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PROGRAMS FOR TRANSFERRING DATA BETWEEN A RELATIONAL DATA BASE AND A FINITE-ELEMENT STRUCTURAL ANALYSIS PROGRAM

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SUMMARY

This report documents an interface system for passing data between a Relational Information Management (RIM) data base complex and Engineering Analysis Language (EAL), a finite-element structural-analysis program. The interface system, implemented on a CDC Cyber computer, is composed of two FORTRAN programs called RIM2EAL and EAL2RIM. RIM2EAL reads model definition data from RIM and creates a file of EAL commands to define the model. EAL2RIM reads model definition and EAL-generated analysis data from EAL's data library and stores these data directly in a RIM data base. Descriptions of these two interface programs and the format for the RIM data complex are presented. This information may serve as a user's guide for running the interface programs, or may be used in interfacing to other programs.

INTRODUCTION

An interface system linking EAL, a finite-element structural-analysis program (refs. 1-3), to RIM, a central data complex (ref. 4), is documented. Descriptions of the two FORTRAN programs for passing data, RIM2EAL and EAL2RIM, are presented as well as a full description of the schema for the RIM data complex.

The interface system may be used in two ways. The model may be defined in some other program, stored in RIM, and defined in EAL using the RIM2EAL program (eg. a data generator). In this case, the model data are already stored in RIM, and only the EAL-generated analysis data should be stored in RIM by EAL2RIM. On the other hand, the model data can be originally defined in EAL. The model can still be passed to other systems for further analysis by using EAL2RIM to store model definition data as well as analysis data in RIM.

A finite-element model defined in a RIM data base with the proper format can easily be input to EAL using RIM2EAL. The model is then analyzed by EAL as specified by the user. Using EAL2RIM, the user may then store the desired types of analysis data into RIM, where they may be displayed or used by other programs. The analysis data that may be stored in RIM include static displacements, static reactions, stresses, vibrational eigenvectors and eigenvalues, buckling eigenvectors and eigenvalues, nodal temperatures, and transient analysis matrices. Model definition data may also be stored in RIM by the EAL2RIM program. This is useful for defining a new model in RIM, making changes to a model, or defining an old model in a different data base.

RIM2EAL

The RIM2EAL interface program creates an EAL runstream from the model definition in a RIM data base. The user is prompted for the names of the model, material, and section property data bases. Diagnostics are printed to inform the user of progress as the data are processed. The following menu is then displayed:

```
--ENTER CONSTRAINED DEGREES--
--OF FREEDOM, ONE AT A TIME--
--                         --
--  TO EXIT, OR IF GLOBAL  --
--   CONSTRAINTS ALREADY   --
--   DEFINED, ENTER "7"    --

      1.  X - DIRECTION
      2.  Y - DIRECTION
      3.  Z - DIRECTION
      4.  X - ROTATION
      5.  Y - ROTATION
      6.  Z - ROTATION
      7.  >>EXIT<<
```

The user should enter the numbers of any degrees of freedom he wants constrained, then enter "7." For example, if the Y-direction and Z-rotation of every joint in the model are constrained, the user should enter "2," then after the menu reappears, enter "6," then enter "7." If all the model constraints have been defined in RIM relation "CONSTRN," or if there are no model constraints, "7" should be entered. This section is for overall model constraints; constraints on specific joints should be defined in RIM relation "CONSTRN" prior to execution.

Diagnostic messages are printed to inform the user of progress while the EAL runstream is generated, then the following message is displayed:

```
ANY APPLIED FORCES?
```

An answer of "Y" will cause the EAL control cards for entering applied forces to be inserted in the EAL command file, but no applied forces will be entered. The user should later edit the EAL runstream and specify the applied forces, described in reference 2, before using the runstream. The following menu is then displayed:

```
--------------------------------
  -PICK # FOR TYPE OF ANALYSIS-
--------------------------------
1.  STATIC SOLUTION WITH STRESSES
2.  VIBRATION ANALYSIS
3.  BUCKLING ANALYSIS
4.  DYNAMIC RESPONSE
```

The user must choose the type of analysis to be done by EAL. If "1" is chosen, the following control statements are added to the EAL command file:

```
*XQT SSOL
*XQT VPRT
PRINT STAT DISP
PRINT APPL FORC
PRINT STAT REAC
*XQT GSF
*XQT PSF
```

If "2" is chosen, the following EAL control statements are added to the EAL command file:

```
*XQT EIG
RESET INIT=2, NREQ=10
```

If "3" is chosen, the following EAL control statements are added:

```
*XQT SSOL
*XQT GSF
RESET EMBED=1
*XQT KG
*XQT EIG
RESET PROB=BUCKLING, INIT=2, NREQ=10
```

If "4" is chosen, the following EAL control statements are added:

```
*XQT AUS
*XQT DR
```

The user is then informed of the name of the EAL runstream file, and the program is terminated. The user may now edit the runstream to add applied forces and other changes, and execute EAL with the runstream input. Appendix A is a sample EAL runstream generated from a RIM data base with the RIM origin of each data section noted.

EAL2RIM

The EAL2RIM interface program allows the user to store EAL-generated model definition and structural analysis data in a RIM data base. Only the types of data chosen by the user are stored. For example, if a model is already defined in the data base, storing node location and element connectivities again is unnecessary. The user is prompted for the names of the model, material, and section property data bases. The following data type menu is then displayed:

1. NODE LOCATIONS
2. ELEMENT CONNECTIVITIES
3. STATIC DISPLACEMENTS
4. STATIC REACTIONS
5. STRESSES
6. VIBRATIONAL EIGENVECTORS
7. VIBRATIONAL EIGENVALUES
8. BUCKLING EIGENVECTORS
9. BUCKLING EIGENVALUES
10. NODAL TEMPERATURES
11. TRANSIENT ANALYSIS

The user must select the type of data to store by number. The following sections explain each menu choice. After each type of data is successfully stored, the following message is displayed:

DO YOU WISH TO STORE MORE EAL GENERATED DATA?

If the user answers "Y," the data type menu is displayed for another choice. Otherwise, the data bases are closed and the program is terminated.

The EAL2RIM program reads the EAL data set "JDF1 BTAB" to determine the number of joints and which joint motion components are constrained. These data are necessary for reading certain other EAL data sets. The contents of each RIM relation are deleted before new data are written to the relation. Storing the same type twice will result in only the final copy being stored.

1. NODE LOCATIONS

If "1" is chosen, the node locations and nodal constraints are stored in RIM. The node locations are read from EAL data set "JLOC BTAB 2 5" and stored in RIM relation "NODES." The user is prompted for a constraint case number. If an EAL "CON" data set is found with the specified constraint case number, this set of constraints is stored in RIM relation "CONSTRN." Otherwise, the user is notified that the constraint case was not found, and the first available "CON" data set is used instead. EAL data set "JREF" is used in decoding the contents of the "CON" data set.

2. ELEMENT CONNECTIVITIES

If "2" is chosen, element connectivity data are stored in RIM. The beam orientation entries are read from the EAL data set "MREF BTAB" and stored into the RIM relation "ORIENT." The non-structural weight entries are read from the EAL data set "NSW BTAB" and stored into the RIM relation "NSWEIGHT." Beams, then triangles, then quadrilaterals are processed in the following manner. The EAL "DEF" data sets are read, and data stored in the RIM scratch relation "SCRREL." The element type name for each element is determined from the third name of the "DEF" data set. If beams are being processed, data from each EAL section property data set are written into the corresponding RIM section property relations. If triangles or quadrilaterals are being processed, the EAL "SA BTAB" or "SB BTAB" data sets are read and the thicknesses are stored in "SCRREL." Data for each element in "SCRREL" are then stored in the appropriate relation--"BEAMS," "TRIANGLS," or "QUADS." The elements are renumbered to avoid duplication, so RIM element numbers do not correspond to EAL element numbers. All of the material entries in the EAL data set "MATC BTAB" are written into the RIM relation "MAT-PROP".

3. STATIC DISPLACEMENTS

If "3" is chosen, static displacement data from every EAL "STAT DISP" data set are stored in the RIM relation "STATDISP." The third and fourth names of the EAL data set and the block number are stored with each row. One set of displacements consists of an entry for each joint in the model with identical third and fourth names and block numbers.

4. STATIC REACTIONS

If "4" is chosen, static reaction data from every EAL "STAT REAC" data set are stored in RIM relation "STATREAC." The third and fourth names of the EAL data set and the block number are stored with each row. One set of reactions consists of an entry for each joint in the model with identical third and fourth names and block numbers.

