} \cdot \sum_i F_{xi} \\
F_{yj} &= V_{yj} = \text{SCALE} \cdot \sum_i F_{yi} \\
F_{zj} &= V_{zj} = \text{SCALE} \cdot \sum_i F_{zi}
\end{align*}
\]
dummy node forces

at dummy node \( j \)

Note: See the previous note on \( \text{SCALE} \).

For slender bodies (Z bodies) where the force is in the Z direction:

\[
\begin{align*}
F_{x \text{inertia axis}} &= 0 \\
F_{y \text{inertia axis}} &= 0 \\
F_{z \text{inertia axis}} &= F_{z \text{ aero local axis}}
\end{align*}
\]

For slender bodies (Y bodies) where the force is in the Y direction:

\[
\begin{align*}
F_{x \text{inertia axis}} &= 0 \\
F_{y \text{inertia axis}} &= -F_{y \text{ aero local axis}} \\
F_{z \text{inertia axis}} &= 0
\end{align*}
\]
The force coefficient matrices from EOM are partitioned for slender bodies to contain $F_y$ and $F_z$. For example, $F_{PL}(\dot{q})$ for a slender body with $y$ and $z$ forces would appear as follows:

$$[F_{PL}(\dot{q})] = \begin{bmatrix} F_{PL}(\dot{q})_y \\ \vdots \\ F_{PL}(\dot{q})_z \\ \vdots \end{bmatrix}$$

Note: $F_y$ or $F_z$ may be zero, but both $F_y$ and $F_z$ will be on the magnetic file.

This is possible since the maximum possible number of nodes for slender bodies is less than 50. Thus, the maximum number of nodes for $[F_y$ and $F_z]$ would be less than 100.

The bending moments at point A (load station or dummy load station) are obtained by summing over all required nodes:

$$M_{x A} = \text{SCALE} \sum_i (\Delta y_i F_{z i} + \Delta z_i F_{y i}) + \sum_j M_{x j}$$

$$M_{y A} = \text{SCALE} \sum_i (\Delta x_i F_{z i} - \Delta z_i F_{x i}) + \sum_j M_{y j}$$

$$M_{z A} = \text{SCALE} \sum_i (-\Delta y_i F_{x i} - \Delta x_i F_{y i}) + \sum_j M_{z j}$$

where:

$$\Delta x_i = B_{S i} - B_{S A}$$

$$\Delta y_i = B_{B L i} - B_{B L A}$$

$$\Delta z_i = W_{L i} - W_{L A}$$

$$M_{x j} = \text{SCALE} D_j (\Delta y_{D j} F_{z D j} + \Delta z_{D j} F_{y D j} + M_{x D j})$$

$$M_{y j} = \text{SCALE} D_j (\Delta x_{D j} F_{z D j} - \Delta z_{D j} F_{x D j} + M_{y D j})$$

$$M_{z j} = \text{SCALE} D_j (-\Delta y_{D j} F_{x D j} - \Delta x_{D j} F_{y D j} + M_{z D j})$$
\[
\Delta x_{D_j} = B S_{D_j} - B S_A \\
\Delta y_{D_j} = B B L_{D_j} - B B L_A \\
\Delta z_{D_j} = W L_{D_j} - W L_A
\]

\(D_j\) is the \(j^{th}\) dummy node

\[
\text{SCALE} = \text{SCALE2 for } M_4 \text{ and } M_5 \\
= \text{SCALE3 for } \bar{\phi}
\]

Note: See the previous note on \(\text{SCALE}_{D_j}\).