5. STRESSES

If "5" is chosen, stress data from every EAL "STRS" data set are stored in the RIM stress relations. Because stress data are indexed by element number instead of joint number, and the element numbers in RIM do not correspond to the EAL element numbers, the appropriate RIM relation ("BEAMS," "TRIANGLS," or "QUADS") is searched to match the element's joint numbers. These RIM data areused to find the element's GROUP#, ELEMENT#, and EL-TYPE. Each element type has different stress data associated with it, so each RIM element type has a separate stress relation. The relation name is formed by appending "-STRS" (or "STRS" if the EL-TYPE is four letters) to the element's EL-TYPE.

6. VIBRATIONAL EIGENVECTORS

If "6" is chosen, the following message is displayed:

HOW MANY EIGENVECTORS DO YOU WANT STORED?

The user should enter the maximum number of eigenvectors to be stored. Up to the specified number of vibrational eigenvectors from EAL "VIBR MODE" data sets are stored in the RIM relation "VIBRVECS." The third and fourth names of the EAL data set and the block number are stored with each row. One eigenvector consists of an entry for each joint in the model with identical third and fourth names and block numbers. The corresponding eigenvalue can be found if "7" is also chosen by searching the RIM relation "VIBRVALS" for an entry with matching third and fourth names and entry number.

7. VIBRATIONAL EIGENVALUES

If "7" is chosen, all vibrational eigenvalues from the EAL "VIBR EVAL" data sets are stored in the RIM relation "VIBRVALS." The third and fourth names of the EAL data set and the entry number are stored with each row. The corresponding eigenvalue can be found by searching the RIM relation "VIBRVECS" for all entries with matching third and fourth names and block numbers matching this entry number.

8. BUCKLING EIGENVECTORS

If "8" is chosen, the following message is displayed:

HOW MANY EIGENVECTORS DO YOU WANT STORED?

The user should enter the maximum number of eigenvectors to be stored. Up to the specified number of buckling eigenvectors from EAL "BUCK MODE" data sets are stored in the RIM relation "BUCKVECS." The third and fourth names of the EAL data set and the block number are stored with each row. One eigenvector consists of an entry for each joint in the model with identical third and fourth names and block numbers. The corresponding eigenvalue can be found if "9" is also chosen by searching the RIM relation "BUCKVALS" for an entry with matching third and fourth names and entry number.

9. BUCKLING EIGENVALUES

If "9" is chosen, all buckling eigenvalues from the EAL "BUCK EVAL" data sets are stored in RIM relation "BUCKVALS." The third and fourth names of the EAL data set and the entry number are stored with each row. The corresponding eigenvalue can be found by searching RIM relation "BUCKVECS" for all entries with matching third and fourth names and block numbers matching this entry number.

10. NODAL TEMPERATURES

If "10" is chosen, nodal temperatures from every EAL "NODA TEMP" data set are stored in the RIM relation "NODATEMP." The third name of the EAL data set and the block number are stored with each temperature value. One set of temperatures consists of a temperature for each joint with matching third names and block numbers.

11. TRANSIENT ANALYSIS

If "11" is chosen, transient analysis data from all of the following EAL data sets found are stored in the RIM relation "TRANSAN":

"TIME"	"QX"	"QR1"
"CA"	"QX1"	"QR2"
"CQR2"	"QX2"	
"A"	"QR"	

Each data value from each transient analysis matrix is put into a separate entry in the RIM relation. The data type and the time interval and node number corresponding to the data value are included in the RIM entry.

RIM DATA BASE COMPLEX

The most common approaches for managing data to be shared among many application programs are global integration and local networking. Global integration involves communication between programs by means of a central data base complex, while networking means direct communication links between programs. Global integration was chosen for this system over networking because: (1) data can be easily examined or changed in the central data base; (2) integrating a new program involves writing only two interfaces instead of many; (3) writing an interface only requires knowledge of the program to be added and the data base complex; and (4) removing or altering any program does not directly affect any other program.

Because of its good data access capabilities, availability, and relational nature, RIM was chosen for the central data base of the system. EAL's own data base system was deemed unsuitable for use as the central data base because its data can only be examined in large blocks and is often encoded and hard to understand. RIM, on the other hand, displays data neatly in relations with headers, accesses the data one row at a time, and provides sorting and searching capabilities. A relation is a two-dimensional table of data. The column headings are the attributes of the relation, and the rows are the data entries, called tuples. Data is accessed one row at a time, where a row makes up a complete set of data. For example, one row of the relation "NODES" contains one node's identification number and X-, Y-, and Z-coordinates.

The RIM data base complex consists of three parts; the model data base, the material properties data base, and the section properties data base. The model data base contains the model definition data and the EAL-generated analysis data. The material properties data base consists of a single relation containing material numbers and associated properties. The section properties data base contains a relation matching each possible beam element type name. These relations contain nominal size numbers for beam elements and associated properties. The model, material properties, and section properties may all be in the same data base, or the properties can be stored in other data bases and used with several different models. Appendix B shows the necessary RIM interactive commands for setting up these three data bases. Following is a list of the contents of each RIM relation in each data base.

"NODES"

"NODES" contains the x-, y-, and z-coordinates of each node in the model. The RIM node numbers match the EAL node numbers. These data correspond to EAL data set "JLOC BTAB 2 5."

Relation contents:

Attribute	Type	Explanation
ORG-NODE	integer	Node number
X	real	X-coordinate
Y	real	Y-coordinate
Z	real	Z-coordinate

"CONSTRN"

"CONSTRN" contains an entry for each node in the model, indicating which directional and rotational components are constrained for that node. Each text attribute in the relation contains either "YES" indicating that degree of freedom is constrained, or "NO" indicating that degree of freedom is not constrained. Data for this relation are taken from the EAL "CON" data set.

Relation contents:

Attribute	Type	Explanation
ORG-NODE	integer	Node number
X-DISP	text 4	Constrained in X-displacement? ("YES" or "NO")
Y-DISP	text 4	Constrained in Y-displacement?
Z-DISP	text 4	Constrained in Z-displacement?
X-ROT	text 4	Constrained in X-rotation?
Y-ROT	text 4	Constrained in Y-rotation?
Z-ROT	text 4	Constrained in Z-rotation?

"BEAMS"

"BEAMS" contains basic element definition data for all 2-node elements. RIM element numbers do not necessarily match the EAL element numbers. Data for this relation are taken from EAL data sets "DEF" and "BA".

Relation contents:

Attribute	Type	Explanation
GROUP#	integer	Group number of element (=EAL group number)
ELEMENT#	integer	Element number within BEAM relation
NODE1	integer	Node #1
NODE2	integer	Node #2
EL-TYPE	text 8	RIM element type
NOM-SIZE	integer	Nominal size number (index to relation with name matching EL-TYPE)
MATNUM	integer	Material number (index to MAT-PROP relation)
ORIENT	integer	Beam orientation index (index to ORIENT relation)
NSWEIGHT	integer	Non-structural weight index (index to NSWEIGHT relation)

"TRIANGLS"

"TRIANGLS" contains basic element definition data for all 3-node elements. RIM element numbers do not necessarily match the EAL element numbers. Data for this relation are taken from EAL data set "DEF".

Relation contents:

Attribute	Type	Explanation
GROUP#	integer	Group number of element (=EAL group number)
ELEMENT#	integer	Element number within TRIANGLS relation
NODE1	integer	Node #1
NODE2	integer	Node #2
NODE3	integer	Node #3
EL-TYPE	text 8	RIM element type
MATNUM	integer	Material number (index to MAT-PROP relation)
THICKNES	real	Thickness of element (isotropic)
ORIENT	integer	Orientation index (index to ORIENT relation)
NSWEIGHT	integer	Non-structural weight index (index to NSWEIGHT relation

---

"QUADS"

"QUADS" contains basic element definition data for all 4-node elements. RIM element numbers do not necessarily match the EAL element numbers. Data for this relation are taken from EAL dataset "DEF."

Relation contents:

Attribute	Type	Explanation
GROUP#	integer	Group number of element (=EAL group number)
ELEMENT#	integer	Element number within QUAD relation
NODE1	integer	Node #1
NODE2	integer	Node #2
NODE3	integer	Node #3
NODE4	integer	Node #4
EL-TYPE	text 8	RIM element type
MATNUM	integer	Material number (index to MAT-PROP relation)
THICKNES	real	Thickness of element (isotropic)
ORIENT	integer	Orientation index (index to ORIENT relation)
NSWEIGHT	integer	Nonstructural weight index (index to NSWEIGHT relation)

"SCRREL"

This scratch relation is used by the RIM to EAL and EAL to RIM interface programs as an intermediate storage area to reformat element connectivity data.

Relation contents:

Attribute	Type	Explanation
GROUP#	integer	Group number of element (=EAL group number)
ELTNUM	integer	EAL element number
EL-TYPE	text 8	RIM element type
ELD	text 4	EAL element type
NODE1	integer	Node #1
NODE2	integer	Node #2
NODE3	integer	Node #3
NODE4	integer	Node #4
MATNUM	integer	Material number
SECTION	text 4	EAL section type
NOM-SIZE	integer	Nominal Size number
THICKNES	real	Thickness of triangular or quadrilateral element
ORIENT	integer	Orientation index
NSWEIGHT	integer	Nonstructural weight index

"ORIENT"

"ORIENT" contains element orientation data corresponding to the orientation index numbers found in relations "BEAMS", "TRIANGLS", and "QUADS." Data for this relation are taken from EAL dataset "MREF BTAB." The contents of each entry depend on the format number. (See reference 2 description of EAL MREF input.)

Relation contents:

Attribute	Type	Explanation
MREF	integer	Orientation index
NB	real	If FORMAT=1, contains beam axis; If FORMAT=2, contains axis orientation
NB	real	If FORMAT=1, contains global axis; If FORMAT=2, contains x_1
ISIGN	real	If FORMAT=1, contains a 1 if cosine is positive, -1, otherwise; if FORMAT=2, contains x_2
COSINE	real	If FORMAT=1, contains cosine between NB and NG; if FORMAT=2, contains x_3
FORMAT	integer	Format number, either 1 or 2

"STATDISP"

"STATDISP" contains static displacements for each joint in each direction and rotation for various load sets and constraint cases. Data for this relation are taken from EAL datasets "STAT DISP iset ncon," where iset is the load set number and ncon is the constraint case number.

Relation contents:

Attribute	Type	Explanation
JOINT#	integer	Joint number
X	real	Displacement in the x-direction
Y	real	Displacement in the y-direction
Z	real	Displacement in the z-direction
THETA-X	real	Rotation about the x-axis
THETA-Y	real	Rotation about the y-axis
THETA-Z	real	Rotation about the z-axis
LOADSET	integer	Load set, corresponds to the third word of EAL dataset names
CON	integer	Constraint case, corresponds to the fourth word of EAL dataset names
CASE	integer	Load case within load set, corresponds to the block number in the EAL dataset

---

"STATREAC"

"STATREAC" contains static reactions for each joint in each direction and rotation for various load sets and constraint cases. Data for this relation are taken from EAL datasets "STAT REAC iset ncon," where iset is the load set number and ncon is the constraint case number.

Relation contents:

Attribute	Type	Explanation
JOINT#	integer	Joint number
X	real	Reaction in the x-direction
Y	real	Reaction in the y-direction
Z	real	Reaction in the z-direction
THETA-X	real	Rotation about the x-axis
THETA-Y	real	Rotation about the y-axis
THETA-Z	real	Rotation about the z-axis
LOADSET	integer	Load set, corresponds to the third word of EAL dataset names
CON	integer	Constraint case, corresponds to the fourth word of EAL dataset names
CASE	integer	Load case within load set corresponds to the block number in the EAL dataset

"VIBRVECS"

"VIBRVECS" contains vibrational displacements for each joint in each direction and rotation for various load sets and constraint cases. Data for this relation are taken from EAL datasets "VIBR MODE iset ncon," where iset is the load set number and ncon is the constraint case number.

Relation contents:

Attribute	Type	Explanation
JOINT#	integer	Joint number
X	real	Normalized x-component of the vibrational displacement
Y	real	Normalized y-component of the vibrational displacement
Z	real	Normalized z-component of the vibrational displacement
THETA-X	real	Normalized rotation about the x-axis of the vibrational displacement
THETA-Y	real	Normalized rotation about the y-axis of the vibrational displacement
THETA-Z	real	Normalized rotation about the z-axis of the vibrational displacement
LOADSET	integer	Load set, corresponding to the third word of EAL dataset names
CON	integer	Constraint case, corresponding to the fourth word of EAL dataset names
APPROX	integer	Eigenvector approximation number for this set number and constraint case, corresponding to the block number of the EAL dataset

"VIBRVALS"

"VIBRVALS" contains a vibrational frequency for each set of vibrational displacements in "VIBRVECS." Data for this relation are taken from EAL datasets "VIBR EVAL iset ncon," where iset is the load set number and ncon is the constraint case number.

Relation Contents:

Attribute	Type	Explanation
FREQ	real	Vibrational frequency
LOADSET	integer	Load set, corresponding to the third word of EAL dataset names
CON	integer	Constraint case, corresponding to the fourth word of EAL dataset names
APPROX	integer	Eigenvector approximation number for this set number and constraint case, corresponding to the block number of the eigenvector dataset

"BUCKVECS"

"BUCKVECS" contains buckling displacements for each joint in each direction and rotation for various load sets and constraint cases. Data for this relation are taken from EAL datasets "BUCK MODE iset ncon," where iset is the load set number and ncon is the constraint case number.

Relation contents:

Attribute	Type	Explanation
JOINT#	integer	Joint number
X	real	Normalized x-component of the buckling displacement
Y	real	Normalized y-component of the buckling displacement
Z	real	Normalized z-component of the buckling displacement
THETA-X	real	Normalized rotation about the x-axis of the buckling displacement
THETA-Y	real	Normalized rotation about the y-axis of the buckling displacement
THETA-Z	real	Normalized rotation about the z-axis of the buckling displacement
LOADSET	integer	Load set, corresponding to the third word of EAL dataset names
CON	integer	Constraint case, corresponding to the fourth word of EAL dataset names.
APPROX	integer	Eigenvector approximation number for this set number and constraint case, corresponding to the block number of the EAL dataset

---

"BUCKVALS"

"BUCKVALS" contains a buckling frequency for each set of buckling displacements in "BUCK VECS." Data for this relation are taken from EAL datasets "BUCK EVAL iset ncon," where iset is the load set number and ncon is the constraint case number.

Relation contents:

Attribute	Type	Explanation
FREQ	real	Buckling frequency
LOADSET	integer	Load set, corresponding to the third word of EAL dataset names
CON	integer	Constraint case, corresponding to the fourth word of EAL dataset names
APPROX	integer	Eigenvector approximation number of this set number and constraint case, corresponding to the block number of the EAL eigenvector dataset

---

STRESS RELATIONS

The stress data for each element type are stored in a separate relation. The name of each stress relation may be found by appending "-STRS" (or "STRS" for four-letter element types) to the EL-TYPE name of the element. For example, stress data for a triangular element with EL-TYPE of "TB" would be found in relation "TB-STRS."

"BM-STRS"

Stress data for beam elements with EL-TYPE of "BM," "DSY," "GIVN," "WFL," "I," "CHN," or "ANG" are stored in the following relations, all of which have identical contents:

"BM-STRS"	"I-STRS"
"DSY-STRS"	"CHN-STRS"
"GIVN STRS"	"ANG-STRS"
"WFL-STRS"	

The data for these relations are taken from EAL datasets "STRS E21 iset icase" where iset is the load set number and icase is the constraint case number.

Relation Contents:

Attribute	Type	Explanation
GROUP#	integer	Group number
ELEMENT#	integer	Element number within group
MAXTENS	real	Maximum combined P/A + bending (tension)
MAXCOMP	real	Maximum combined P/A + bending (compression)
P/A	real	Pressure/Area
S1	real	Transverse shear stress, S_1
S2	real	Transverse shear stress, S_2
TWISHEAR	real	Twist Shear
LOADSET	integer	Load set, corresponds to the third word of EAL dataset names
CASE	integer	Load case within set, corresponds to the fourth word of EAL dataset names

---

"B6X6STRS"

"B6X6STRS" contains stress data for beam elements with EL-TYPE of "B6X6" for various load cases. The data for this relation are taken from EAL datasets "STRS E22 iset icase," where iset is the load set number and icase is the load case number within the set.

Relation contents:

Attribute	Type	Explanation
GROUP#	integer	Group number
ELEMENT#	integer	Element number within group
ONEP1	real	Vertical force at joint #1
ONEP2	real	Lateral force at joint #1
ONEP3	real	Axial force at joint #1
ONEP4	real	Rotational force about the vertical axis at joint #1
ONEP5	real	Rotational force about the lateral axis at joint #1
ONEP6	real	Rotational force about the axial axis at joint #1
TWOP1	real	Vertical force at joint #2
TWOP2	real	Lateral force at joint #2
TWOP3	real	Axial force at joint #2

TWOP4	real	Rotational force about the vertical axis at joint #2
TWOP5	real	Rotational force about the lateral axis at joint #2
TWOP6	real	Rotational force about the axial axis at joint #2
LOADSET	integer	Set number, corresponds to the third word of EAL dataset names
CASE	integer	Load case within set, corresponds to the fourth word of EAL dataset names

---

"ROD-STRS"

"ROD-STRS" contains stress data for beam elements with EL-TYPE of "ROD" for various load cases. The data for this relation are taken from EAL datasets "STRS E23 iset icase," where iset is the load set and icase is the load case within the set.