The dummy node forces and moments at each dummy load station are saved for future use. For load stations, the shears and moments are then transformed to the requested orientation (for a dummy load there is no transformation). The angles \(\theta_x\), \(\theta_y\), and \(\theta_z\) are obtained from card input (see card set 6.0, sec. 6.3, vol. I).

\[
\begin{bmatrix}
V_x \\
V_y \\
V_z
\end{bmatrix}
= [T^{-1}]
\begin{bmatrix}
V_x \\
V_y \\
V_z
\end{bmatrix}
\]

A, requested axis

and:

\[
\begin{bmatrix}
M_x \\
M_y \\
M_z
\end{bmatrix}
= [T^{-1}]
\begin{bmatrix}
M_x \\
M_y \\
M_z
\end{bmatrix}
\]

A, requested axis

Thus:

\[
[M_4]_A =
\begin{bmatrix}
V_x \\
V_y \\
V_z \\
M_x \\
M_y \\
M_z
\end{bmatrix}
= \begin{bmatrix}
V_{x_1} \\
V_{x_2} \\
\vdots \\
V_{x_n}
\end{bmatrix}
\]

where \(n = \) number of modes. Similarly for \(M_5:\)

\[
[\bar{\phi}]_A =
\begin{bmatrix}
V_x \\
V_y \\
V_z \\
M_x \\
M_z
\end{bmatrix}
= \begin{bmatrix}
V_{x_1} \\
V_{x_2} \\
\vdots \\
V_{x_g}
\end{bmatrix}
\]

where \(g = \) number of gust zones.
VBMT Output TAPE (LTAP)

Note: A load set is the result of processing all surfaces requested following the LOAD-SET card, but before the next LOAD-SET or $ card.

\[
\begin{align*}
[\text{Header}] \\
[M_3] \\
[M_4] \\
[M_5] \\
\phi \\
\vdots \\
[M_4] \\
[M_5] \\
\phi \\
k=1 \\
\vdots \\
k=Nk \\
\text{EOF}
\end{align*}
\]

Load set 1

Load set 2

Maximum size of \([M_3] = [M_4] = [M_5]\) is 100 x 70; of \([\phi]\) is 100 x 2(35).

Expansion of \([M_3]\) on LTAP (the first output on LTAP):

\[
[M_3] = 
\begin{bmatrix}
V_{x1} \\
\vdots \\
V_{xm} \\
\vdots \\
M_{z1} \\
\vdots \\
M_{zm} \\
V_{x1} \\
\vdots \\
M_{zn}
\end{bmatrix}
\]

\[
\text{point 1} \\
\vdots \\
\text{point m} \\
\vdots \\
\text{point 1} \\
\vdots \\
\text{point m} \\
\text{point 1} \\
\vdots \\
\text{point n}
\]

Surface 1

Surface 1

Surface 2

Similarly for \([M_4], [M_5], \) and \([\phi]\) and for all values of k.
Local to Reference Coordinates

The coordinate locations \((X,Y,Z)\) of the loads from card 6.9.2 (sec. 6.3, vol. I) are always in reference coordinates. Thus it can be directly compared with the reference coordinates from INTERP to determine the structural nodes to be included in the summation for \(\{\bar{M}_3\}\).

However, the coordinates \((X,Y)\) associated with the aero data (from the EOM tape) are in local coordinates. They must be changed back to structural coordinates before being compared to load coordinate locations \((X,Y,Z)\) in the selection of the aero nodes to get summation for \(\{\bar{M}_4\}, \{\bar{M}_5\},\) and \(\{\bar{G}\}\).

This is accomplished by LTOGT from the DYLOFLEX library. CALL LTOGT \((X,Y,Z, NPTS, R,T)\), where \((X,Y,Z)\) input is \((X,Y)\) from EOM with \(Z\) being zero, and \(R\) and \(T\) are from the SA array from INTERP (rotation and transformation). LTOG will then return \((X,Y,Z)\) in structural coordinates. (LTOGT is an entry point in AINTT).

For slender bodies, the \(Z\) coordinate in \((X,Y,Z)\) from LTOGT may be replaced by the \(Z\) from input card 6.6.

3.6 DATA BASES

L218 (LOADS) data bases include input and output files plus internal scratch files and common block storage.

3.6.1 INPUT DATA

The input data is from two sources, cards and magnetic files.

Card Input Data

For a complete description of all the card input formats, see section 6.3 in volume I of this document.

Tape Input Data

For a complete description of the tape input data see section 6.4 in volume I of this document.