Relation contents:

Attribute	Type	Explanation
GROUP#	integer	Group number
ELEMENT#	integer	Element number within group
FORCE	real	Force in element
STRESS	real	Stress in element
LOADSET	integer	Load set, corresponds to the third word of EAL dataset names
CASE	integer	Load case within set corresponds to the fourth word of EAL dataset names

---

"PLB-STRS"

"PLB-STRS" contains stress data for beam elements with EL-TYPE of "PLB" for various load cases. The data for this relation are taken from EAL datasets "STRS E24 iset icase," where iset is the load set and icase is the load case within the set.

Relation contents:

Attribute	Type	Explanation
GROUP#	integer	Group number
ELEMENT#	integer	Element number within group
P1	real	Axial force at joint #1
V1	real	Transverse shear at joint #1
M1	real	Moment at joint #1
P2	real	Axial force at joint #2
V2	real	Transverse shear at joint #2
M2	real	Moment at joint #2
P/A1	real	Axial stress at joint #1
SS1	real	Shear Stress at joint #1
MC1/I1	real	Bending stress on upper surface at joint #1
MH1/I1	real	Bending stress on lower surface at joint #1
P/A2	real	Axial stress at joint #2
SS2	real	Shear stress at joint #2
MC1/I2	real	Bending stress on upper surface at joint #2
MH1/I2	real	Bending stress on lower surface at joint #2
LOADSET	integer	Load set, corresponds to the third word of EAL dataset names
CASE	integer	Load case within set, corresponds to the fourth word of EAL dataset names

"ZEROSTRS"

"ZEROSTRS" contains stress data for beam elements with EL-TYPE of "ZERO" for various load cases. The data for this relation are taken from EAL datasets "STRS E25 iset icase," where iset is the load set and icase is the load case within the set.

Relation contents:

Attribute	Type	Explanation
GROUP#	integer	Group number
ELEMENT#	integer	Element number within group
ONEP1	real	Vertical force at joint #1
ONEP2	real	Lateral force at joint #1
ONEP3	real	Axial force at joint #1
ONEP4	real	Rotational force about the vertical axis at joint #1
ONEP5	real	Rotational force about the vertical axis at joint #1
ONEP6	real	Rotational force about the axial axis at joint #1
TWOP1	real	Vertical force at joint #2
TWOP2	real	Lateral force at joint #2
TWOP3	real	Axial force at joint #2
TWOP4	real	Rotational force about the vertical axis at joint #2
TWOP5	real	Rotational force about the lateral axis at joint #2
TWOP6	real	Rotational force about the axial axis at joint #2
LOADSET	integer	Load set, corresponds to the third word of EAL dataset names
CASE	integer	Load case within set, corresponds to the fourth word of EAL dataset names

---

"TM-STRS"

"TM-STRS" contains stress data for triangular elements with EL-TYPE of "TM" for various load cases. The data for this relation are taken from EAL datasets "STRS E31 iset icase," where iset is the load set number and icase is the load case within the set.

Relation contents:

Attribute	Type	Explanation
GROUP#	integer	Group number
ELEMENT#	integer	Element number within group
NX	real	Tractive force in x-direction
NY	real	Tractive force in y-direction
NXY	real	Shearing force
LOADSET	integer	Load set, corresponds to third word of EAL dataset names
CASE	integer	Load case within set, corresponds to the fourth word of EAL dataset names

"TB-STRS"

"TB-STRS" contains stress data for triangular elements with EL-TYPE of "TB" for various load cases. The data for this relation are taken from EAL datasets "STRS E32 iset icase," where iset is the load set number and icase is the load case within the set.

Relation contents:

Attribute	Type	Explanation
GROUP#	integer	Group number
ELEMENT#	integer	Element number within group
MX1	real	Bending moment about x-axis at joint #1
MY1	real	Bending moment about y-axis at joint #1
MXY1	real	Twisting moment at joint #1
QX1	real	Transverse shear in x-direction at joint #1
QY1	real	Transverse shear in y-direction at joint #1
MX2	real	Bending moment about x-axis at joint #2
MY2	real	Bending moment about y-axis at joint #2
MXY2	real	Twisting moment at joint #2
QX2	real	Transverse shear in x-direction at joint #2
QY2	real	Transverse shear in y-direction at joint #2
MX3	real	Bending moment about x-axis at joint #3
MY3	real	Bending moment about y-axis at joint #3
MXY3	real	Twisting moment at joint #3
QX3	real	Transverse shear in x-direction at joint #3
QY3	real	Transverse shear in y-direction at joint #3
MXC	real	Bending moment about x-axis at the center
MYC	real	Bending moment about y-axis at the center
MXYC	real	Twisting moment at the center
QXC	real	Transverse shear in x-direction at the center
QYC	real	Transverse shear in y-direction at the center
LOADSET	integer	Load set, corresponds to the third word of EAL dataset names
CASE	integer	Load case within set, corresponds to the fourth word of EAL dataset names

---

"TBM-STRS"

"TBM-STRS" contains stress data for triangular elements with EL-TYPE of "TBM" for various load cases. The data for this relation are taken from EAL datasets "STRS E33 iset icase," where iset is the load set number and icase is the load case within the set.

Relation contents:

Attribute	Type	Explanation
GROUP#	integer	Group number
ELEMENT#	integer	Element number within group
NX	real	Tractive force in x-direction
NY	real	Tractive force in y-direction
NXY	real	Shearing force
MX1	real	Bending moment about x-axis at joint #1
MY1	real	Bending moment about y-axis at joint #1
MXY1	real	Twisting moment at joint #1
QX1	real	Transverse shear in x-direction at joint #1
QY1	real	Transverse shear in y-direction at joint #1
MX2	real	Bending moment about x-axis at joint #2
MY2	real	Bendinm moment about y-axis at joint #2
MXY2	real	Twisting moment at joint #2

QX2	real	Transverse shear in x-direction at joint #2
QY2	real	Transverse shear in y-direction at joint #2
MX3	real	Bending moment about x-axis at joint #3
MY3	real	Bending moment about y-axis at joint #3
MXY3	real	Twisting moment at joint #3
QX3	real	Transverse shear in x-direction at joint #3
QY3	real	Transverse shear in y-direction at joint #3
MXC	real	Bending moment about x-axis at the center
MYC	real	Bending moment about y-axis at the center
MXYC	real	Twisting moment at the center
QXC	real	Transverse shear in x-direction at the center
QYC	real	Transverse shear in y-direction at the center
LOADSET	integer	Load set, corresponds to the third word of EAL dataset names
CASE	integer	Load case within set, corresponds to the fourth word of EAL dataset names

---

"QM-STRS"

"QM-STRS" contains stress data for quadrilateral elements with EL-TYPE of "QM" for various load cases. The data for this relation are taken from EAL datasets "STRS E41 iset icase," where iset is the load set number and icase is the load case number within the set.

Relation contents:

Attribute	Type	Explanation
GROUP#	integer	Group number
ELEMENT#	integer	Element number within group
NX1	real	Tractive force in x-direction at joint #1
NY1	real	Tractive force in y-direction at joint #1
NXY1	real	Shearing force at joint #1
NX2	real	Tractive force in x-direction at joint #2
NY2	real	Tractive force in y-direction at joint #2
NXY2	real	Shearing force at joint #2
NX3	real	Tractive force in x-direction at joint #3
NY3	real	Tractive force in y-direction at joint #3
NXY3	real	Shearing force at joint #3
NX4	real	Tractive force in x-direction at joint #4
NY4	real	Tractive force in y-direction at joint #4
NXY4	real	Shearing force at joint #4
NXC	real	Tractive force in x-direction at the center
NYC	real	Tractive force in y-direction at the center
NXYC	real	Shearing force at the center
LOADSET	integer	Load set, corresponds to the third word of EAL dataset names
CASE	integer	Load case within set, corresponds to the fourth word of EAL dataset names

"QB-STRS"

"QB-STRS" contains stress data for quadrilateral elements with El-TYPE of "QB" for various load cases. The data for this relation are taken from EAL datasets "STRS E42 iset icase", where iset is the load set number and icase is the load case within the set.

Relation contents:

Attribute	Type	Explanation
GROUP#	integer	Group number
ELEMENT#	integer	Element number within group
MX1	real	Bending moment about x-axis at joint #1
MY1	real	Bending moment about y-axis at joint #1
MXY1	real	Twisting moment at joint #1
QX1	real	Transverse shear in x-direction at joint #1
QY1	real	Transverse shear in y-direction at joint #1
MX2	real	Bending moment about x-axis at joint #2
MY2	real	Bending moment about y-axis at joint #2
MXY2	real	Twisting moment at joint #2
QX2	real	Transverse shear in x-direction at joint #2
QY2	real	Transverse shear in y-direction at joint #2
MX3	real	Bending moment about x-axis at joint #3
MY3	real	Bending moment about y-axis at joint #3
MXY3	real	Twisting moment at joint #3
QX3	real	Transverse shear in x-direction at joint #3
QY3	real	Transverse shear in y-direction at joint #3
MX4	real	Bending moment about x-axis at joint #4
MY4	real	Bending moment about y-axis at joint #4
MXY4	real	Twisting moment at joint #4
QX4	real	Transverse shear in x-direction at joint #4
QY4	real	Transverse shear in y-direction at joint #4
MXC	real	Bending moment about x-axis at the center
MYC	real	Bending moment about y-axis at the center
MXYC	real	Twisting moment at the center
QXC	real	Transverse shear in x-direction at the center
QYC	real	Transverse shear in y-direction at the center
LOADSET	integer	Load set, corresponds to the third word of EAL dataset names
CASE	integer	Load case within set, corresponds to the fourth word of EAL dataset names

---

"QBM-STRS"

"QBM-STRS" contains stress data for quadrilateral elements with EL-TYPE of "QBM" for various load cases. The data for this relation are taken from EAL datasets "STRS E43 iset icase", where iset is the load set number and icase is the load case within the set.

Relation contents:

Attribute	Type	Explanation
GROUP#	integer	Group number
ELEMENT#	integer	Element number within group
NX1	real	Tractive force in the x-direction at joint #1
NY1	real	Tractive force in the y-direction at joint #1
NXY1	real	Shearing force at joint #1
NX2	real	Tractive force in the x-direction at joint #2
NY2	real	Tractive force in the y-direction at joint #2

"QBM-STRS" (cont.)

Relation contents:

Attribute	Type	Explanation
NXY2	real	Shearing force at joint #2
NX3	real	Tractive force in the x-direction at joint #3
NY3	real	Tractive force in the y-direction at joint #3
NXY3	real	Shearing force at joint #3
NX4	real	Tractive force in the x-direction at joint #4
NY4	real	Tractive force in the y-direction at joint #4
NXY4	real	Shearing force at joint #4
NXC	real	Tractive force in the x-direction at the center
NYC	real	Tractive force in the y-direction at the center
NXYC	real	Shearing force at the center
MX1	real	Bending moment about x-axis at joint #1
MY1	real	Bending moment about y-axis at joint #1
MXY1	real	Twisting moment at joint #1
QX1	real	Transverse shear in x-direction at joint #1
QY1	real	Transverse shear in y-direction at joint #1
MX2	real	Bending moment about x-axis at joint #2
MY2	real	Bending moment about y-axis at joint #2
MXY2	real	Twisting moment at joint #2
QX2	real	Transverse shear in x-direction at joint #2
QY2	real	Transverse shear in y-direction at joint #2
MX3	real	Bending moment about x-axis at joint #3
MY3	real	Bending moment about y-axis at joint #3
MXY3	real	Twisting moment at joint #3
QX3	real	Transverse shear in x-direction at joint #3
QY3	real	Transverse shear in y-direction at joint #3
MX4	real	Bending moment about x-axis at joint #4
MY4	real	Bending moment about y-axis at joint $3
MXY4	real	Twisting moment at joint #4
QX4	real	Transverse shear in x-direction at joint #4
QY4	real	Transverse shear in y-direction at joint #4
MXC	real	Bending moment about x-axis at the center
MYC	real	Bending moment about y-axis at the center
MXYC	real	Twisting moment at the center
QXC	real	Transverse shear in x-direction at the center
QYC	real	Transverse shear in y-direction at the center
LOADSET	integer	Load set, corresponds to the third word of EAL dataset names
CASE	integer	Load case within set, corresponds to the fourth word of EAL dataset names

"SHR-STRS"

"SHR-STRS" contains stress data for quadrilateral elements with EL-TYPE of "SHR" for various load cases. The data for this relation are taken from EAL datasets "STRS E44 iset icase," where iset is the load set number and icase is the load case within the set.

Relation contents:

Attribute	Type	Explanation
GROUP#	integer	Group number
ELEMENT#	integer	Element number within group
STRESS	real	Stress in element
LOADSET	integer	Load set, corresponds to the third word of EAL dataset names
CASE	integer	Load case within set, corresponds to the fourth word of EAL dataset names

---

"NODATEMP"

"NODATEMP" contains the temperature at each joint of the model for various load cases. The data for this relation are taken from EAL datasets "NODA TEMP iset," where iset is the load set number.

Relation contents:

Attribute	Type	Explanation
JOINT#	integer	Joint number
TEMP	real	Temperature at that joint
LOADSET	integer	Load set, corresponds to the third word of EAL dataset names
CASE	integer	Load case within set, corresponds to the block number in the EAL dataset

---

"TRANSAN"

"TRANSAN" contains various types of transient analysis data. Data for this relation may be taken from any or all of the following EAL datasets:

"TIME n2 ncase n4"	"QX1 n2 ncase n4"
"CA n2 ncase n4"	"QX2 n2 ncase n4"
"CQR2 n2 ncase n4"	"QR n2 ncase n4"
"A n2 ncase n4"	"QR1 n2 ncase n4"
"QX n2 ncase n4"	"QR2 n2 ncase n4"

Each row of the RIM relation represents one data value out of a 2-dimensional matrix representing node number versus time interval number.

Relation contents:

Attribute	Type	Explanation
DATATYPE	text 4	Type of data stored, corresponds to the first word of EAL data set name
NAME2	text 4	Second word of EAL dataset name
NCASE	integer	Third word of EAL dataset name
NAME4	integer	Fourth word of EAL dataset name
TIMEINT#	integer	Time point number
NODE#	integer	Node number
VALUE	real	Data for this point of the matrix

MATERIAL PROPERTIES

The material properties database consists of a single relation, "MAT-PROP." This relation contains material properties associated with the material numbers used in model relations "BEAMS," "TRIANGLS," AND "QUADS." "MAT-PROP" may be a relation in the model database, or it may be in a separate database. This relation corresponds to EAL dataset "MATC."

Relation contents:

Attribute	Type	Explanation
MATNUM	integer	Material number
MOD-ELAS	real	Modulus of elasticity
POISSON	real	Poisson's ratio
MOD-RIGI	real	Modulus of rigidity
SPEC-WT	real	Weight per unit volume
THERM-X	real	Thermal expansion coefficient, direction $\overline{X}$
THERM-Y	real	Thermal expansion coefficient, direction $\overline{Y}$
THERMANG	real	Angle between element reference frame (X,Y) and ($\overline{X}$, $\overline{Y}$)

SECTION PROPERTIES

The section properties database consists of a relation for each possible beam element type. These relations contain section properties associated with the Nominal Size numbers in the relation "BEAMS." All of the following may be relations in the model database, or they may all be contained in a separate section properties database.

"DSY"

"DSY" contains section property data for beam elements with EL-TYPE of "DSY." This relation corresponds to EAL dataset "BA."

Relation contents:

Attribute	Type	Explanation
NOM-SIZE	integer	Nominal size number
I1	real	Moment of inertia 1
ALPHA1	real	Transverse shear 1
I2	real	Moment of inertia 2
ALPHA2	real	Transverse shear 2
AREA	real	Cross-sectional area
F	real	Uniform torsion constant
F1	real	Nonuniform torsion constant
Q1	real	Section shape factor 1
Q2	real	Section shape factor 2
Q3	real	Section shape factor 3
Y11	real	Location 11
Y12	real	Location 12
Y21	real	Location 21
Y22	real	Location 22
Y31	real	Location 31
Y32	real	Location 32
Y41	real	Location 41
Y42	real	Location 42

"GIVN"

"GIVN" contains section property data for beam elements with EL-TYPE of "GIVN." This relation corresponds to EAL dataset "BA."

Relation contents:

Attribute	Type	Explanation
NOM-SIZE	integer	Nominal size number
I1	real	Moment of inertia 1
ALPHA1	real	Transverse shear 1
I2	real	Moment of inertia 2
ALPHA2	real	Transverse shear 2
AREA	real	Cross-sectional area
F	real	Uniform torsion constant
F1	real	Nonuniform torsion constant
Z1	real	Shear center 1
Z2	real	Shear center 2
THETA	real	Inclination

"BM"

"BM" contains section property data for beam elements with EL-TYPE of "BM." All E21 elements in EAL that are not type "DSY" or "GIVN" will be given type "BM" by the EAL to RIM interface program because the other types are indistinguishable. This relation corresponds to EAL dataset "BA."

Relation contents:

Attribute	Type	Explanation
NOM-SIZE	integer	Nominal size number
LEN1	real	Length of base
THK1	real	Thickness of base
LEN2	real	Length of side
THK2	real	Thickness of side
LEN3	real	Length of top
THK3	real	Thickness of top

"WFL"

"WFL" contains section property data for beam elements with EL-TYPE of "WFL," meaning wide flange beams. Elements of type "WFL" that are defined in EAL then stored in RIM using EAL2RIM will be converted to type "BM."