3.6.2 OUTPUT DATA

The output data may be of two types, printed and magnetic files.

Printed Output Data

For a complete description of the printed output data, see section 6.5.1 in volume I of this document.
Magnetic Files (Tape or Disk)

For a complete description of the magnetic file output data, see section 6.5.2 in volume I of this document.

3.6.3 INTERNAL DATA

Common blocks and blank common (dynamic storage) are used to pass data from one routine to another within an overlay. Temporary (scratch) disk files are used in (L218,2,0), AVD. Random access disk files are used in (L218,3,0), NPLDS, and (L218,4,0), VBMT.

AVD Internal (Temporary) Disk Storage

FETADD is used to initialize buffer storage. FETDEL and RETURNF are called to delete the files after they are no longer needed. Three files are used:

- IFM₁ contains merged \( \overline{M}_1 \) data.
- IFM₂ contains merged \( \overline{M}_2 \) data.
- IFM₃ contains merged \( \overline{M}_3 \) data.

These data are written on these three files in subroutine MERGE with FORTRAN write statements and read in subroutine AVDTAP. The files are initialized and deleted in AVD. The record structure (fig. 9) for IFM₁, IFM₂, and IFM₃ is identical.

NPLDS/PLDS Internal (Temporary) Disk Storage

All temporary disk storage in this overlay is accomplished on the file MERGMB using random access methods. The file MERGMB is initialized and deleted in NPLDS. The subroutines that call WRITEMS to write on MERGMB are NPLDB2 and NPLDD₄. NPLDB₂ writes the matrix \( \overline{M}_3 \), and NPLDD₄ writes the matrices \( \overline{M}_4, \overline{M}_5 \), and \( \overline{\phi} \). The subroutine that calls READMS from MERGMB is NPLDH₁.

The matrices or records are indexed with the following numbers:

<table>
<thead>
<tr>
<th>Matrix</th>
<th>Random access key</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \overline{M}_3 )</td>
<td>1 to ISMAX</td>
</tr>
<tr>
<td>( \overline{M}_4 )</td>
<td>ISMAX + 1 to 21(ISMAX)</td>
</tr>
<tr>
<td>( \overline{M}_5 )</td>
<td>21(ISMAX) + 1 to 41(ISMAX)</td>
</tr>
<tr>
<td>( \overline{\phi} )</td>
<td>41(ISMAX) + 1 to 61(ISMAX)</td>
</tr>
</tbody>
</table>

where ISMAX is the maximum number of surfaces.

The read/write activity on MERGMB in NPLDS/PLDS is displayed in figure 10.
\[ \text{isiza NRCWS} \]

\[ \text{NROWS} \]

\[ \text{X MODES} \]

\[ \begin{array}{c}
\text{NROWS}_1 \quad \text{X MODES} \\
\text{NROWS}_2 \quad \text{X MODES} \\
\text{NROWS}_i \quad \text{X MODES} \\
\text{NROWS} \quad \text{X MODES} \\
\text{NSURF} \\
\end{array} \]

where \([M_3]\) is the \([M_3]\) for surface \(i\)

NSURF is the last surface

MODES is the number of modes

NROWS is dependent on the number of selected nodes,

and the selected matrix components.

\[ \text{IFM}_1 \]

\[ \text{IFM}_2 \]

\[ \text{IFM}_3 \]

\[ \begin{array}{c}
[M_3]_1 \\
[M_3]_2 \\
[M_3]_i \\
[M_3] \text{ NSURF} \\
\end{array} \]

\[ \text{Figure 9.} \quad \text{Record Structure of IFM}_1, \text{IFM}_2, \text{and IFM}_3 \]
<table>
<thead>
<tr>
<th>Record No.</th>
<th>Record Size</th>
<th>Written In</th>
<th>Read In</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NODES(MXMODE+1)</td>
<td>NPLDB2</td>
<td>NPLDH1</td>
<td>$\overline{M}_3$ - Surface 1</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td>$\dot{M}_3$ - Surface ISMAX</td>
</tr>
<tr>
<td>ISMAX</td>
<td></td>
<td></td>
<td></td>
<td>$\overline{M}_4$ - Surface 1, freq 1</td>
</tr>
<tr>
<td>ISMAX+1</td>
<td></td>
<td></td>
<td></td>
<td>freq 2</td>
</tr>
<tr>
<td>+2</td>
<td></td>
<td></td>
<td></td>
<td>$\overline{M}_5$ - Surface 1, freq 1</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td>Surface 2, freq 20</td>
</tr>
<tr>
<td>21(ISMAX)+1</td>
<td>NODES(COL+1)</td>
<td></td>
<td></td>
<td>$\overline{\phi}$ - Surface ISMAX, freq 20</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td>$\overline{\phi}$ - Surface ISMAX, freq 20</td>
</tr>
<tr>
<td>41(ISMAX)+1</td>
<td></td>
<td></td>
<td></td>
<td>$\overline{\phi}$ - Surface ISMAX, freq 20</td>
</tr>
<tr>
<td>...</td>
<td></td>
<td></td>
<td></td>
<td>$\overline{\phi}$ - Surface ISMAX, freq 20</td>
</tr>
</tbody>
</table>

*Figure 10. — Read/Write Activity on MERGMB in NPLDS/PLDS*
VBMT Internal (Temporary) Disk Storage

All temporary disk storage in this overlay is accomplished on the file MERGMB using random access methods. MERGMB is initialized and deleted in VBMT. The subroutines that call WRITEMS to write on MERGMB are VBMT2, VBMTD3, and VBMTD4. The subroutines that call READMS to read from MERGMB are VBMT2, VBMTD4, and VBMTF1. The read/write activity on the file MERGMB in VBMT is displayed in figure 11.

Common Blocks

Table 6 displays the common blocks used in the program and the overlays in which they are used.

The LABELED common blocks are used for communication between the main and primary overlays, and for communication between routines in a primary overlay. The block names and contents are described in table 7. The “T” heading in table 7 refers to variable type. The codes used are as follows:

I  Integer
R  Real
C  Complex
L  Logical
H  Hollerith

Blank common is used in the primary overlays as a variable length working storage area. The length of required arrays is calculated, and the first word address and variable dimension of the array is passed through the subroutine calling sequence for those routines which require it.
<table>
<thead>
<tr>
<th>Record No.</th>
<th>Record Size</th>
<th>Written In</th>
<th>Read In</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>IROW(MXMODE+2)</td>
<td>VBMTC2</td>
<td>NPLDH1</td>
<td>$\vec{\bar{M}}$ for load No. 1</td>
</tr>
<tr>
<td>MXLOAD</td>
<td></td>
<td></td>
<td></td>
<td>$\vec{M}_n$ for load No. 1, freq 1</td>
</tr>
<tr>
<td>MXLOAD+1</td>
<td></td>
<td></td>
<td></td>
<td>$\vec{M}_s$ for load No. 1, freq 1</td>
</tr>
<tr>
<td>MXLOAD(1+NK)+1</td>
<td></td>
<td></td>
<td></td>
<td>$\vec{M}_5$ for load No. 1, freq 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$\vec{M}_5$ for load No. 1, freq 1</td>
</tr>
<tr>
<td>MXLOAD(2+NK)+1</td>
<td></td>
<td></td>
<td></td>
<td>$\vec{M}_5$ for load No. 1, freq 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$\vec{M}_5$ for load No. 1, freq 1</td>
</tr>
<tr>
<td>MXLOAD(3+NK)+1</td>
<td></td>
<td></td>
<td></td>
<td>$\vec{M}_5$ for load No. 1, freq 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$\vec{M}_5$ for load No. 1, freq 1</td>
</tr>
<tr>
<td>LAST</td>
<td></td>
<td></td>
<td></td>
<td>Dummy load No. 1</td>
</tr>
</tbody>
</table>

where

- **MXLOAD** is the number of loads for this load set
- **NK** is the number of frequencies
- **IROW** is the number of rows in this matrix
- **MXMODE** is the number of modes
- **LAST** = MXLOAD(3+NK)+MXDUM(1+NK)
- **MXDUM** is maximum number of dummy loads