Relation contents:

Attribute	Type	Explanation
NOM-SIZE	integer	Nominal size number
WT/FT	real	Weight per foot
AREA	real	Cross sectional area
DEPTH	real	Depth of beam
FLANGE-W	real	Flange width
FLANGE-T	real	Flange thickness
WEB-THK	real	Web thickness

"I"

"I" contains section property data for beam elements with EL-TYPE of "I," meaning I-beams. Elements of type "I" that are defined in EAL then stored in RIM using EAL2RIM will be converted to type "BM."

Relation contents:

Attribute	Type	Explanation
NOM-SIZE	integer	Nominal size number
WT/FT	real	Weight per foot
AREA	real	Cross-sectional area
DEPTH	real	Depth of beam
FLANGE-W	real	Flange width
FLANGE-T	real	Flange thickness
WEB-THK	real	Web thickness

"CHN"

"CHN" contains section property data for beam elements with EL-TYPE of "CHN," meaning channel beams. Elements of type "CHN" that are defined in EAL then stored in RIM using EAL2RIM will be converted to type "BM."

Relation contents:

Attribute	Type	Explanation
NOM-SIZE	integer	Nominal size number
WT/FT	real	Weight per foot
AREA	real	Cross-sectional area
DEPTH	real	Depth of beam
FLANGE-W	real	Flange width
FLANGE-T	real	Flange thickness
WEB-THK	real	Web thickness

"ANG"

"ANG" contains section property data for beam elements with EL-TYPE of "ANG," meaning angle beams. Elements of type "ANG" that are defined in EAL then stored in RIM using EAL2RIM will be converted to type "BM."

Relation contents:

Attribute	Type	Explanation
NOM-SIZE	integer	Nominal size number
THICKNES	real	Thickness
WT/FT	real	Weight per foot
AREA	real	Cross-sectional area

"B6X6"

"B6X6" contains section property data for beam elements with EL-TYPE of "B6X6," in the form of lower triangular matrix elements specifying 6 by 6 intrinsic stiffness matrices. This relation corresponds to EAL dataset "BB."

Relation contents:

Attribute	Type	Explanation
NOM-SIZE	integer	Nominal size number
S11	real	Row 1, column 1
S21	real	Row 2, column 1
S22	real	Row 2, column 2
S31	real	Row 3, column 1
S32	real	Row 3, column 2
S33	real	Row 3, column 3
S41	real	Row 4, column 1
S42	real	Row 4, column 2
S43	real	Row 4, column 3
S44	real	Row 4, column 4
S51	real	Row 5, column 1
S52	real	Row 5, column 2
S53	real	Row 5, column 3
S54	real	Row 5, column 4
S55	real	Row 5, column 5
S61	real	Row 6, column 1
S62	real	Row 6, column 2
S63	real	Row 6, column 3
S64	real	Row 6, column 4
S65	real	Row 6, column 5
S66	real	Row 6, column 6

"ROD"

"ROD" contains section property data for beam elements with EL-TYPE of "ROD." This relation corresponds to EAL dataset "BC."

Relation contents:

Attribute	Type	Explanation
NOM-SIZE	integer	Nominal size number
AREA	real	Cross-sectional area

"PLB"

"PLB" contains section property data for beam elements with EL-TYPE of "PLB." This relation corresponds to EAL dataset "BD."

Relation contents:

Attribute	Type	Explanation
NOM-SIZE	integer	Nominal size number
AREA	real	Cross-sectional area
I1	real	Principal moment of inertia
ALPHA1	real	Transverse shear deflection
H	real	Distance from top of beam to center axis
C	real	Beam depth minus H
Q1	real	Section shape factor

"ZERO"

"ZERO" contains section property data for beam elements with EL-TYPE of "ZERO," in the form of lower triangular matrix elements specifying 6 by 6 intrinsic stiffness matrices. This relation corresponds to EAL dataset "BB."

Relation contents:

Attribute	Type	Explanation
NOM-SIZE	integer	Nominal size number
S11	real	Row 1, column 1
S21	real	Row 2, column 1
S22	real	Row 2, column 2
S31	real	Row 3, column 1
S32	real	Row 3, column 2
S33	real	Row 3, column 3
S41	real	Row 4, column 1
S42	real	Row 4, column 2
S43	real	Row 4, column 3
S44	real	Row 4, column 4
S51	real	Row 5, column 1
S52	real	Row 5, column 2
S53	real	Row 5, column 3
S54	real	Row 5, column 4
S55	real	Row 5, column 5
S61	real	Row 6, column 1
S62	real	Row 6, column 2
S63	real	Row 6, column 3
S64	real	Row 6, column 4
S65	real	Row 6, column 5
S66	real	Row 6, column 6

CONCLUDING REMARKS

An interface system for passing data between EAL and RIM is described. The operation and typical uses of the two FORTRAN interface programs are discussed. The schema of the RIM data base complex is also presented. This information can serve as a user's guide for running the interface programs, or may be used in interfacing other analysis or optimization programs with the RIM data base.

REFERENCES

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2. Giles, Gary L.; and Haftka, Raphael T.: SPAR Data Handling Utilities. NASA TM-78701, September 1978.

3. Cunningham, Sally W.: SPAR Data Set Contents. NASA TM-83181, October 1981.

4. Erickson, Wayne J.: User Guide: Relational Information Management (RIM). Report No. D6-IPAD-70023-M, Boeing Commercial Airplane Company, Seattle, Washington, 1981.

APPENDIX A

EAL RUNSTREAM CREATED BY RIM2EAL

This section contains a listing of an EAL runstream created from a RIM data base by the RIM2EAL program. The RIM relation each type of data is read from is noted.

```
* CHAR $*!"';>
*XQT TAB
START     12
MATC$                                                **** MATERIAL CONSTANTS ****
    1    .300000E+08    .740000E+02    .283000E+00    .830000E-05 >
   .830000E-05  0.
    2    .720000E+06    .300000E+00    .276923E+06    .280000E-02 >
   .220000E+01    .220000E+01
```

All of the materials in the RIM relation "MAT-PROP" are included.

```
JLOC$                                                **** JOINT LOCATIONS ****
    1    .800000E+02    .100000E+02  0.
    2    .800000E+02   -.100000E+02  0.
    3    .600000E+02    .100000E+02  0.
    4    .600000E+02   -.100000E+02  0.
    5    .400000E+02    .100000E+02  0.
    6    .400000E+02   -.100000E+02  0.
    7    .200000E+02    .100000E+02  0.
    8    .200000E+02   -.100000E+02  0.
    9   0.              .100000E+02  0.
   10   0.             -.100000E+02  0.
   11   0.              .100000E+02  0.
   12   0.             -.100000E+02  0.
```

Joint locations are read from the RIM relation "NODES."

```
MREF$                                                **** BEAM ORIENTATIONS ****
 FORMAT=     1
 1 1. 3. 1. 1.
 FORMAT=     2
 2 1. 1000. 0. 0.
NSW$                                                 **** NON-STRUCTURAL WEIGHT ****
 1 23.
 2 15.
 3 0.
```

Beam orientations are read from the RIM relation "ORIENT," and nonstructural weight entries are read from the RIM relation "NSWEIGHT."

```
CONSTRAINT DEFINITION 1$                              **** NODE CONSTRAINTS ****
ZERO 3 4 5 :       1
ZERO 3 4 5 :       2
ZERO 3 4 5 :       3
ZERO 3 4 5 :       4
ZERO 3 4 5 :       5
ZERO 3 4 5 :       6
ZERO 3 4 5 :       7
ZERO 3 4 5 :       8
ZERO 3 4 5 :       9
ZERO 3 4 5 :      10
ZERO 1 2 3 4 5 :      11
ZERO 1 2 3 4 5 :      12
BA
WFL      1  .100000E+01  .100000E+00  .500000E+00  .500000E-01 >
   .100000E+01  .100000E+00
BB
    1  .110000E+05
   .210000E+02  .220000E+02
   .310000E+02  .320000E+02  .330000E+02
   .410000E+02  .420000E+02  .430000E+02  .440000E+02
   .510000E+02  .520000E+02  .530000E+02  .540000E+02  .550000E+02
   .610000E+02  .620000E+02  .630000E+02  .640000E+02  .650000E+02  .660000E+02
    2  .110000E+05
   .210000E+02  .220000E+02
   .310000E+02  .320000E+02  .330000E+02
   .410000E+02  .420000E+02  .430000E+02  .440000E+02
   .510000E+02  .520000E+02  .530000E+02  .540000E+02  .550000E+02
   .610000E+02  .620000E+02  .630000E+02  .640000E+02  .650000E+02  .660000E+02
BC
    1   .500000E+00
    2   .150000E+01
BD
    1  .500000E+00  .100000E+03 0.            .100000E+01  .100000E+01 >
 0.
SA
    1   .100000E-01
    2   .100000E-01
    3   .400000E-01
    4   .100000E-01
    5   .500000E-02
    6   .500000E-02
SB
    1   .300000E-01
```

Nodal constraints are read from the RIM relation "CONSTRN." All the nominal size entries in the RIM section property relations are entered. An entry is made under "SA" for each distinct thickness value for each element type except "E44" in the RIM relations "TRIANGLS" and "QUADS." Each distinct "E44" thickness value is entered under "SB."

```
*XQT ELD
E21
 NMAT=      1 :NSECT=     1 :NREF=     1 :NNSW=     3
        3       1
 NMAT=      1 :NSECT=     1 :NREF=     1 :NNSW=     3
        4       2
 NMAT=      1 :NSECT=     1 :NREF=     2 :NNSW=     1
        1       2
E22
 NMAT=      1 :NSECT=     1 :NREF=     1 :NNSW=     3
        5       3
 NMAT=      1 :NSECT=     1 :NREF=     1 :NNSW=     3
        6       4
 NMAT=      1 :NSECT=     1 :NREF=     2 :NNSW=     2
        3       4
E23
 NMAT=      1 :NSECT=     1 :NREF=     1 :NNSW=     3
        7       5
 NMAT=      1 :NSECT=     2 :NREF=     1 :NNSW=     3
        8       6
 NMAT=      2 :NSECT=     2 :NREF=     1 :NNSW=     3
        5       6
E24
 NMAT=      1 :NSECT=     1 :NREF=     1 :NNSW=     3
        9       7
 NMAT=      1 :NSECT=     1 :NREF=     1 :NNSW=     3
       10       8
 NMAT=      1 :NSECT=     1 :NREF=     2 :NNSW=     3
        7       8
 NMAT=      1 :NSECT=     1 :NREF=     2 :NNSW=     3
        9      10
E25
 NMAT=      1 :NSECT=     2 :NREF=     1 :NNSW=     3
       11       9
 NMAT=      1 :NSECT=     2 :NREF=     1 :NNSW=     3
       12      10
E31
 NMAT=      1 :NSECT=     1 :NREF=     1 :NNSW=     3
        1       3       2
 NMAT=      1 :NSECT=     1 :NREF=     1 :NNSW=     3
        4       2       3
E32
 NMAT=      1 :NSECT=     2 :NREF=     1 :NNSW=     3
        3       5       4
 NMAT=      2 :NSECT=     2 :NREF=     1 :NNSW=     3
        6       4       5
E33
 NMAT=      1 :NSECT=     3 :NREF=     1 :NNSW=     3
        5       7       6
 NMAT=      1 :NSECT=     3 :NREF=     1 :NNSW=     2
        8       6       7
```

```
E41
 NMAT=     1 :NSECT=     4 :NREF=     1 :NNSW=     3
       1       3      4       2
E42
 NMAT=     1 :NSECT=     5 :NREF=     1 :NNSW=     3
       3       5      6       4
E43
 NMAT=     1 :NSECT=     6 :NREF=     1 :NNSW=     1
       5       7      8       6
E44
 NMAT=     1 :NSECT=     1 :NREF=     1 :NNSW=     3
       7       9     10       8
```

Element definitions are read from the RIM relations "BEAMS," "TRIANGLS," and "QUADS." The user is then queried interactively for the type of analysis to be performed, and the appropriate control cards are inserted. In this case, "1. STATIC SOLUTION WITH STRESSES" was chosen. If there are forces to be applied on the model, the user must add them after the control card "SYSVEC: APPLIED FORCES 1" in the proper EAL format. (See ref. 2.)

```
*XQT TOPO
*XQT E
RESET G=386.04
*XQT EKS
*XQT K
*XQT INV
*XQT AUS
SYSVEC:APPLIED FORCES 1
$
$  APPLIED FORCES SHOULD BE ADDED HERE
$
*XQT SSOL
*XQT VPRT
PRINT STAT DISP
PRINT APPL FORC
PRINT STAT REAC
*XQT GSF
*XQT PSF
```