*Figure 11. — Read/Write Activity on MERGMB in VBMT*
Table 6. – Common Blocks in Each Overlay

<table>
<thead>
<tr>
<th>COMMON BLOCK</th>
<th>OVERLAY</th>
<th>CGEN</th>
<th>CGEN1</th>
<th>CGEN2</th>
<th>RWBUF</th>
<th>CAUD</th>
<th>CLOC</th>
<th>CITMRM</th>
<th>CMAT</th>
<th>CARRAY</th>
<th>Q3</th>
<th>CNPLD1</th>
<th>CNPLD2</th>
<th>CVBM1</th>
<th>CVBM2</th>
<th>CVBM3</th>
<th>BLANK</th>
</tr>
</thead>
<tbody>
<tr>
<td>(L218,0,0)</td>
<td>L218</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(L218,1,0)</td>
<td>RGFN</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(L218,2,0)</td>
<td>AVD</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(L218,3,0)</td>
<td>NPLDS</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(L218,4,0)</td>
<td>VBMT</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Table 7. — Contents of Common Blocks**

<table>
<thead>
<tr>
<th>NO.</th>
<th>VARIABLE</th>
<th>T</th>
<th>DIM.</th>
<th>ENG. NOM.</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>INODE</td>
<td>I</td>
<td>100</td>
<td>i</td>
<td>Contain selected nodes</td>
</tr>
<tr>
<td>2</td>
<td>LFM1</td>
<td>I</td>
<td>LBUF</td>
<td></td>
<td>FET buffer for IFM1</td>
</tr>
<tr>
<td>3</td>
<td>LFM2</td>
<td>I</td>
<td>LBUF</td>
<td></td>
<td>FET buffer for IFM2</td>
</tr>
<tr>
<td>4</td>
<td>LFM3</td>
<td>I</td>
<td>LBUF</td>
<td></td>
<td>FET buffer for IFM3</td>
</tr>
<tr>
<td>5</td>
<td>LARRAY</td>
<td>I</td>
<td>LBUF</td>
<td></td>
<td>FET buffer for IDISK</td>
</tr>
<tr>
<td>6</td>
<td>XYZCOR</td>
<td>R</td>
<td>3*NODES</td>
<td>(X,Y,Z) coordinates for surface IS (card input)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>ALB</td>
<td>R</td>
<td>NODES</td>
<td>LB</td>
<td>(LB) interpolation coefficient</td>
</tr>
<tr>
<td>8</td>
<td>ALT</td>
<td>R</td>
<td>NODES</td>
<td>LT</td>
<td>(LT) interpolation coefficient</td>
</tr>
<tr>
<td>9</td>
<td>ALTT</td>
<td>R</td>
<td>NODES</td>
<td>LTT</td>
<td>(LTT) interpolation coefficient</td>
</tr>
<tr>
<td>10</td>
<td>ISUB</td>
<td>I</td>
<td>NODES</td>
<td></td>
<td>Requested nodes</td>
</tr>
<tr>
<td>11</td>
<td>GEOM</td>
<td>R</td>
<td>3*NODES</td>
<td>(X,Y,Z) coordinates from INTERP</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>BS2</td>
<td>R</td>
<td>NODES</td>
<td>BS_i+1</td>
<td>X coordinate from INTERP for the (I+1) node</td>
</tr>
<tr>
<td>13</td>
<td>THXYZ</td>
<td>R</td>
<td>3*NODES</td>
<td>θ_x, θ_y, θ_z for surface IS</td>
<td></td>
</tr>
</tbody>
</table>
| 14  | PX       | R | NODES* | φ_x
| 15  | PX2      | R | NODES* | φ_x
| 16  | PY       | R | NODES* | φ_y
| 17  | PY2      | R | NODES* | φ_y
| 18  | PZ       | R | NODES* | φ_z
| 19  | PZ2      | R | NODES* | φ_z
| 20  | PPX      | R | NODES* | φ_θ_x

**BLANK COMMON:** AVD Dynamic Storage

**DESCRIPTION:** Varibly dimensioned arrays
Table 7. – (Continued)

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<th>DESCRIPTION</th>
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<tbody>
<tr>
<td>21</td>
<td>PPX2</td>
<td>R</td>
<td>NODES* MXMODE</td>
<td>x_{i+1}</td>
<td>( \theta_x ) for (I+1) node</td>
</tr>
<tr>
<td>22</td>
<td>PPY</td>
<td>R</td>
<td>NODES* MXMODE</td>
<td>y_{i}</td>
<td>( \theta_y )</td>
</tr>
<tr>
<td>23</td>
<td>PPy2</td>
<td>R</td>
<td>NODES* MXMODE</td>
<td>y_{i+1}</td>
<td>( \theta_y ) for (I+1) node</td>
</tr>
<tr>
<td>24</td>
<td>PPZ</td>
<td>R</td>
<td>NODES* MXMODE</td>
<td>z_{i}</td>
<td>( \theta_z )</td>
</tr>
<tr>
<td>25</td>
<td>PPZ2</td>
<td>R</td>
<td>NODES* MXMODE</td>
<td>z_{i+1}</td>
<td>( \theta_z ) for (I+1) node</td>
</tr>
<tr>
<td>26</td>
<td>SA</td>
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Table 7. — (Continued)

Labeled Common Name: CGEN

Description: Contains general data required by all overlays.

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<th>Description</th>
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<td>TDUM</td>
<td>H</td>
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<tr>
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<td>I</td>
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<td></td>
<td>Name of card input file (=5)</td>
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<tr>
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<td>I</td>
<td>1</td>
<td></td>
<td>Name of card output file (=6)</td>
</tr>
<tr>
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<td>IGFRTNT</td>
<td>I</td>
<td>1</td>
<td></td>
<td>General print control</td>
</tr>
<tr>
<td>5</td>
<td>KMOD</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Module option control (AVD=1, NPLDS=2, PLDS=3, VBMT=4)</td>
</tr>
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<td>I</td>
<td>1</td>
<td></td>
<td>Name of temporary general output file</td>
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<td>7</td>
<td>IGS</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Load-Set counter</td>
</tr>
<tr>
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<td>NERROR</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Fatal Error Counter</td>
</tr>
<tr>
<td>9</td>
<td>ISMAX</td>
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<td>Maximum Number of surfaces for this load-set</td>
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<td>H</td>
<td>3</td>
<td></td>
<td>Warning Message</td>
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<td>FAT</td>
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<td>Fatal Error Message</td>
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<tr>
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<td>Dimension value for OUTBUF-buffer length.</td>
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<td>H</td>
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<td></td>
<td>NPLDS output tape name</td>
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<td>IPTAP</td>
<td>H</td>
<td>1</td>
<td></td>
<td>PLDS output tape name</td>
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<td>16</td>
<td>LTAP</td>
<td>H</td>
<td>1</td>
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<td>JTAPE</td>
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<td>File name for the J-Matrix tape</td>
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<tr>
<td>21</td>
<td>IXYZ</td>
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<td>1</td>
<td></td>
<td>Indicator defining transformation order</td>
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<td>LC</td>
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<td>Line Count for FETADD</td>
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<td>ENG. NOM.</td>
<td>DESCRIPTION</td>
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<td>----------</td>
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<td>------</td>
<td>-----------</td>
<td>--------------------------------------</td>
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<tr>
<td>1</td>
<td>IFM1</td>
<td>I</td>
<td>1</td>
<td></td>
<td>File name for $M_1$ merged</td>
</tr>
<tr>
<td>2</td>
<td>IFM2</td>
<td>I</td>
<td>1</td>
<td></td>
<td>File name for $M_2$ merged</td>
</tr>
<tr>
<td>3</td>
<td>IFM3</td>
<td>I</td>
<td>1</td>
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<td>File name for $M_3$ merged</td>
</tr>
<tr>
<td>4</td>
<td>LFM1</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Buffer length for IFM1</td>
</tr>
<tr>
<td>5</td>
<td>LFM2</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Buffer length for IFM2</td>
</tr>
<tr>
<td>6</td>
<td>LFM3</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Buffer length for IFM3</td>
</tr>
<tr>
<td>7</td>
<td>LARRAY</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Buffer length for IDISK</td>
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</table>