APPENDIX B

RIM INTERACTIVE COMMANDS TO SET UP THE RIM DATA BASES

This section contains the RIM interactive commands necessary to create the model, material, and section property data bases needed by the EAL2RIM program. These can be stored in a file, then read automatically by invoking RIM, then entering the command "INPUT fn," where fn is the name of the file. The last card will cause control to be returned to the user.

```
DEFINE MODDB
OWNER ME
ELEMENTS
GROUP# INT
ELEMENT# INT KEY
NODE1 INT KEY
NODE2 INT KEY
NODE3 INT KEY
NODE4 INT KEY
EL-TYPE TEXT 8
ELD TEXT 4
SECTION TEXT 4
ELTNUM INT KEY
MATNUM INT KEY
NOM-SIZE INT KEY
THICKNES REAL
ORG-NODE INT KEY
X REAL 1
Y REAL 1
Z REAL 1
X-DISP TEXT 4
Y-DISP TEXT 4
Z-DISP TEXT 4
X-ROT TEXT 4
Y-ROT TEXT 4
Z-ROT TEXT 4
JOINT# INT 1
THETA-X REAL 1
THETA-Y REAL 1
THETA-Z REAL 1
LOADSET INT 1
CON INT 1
CASE INT 1
APPROX INT 1
MAXTENS REAL 1
MAXCOMP REAL 1
P/A REAL 1
S1 REAL 1
S2 REAL 1
TWISHEAR REAL 1
FORCE REAL 1
STRESS REAL 1
NX REAL 1
NY REAL 1
MX1 REAL 1
MY1 REAL 1
```

```
MXY1 REAL 1
MX2 REAL 1
MY2 REAL 1
MXY2 REAL 1
MX3 REAL 1
MY3 REAL 1
MXY3 REAL 1
MX4 REAL 1
MY4 REAL 1
MXY4 REAL 1
MXC REAL 1
MYC REAL 1
MXYC REAL 1
QX1 REAL 1
QY1 REAL 1
QX2 REAL 1
QY2 REAL 1
QX3 REAL 1
QY3 REAL 1
QX4 REAL 1
QY4 REAL 1
QXC REAL 1
QYC REAL 1
NXY REAL 1
FREQ REAL 1
ONEP1 REAL 1
ONEP2 REAL 1
ONEP3 REAL 1
ONEP4 REAL 1
ONEP5 REAL 1
ONEP6 REAL 1
TWOP1 REAL 1
TWOP2 REAL 1
TWOP3 REAL 1
TWOP4 REAL 1
TWOP5 REAL 1
TWOP6 REAL 1
P1 REAL 1
V1 REAL 1
M1 REAL 1
P2 REAL 1
V2 REAL 1
M2 REAL 1
P/A1 REAL 1
P/A2 REAL 1
SS1 REAL 1
SS2 REAL 1
MC1/I1 REAL 1
MC1/I2 REAL 1
MH1/I1 REAL 1
MH1/I2 REAL 1
TEMP REAL 1
```

```
NX1 REAL 1
NX2 REAL 1
NX3 REAL 1
NX4 REAL 1
NY1 REAL 1
NY2 REAL 1
NY3 REAL 1
NY4 REAL 1
NXY1 REAL 1
NXY2 REAL 1
NXY3 REAL 1
NXY4 REAL 1
NXC REAL 1
NYC REAL 1
NXYC REAL 1
DATATYPE TEXT 8
NAME2 TEXT 8
NCASE INT 1
NAME4 INT 1
TIMEINT# INT 1
NODE# INT 1
VALUE REAL 1
MREF INTEGER KEY
NB REAL 1
NG REAL 1
ISIGN REAL 1
COSINE REAL 1
FORMAT INTEGER 1
ORIENT INTEGER 1
NSWEIGHT INT
NNSW INT
WEIGHT REAL
RELATIONS
BEAMS WITH GROUP# ELEMENT# NODE1 NODE2 EL-TYPE NOM-SIZE MATNUM ORIENT  +
          NSWEIGHT
TRIANGLS WITH GROUP# ELEMENT# NODE1 NODE2 NODE3 EL-TYPE MATNUM THICKNES  +
              ORIENT NSWEIGHT
QUADS WITH GROUP# ELEMENT# NODE1 NODE2 NODE3 NODE4 EL-TYPE MATNUM THICKNES +
          ORIENT NSWEIGHT
SCRREL WITH GROUP# ELTNUM EL-TYPE ELD NODE1 NODE2 NODE3 NODE4 MATNUM SECTION +
           NOM-SIZE THICKNES ORIENT NSWEIGHT
NODES WITH ORG-NODE X Y Z
CONSTRN WITH ORG-NODE X-DISP Y-DISP Z-DISP X-ROT Y-ROT Z-ROT
NSWEIGHT WITH NNSW WEIGHT
STATDISP WITH JOINT# X Y Z THETA-X THETA-Y THETA-Z LOADSET CON CASE
STATREAC WITH JOINT# X Y Z THETA-X THETA-Y THETA-Z LOADSET CON CASE
VIBRVECS WITH JOINT# X Y Z THETA-X THETA-Y THETA-Z LOADSET CON APPROX
BUCKVECS WITH JOINT# X Y Z THETA-X THETA-Y THETA-Z LOADSET CON APPROX
VIBRVALS WITH FREQ LOADSET CON APPROX
```

```
BUCKVALS WITH FREQ LOADSET CON APPROX
DSY-STRS WITH GROUP# ELEMENT# MAXTENS MAXCOMP P/A S1 S2 TWISHEAR LOADSET CASE
GIVNSTRS WITH GROUP# ELEMENT# MAXTENS MAXCOMP P/A S1 S2 TWISHEAR LOADSET CASE
BM-STRS WITH GROUP# ELEMENT# MAXTENS MAXCOMP P/A S1 S2 TWISHEAR LOADSET CASE
ROD-STRS WITH GROUP# ELEMENT# FORCE STRESS LOADSET CASE
TM-STRS WITH GROUP# ELEMENT# NX NY NXY LOADSET CASE
TB-STRS WITH GROUP# ELEMENT# MX1 MY1 MXY1 QX1 QY1 +
             MX2 MY2 MXY2 QX2 QY2 MX3 MY3 MXY3 +
             QX3 QY3 MXC MYC MXYC QXC QYC LOADSET CASE
TBM-STRS WITH GROUP# ELEMENT# NX NY NXY MX1 MY1 MXY1 QX1 QY1 +
             MX2 MY2 MXY2 QX2 QY2 MX3 MY3 MXY3 QX3 QY3 MXC MYC MXYC +
             QXC QYC LOADSET CASE
QM-STRS WITH GROUP# ELEMENT# NX1 NY1 NXY1 NX2 NY2 NXY2 +
             NX3 NY3 NXY3 NX4 NY4 NXY4 NXC NYC NXYC LOADSET CASE
NODATEMP WITH JOINT# TEMP LOADSET CASE
TRANSAN WITH DATATYPE NAME2 NCASE NAME4 TIMEINT# NODE# VALUE
ORIENT WITH MREF NB NG ISIGN COSINE FORMAT
B6X6STRS WITH GROUP# ELEMENT# ONEP1 ONEP2 ONEP3 ONEP4 ONEP5 ONEP6 TWOP1  +
              TWOP2 TWOP3 TWOP4 TWOP5 TWOP6 LOADSET CASE
PLB-STRS WITH GROUP# ELEMENT# P1 V1 M1 P2 V2 M2 P/A1 SS1 MC1/I1  +
              MH1/I1 P/A2 SS2 MC1/I2 MH1/I2 LOADSET CASE
ZEROSTRS WITH GROUP# ELEMENT# ONEP1 ONEP2 ONEP3 ONEP4 ONEP5 ONEP6  +
              TWOP1 TWOP2 TWOP3 TWOP4 TWOP5 TWOP6 LOADSET CASE
SHR-STRS WITH GROUP# ELEMENT# STRESS LOADSET CASE
QB-STRS WITH GROUP# ELEMENT# MX1 MY1 MXY1 QX1 QY1 MX2 MY2 MXY2  +
             QX2 QY2 MX3 MY3 MXY3 QX3 QY3 MX4 MY4 MXY4 QX4 QY4  +
             MXC MYC MXYC QXC QYC LOADSET CASE
QBM-STRS WITH GROUP# ELEMENT# NX1 NY1 NXY1 NX2 NY2 NXY2 NX3 NY3  +
              NXY3 NX4 NY4 NXY4 NXC NYC NXYC MX1 MY1 MXY1 QX1 QY1  +
              MX2 MY2 MXY2 QX2 QY2 MX3 MY3 MXY3 QX3 QY3 MX4 MX4  +
              MXY4 QX4 QY4 MXC MYC MXYC QXC QYC LOADSET CASE
WFL-STRS WITH GROUP# ELEMENT# MAXTENS MAXCOMP P/A S1 S2 TWISHEAR  +
              LOADSET CASE
I-STRS WITH GROUP# ELEMENT# MAXTENS MAXCOMP P/A S1 S2 TWISHEAR  +
            LOADSET CASE
CHN-STRS WITH GROUP# ELEMENT# MAXTENS MAXCOMP P/A S1 S2 TWISHEAR  +
              LOADSET CASE
ANG-STRS WITH GROUP# ELEMENT# MAXTENS MAXCOMP P/A S1 S2 TWISHEAR  +
              LOADSET CASE
END
CLOSE MODDB
DEFINE MATDB
OWNER ME
ELEMENTS
MATNUM INT 1
MOD-ELAS REAL 1
POISSON REAL 1
MOD-RIGI REAL 1
SPEC-WT REAL 1
```

```
THERM-X REAL 1
THERM-Y REAL 1
THERMANG REAL 1
RELATIONS
MAT-PROP WITH MATNUM MOD-ELAS POISSON MOD-RIGI SPEC-WT THERM-X  +
                THERM-Y THERMANG
END
CLOSE MATDB
DEFINE SECDB
OWNER ME
ELEMENTS
NUM-SIZE INTEGER 1
THICKNES REAL 1
S11 REAL 1
S21 REAL 1
S22 REAL 1
S31 REAL 1
S32 REAL 1
S33 REAL 1
S41 REAL 1
S42 REAL 1
S43 REAL 1
S44 REAL 1
S51 REAL 1
S52 REAL 1
S53 REAL 1
S54 REAL 1
S55 REAL 1
S61 REAL 1
S62 REAL 1
S63 REAL 1
S64 REAL 1
S65 REAL 1
S66 REAL 1
H REAL 1
C REAL 1
WT/FT REAL 1
AREA REAL 1
DEPTH REAL 1
FLANGE-W REAL 1
FLANGE-T REAL 1
WEB-THK REAL 1
LEN1 REAL 1
LEN2 REAL 1
LEN3 REAL 1
THK1 REAL 1
THK2 REAL 1
THK3 REAL 1
I1 REAL 1
```

```
I2 REAL 1
ALPHA1 REAL 1
ALPHA2 REAL 1
F REAL 1
F1 REAL 1
Z1 REAL 1
Z2 REAL 1
THETA REAL 1
Q1 REAL 1
Q2 REAL 1
Q3 REAL 1
NUMPNTS REAL 1
Y11 REAL 1
Y12 REAL 1
Y21 REAL 1
Y22 REAL 1
Y31 REAL 1
Y32 REAL 1
Y41 REAL 1
Y42 REAL 1
RELATIONS
WFL WITH NOM-SIZE WT/FT AREA DEPTH FLANGE-W FLANGE-T WEB-THK
I WITH NOM-SIZE WT/FT AREA DEPTH FLANGE-W FLANGE-T WEB-THK
CHN WITH NOM-SIZE WT/FT AREA DEPTH FLANGE-W FLANGE-T WEB-THK
ANG WITH NOM-SIZE THICKNES WT/FT AREA
B6X6 WITH NOM-SIZE S11 S21 S22 S31 S32 S33 S41 S42 S43 S44  +
   S51 S52 S53 S54 S55 S61 S62 S63 S64 S65 S66
PLB WITH NOM-SIZE AREA I1 ALPHA1 H C Q1
ZERO WITH NOM-SIZE S11 S21 S22 S31 S32 S33 S41 S42 S43 S44  +
   S51 S52 S53 S54 S55 S61 S62 S63 S64 S65 S66
ROD WITH NOM-SIZE AREA
BM WITH NOM-SIZE LEN1 THK1 LEN2 THK2 LEN3 THK3
DSY WITH NOM-SIZE I1 ALPHA1 I2 ALPHA2 AREA F F1  +
 Q1 Q2 Q3 Y11 Y12 Y21 Y22 Y31 Y32 Y41 Y42
GIVN WITH NOM-SIZE I1 ALPHA1 I2 ALPHA2 AREA F F1 Z1 Z2 THETA
END
EXIT
INPUT INPUT
```

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15. Supplementary Notes

16. Abstract

This report documents an interface system for passing data between a Relational Information Management (RIM) data base complex and Engineering Analysis Language (EAL), a finite-element structural-analysis program. The interface system, implemented on a CDC Cyber computer, is composed of two FORTRAN programs called RIM2EAL and EAL2RIM. RIM2EAL reads model definition data from RIM and creates a file of EAL commands to define the model. EAL2RIM reads model definition and EAL-generated analysis data from EAL's data library and stores these data directly in a RIM data base. Descriptions of these two interface programs and the format for the RIM data complex are presented. This information may serve as a user's guide for running the interface programs, or may be used in interfacing other programs.

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