Table 7. — (Continued)

Labeled Common Name: CARRAY

Description: AVD subroutine file names and buffer lengths
Table 7. – (Continued)

Labeled Common Name: \texttt{CAVD}

Description: \texttt{AVD} subroutine options and scale factors

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<td>1</td>
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<td>I</td>
<td>1</td>
<td></td>
<td>=1 for matrix input by card; =0 otherwise</td>
</tr>
<tr>
<td>2</td>
<td>IIS</td>
<td>I</td>
<td>1</td>
<td></td>
<td>=1 if another surface is to be input; =0 otherwise</td>
</tr>
<tr>
<td>3</td>
<td>INTER</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Interpolation control</td>
</tr>
<tr>
<td>4</td>
<td>IPRINT</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Print control</td>
</tr>
<tr>
<td>5</td>
<td>IROT</td>
<td>I</td>
<td>1</td>
<td></td>
<td>=1 for rotation; =0 otherwise</td>
</tr>
<tr>
<td>6</td>
<td>IS</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Current surface number</td>
</tr>
<tr>
<td>7</td>
<td>IUNIT</td>
<td>I</td>
<td>1</td>
<td></td>
<td>=1 for Metric; =2 for English</td>
</tr>
<tr>
<td>8</td>
<td>NIS</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Not used</td>
</tr>
<tr>
<td>9</td>
<td>NRR</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Diagnostic error variable</td>
</tr>
<tr>
<td>10</td>
<td>SCALR1</td>
<td>R</td>
<td>1</td>
<td></td>
<td>Matrix scale factor</td>
</tr>
<tr>
<td>11</td>
<td>SCALR2</td>
<td>R</td>
<td>1</td>
<td></td>
<td>Matrix scale factor</td>
</tr>
<tr>
<td>12</td>
<td>SCALR3</td>
<td>R</td>
<td>1</td>
<td></td>
<td>Matrix scale factor</td>
</tr>
<tr>
<td>13</td>
<td>IANGLE</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Theta input control</td>
</tr>
<tr>
<td>14</td>
<td>ISP</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Previous surface number</td>
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</table>
**Table 7. — (Continued)**

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<th>DIM.</th>
<th>ENG. NOM.</th>
<th>DESCRIPTION</th>
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<tr>
<td>1</td>
<td>IQLTAP</td>
<td>30</td>
<td></td>
<td></td>
<td>Matrix for the first record of output to tapes IAVD1, NPTAP, IPTAP and LTAP.</td>
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**LABELLED COMMON NAME:** CGEN1

**DESCRIPTION:** Required in each overlay. Contains the header matrix data for final tape output.
Table 7. – (Continued)

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<th>DESCRIPTION</th>
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<tr>
<td>1</td>
<td>IFILEA</td>
<td>I</td>
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<td>Loadset file count for AVD</td>
</tr>
<tr>
<td>2</td>
<td>IFILEP</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Loadset file count for PLDS</td>
</tr>
<tr>
<td>3</td>
<td>IFILENP</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Loadset file count for NPLDS</td>
</tr>
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Labeled Common Name: CGEN2
Description: Contains file count variables
Table 7. — (Continued)

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<th>DESCRIPTION</th>
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<tbody>
<tr>
<td>1</td>
<td>ITM3X</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Code for translational matrix</td>
</tr>
<tr>
<td>2</td>
<td>ITM2X</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Code for translational matrix</td>
</tr>
<tr>
<td>3</td>
<td>ITM1X</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Code for translational matrix</td>
</tr>
<tr>
<td>4</td>
<td>ITM3Y</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Code for translational matrix</td>
</tr>
<tr>
<td>5</td>
<td>ITM2Y</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Code for translational matrix</td>
</tr>
<tr>
<td>6</td>
<td>ITM1Y</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Code for translational matrix</td>
</tr>
<tr>
<td>7</td>
<td>ITM3Z</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Code for translational matrix</td>
</tr>
<tr>
<td>8</td>
<td>ITM2Z</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Code for translational matrix</td>
</tr>
<tr>
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<td>ITM1Z</td>
<td>I</td>
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<td>Code for translational matrix</td>
</tr>
<tr>
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<tr>
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<td></td>
<td>Code for rotational matrix</td>
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<tr>
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<td>I</td>
<td>1</td>
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<td>Code for rotational matrix</td>
</tr>
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<td>Code for rotational matrix</td>
</tr>
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<td>Code for rotational matrix</td>
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<td>Code for rotational matrix</td>
</tr>
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<td>Code for rotational matrix</td>
</tr>
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<td>1</td>
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<td>Code for rotational matrix</td>
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### Table 7. - (Continued)

**LABELED COMMON NAME:** CLOC  
**DESCRIPTION:** AVD subroutine matrix sizes and locations

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<td>Number of nodes requested</td>
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<td>Total number of nodes</td>
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<td>MXMODE</td>
<td>I</td>
<td>1</td>
<td></td>
<td>Total number of modes</td>
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<tr>
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<td>I</td>
<td>1</td>
<td></td>
<td>Dynamic storage location for XYZCOR</td>
</tr>
<tr>
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<td>Dynamic storage location for ALB</td>
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<td>LLT</td>
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**Table 7. — (Continued)**

**Labeled Common Name:** CMAT  
**Description:** AVD subroutine problem size.

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Table 7. — (Continued)

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Labeled Common Name: CNPLD2

Description: NPLDS/PLDS subroutine linkage (temporary storage)
Table 7. — (Continued)

Labeled Common Name: CVBMT1

Description: VBMT subroutine option, array sizes, and
locations.

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<td>Previous surface number</td>
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Table 7. — (Continued)

Labeled Common Name: CVBMTFL

Description: Maximum, first and last surface numbers

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Table 7. — (Continued)

BLANK COMMON: NPLDS/PLDS Dynamic Storage

DESCRIPTION: Variably dimensioned arrays

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<td>$[F_{pL}]$</td>
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### Table 7. – (Continued)

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<td>R</td>
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**Labeled Common Name:** Q3  
**Description:** AVD subroutine linkeage (temporary storage)
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Table 7. – (Continued)

Labeled common name: RWBUFF

Description: READTP/WRTETP Buffer Area
Table 7. – (Continued)

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**Table 7. – (Continued)**

**BLANK COMMON:** VBMT Dynamic Storage (continued)

**DESCRIPTION:** Variably dimensioned arrays

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Table 7. — (Concluded)

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4.0 EXTENT OF CHECKOUT

Each module of L218 (AVD, NPLDS/PLDS, and VBMT) was checked out with preliminary standalone data and then final verification test data, exercising the options indicated in tables 8 through 10.

Boeing Commercial Airplane Company
P.O. Box 3707
Seattle, Washington 98124
May 1977
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* = .0259
Table 9. — NPLDS/PLDS Checkout Summary

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Table 10. – VBMT Checkout Summary

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* = .0259
REFERENCES


The LOADS computer program L218 calculates dynamic load coefficient matrices utilizing the force summation method. The load equations are derived for a flight vehicle in straight and level flight and excited by gusts and/or control motions. In addition, sensor equations are calculated for use with an active control system.

The load coefficient matrices are calculated for the following types of loads:

- Translation and rotational accelerations, velocities, and displacements
- Panel aerodynamic forces
- Net panel forces
- Shears, bending moments, and torsions

Program usage and a brief description of the analysis used are presented in volume I of this document. Volume II contains a description of the design and structure of the program to aid those persons who will maintain and/or modify the program in the future.