Test Analysis Correlation Tools (TACT)

for MSC/PATRAN (v6.0 and later)
and MSC/NASTRAN (v68.2 and later)
Reference Manual

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Release Notes

Version	Date	Notes
1.0	April 23, 1996	Initial Release for PATRAN v6.0, NASTRAN v69.0
1.1	May 27, 1997	Updated to support NASTRAN v69.1
1.2	July 29, 1997	Miscellaneous upgrades, detailed below: • "Auto-match" on/off toggle to automatically align test models/results with analytical model when importing. • "Show Sticks" feature under Create/Modify Stick Model which displays the accelerometer connectivity data for the stick model; individual sticks and accelerometers can also be highlighted. • Export of reduced analytical mass matrix in universal file format (U247 & U252 formats). • Improved graphical user interface for editing of accelerometer numbers. • Bug fix associated with printing frequencies and mode pairs to a file.
1.3	April 3, 1998	Updated to support NASTRAN v70.0
1.4	June 1, 1998	Included support for NASTRAN versions 67.5, 68.0, 68.2, 69.0, 69.1 and 70.0

<table>
<tr><th>Version</th><th>Date</th><th>Notes</th></tr>
<tr><td>1.5</td><td>October 6, 1998</td><td>Miscellaneous improvements, including:
• Allowed ASET nodes to have an analysis or reference coordinate system by including DMAP to transform eigenvector results back to the basic/global coordinate system.
• Modified alters to string-based format instead of line number entries. This change means that TACT now only supports NASTRAN version 68.2 or later, but it also means that no code updates will be required for TACT to be compatible with later versions of NASTRAN.
• Row number labels were eliminated for the 'Show ASET' and 'Show Stick' forms.
• Full FEM eigenvalue and eigenvector results are now punched to a .f18 file rather than the .pch default, so that the user has the option of using the .pch file for their own purposes.</td></tr>
<tr><td>1.6</td><td>January 8, 1999</td><td>Added recording of any geometry (curve), group and field modification commands to session file.</td></tr>
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1•Introduction

1.1•Background

In the world of structural analysis, there are several codes available that facilitate various parts of the finite element analysis (FEA) process. Each code specializes in something different, and (in an ideal world) the structural analyst weighs the pros and cons of each package and selects the combination of packages that best matches his most common types of models and analyses. If the resulting combination of codes is written by different vendors, and sometimes even if the codes are produced by the same vendor, there are usually interface problems. The structural analyst can spend a sizable amount of time making sure that two packages are interfacing correctly and that no details have been omitted when data is transferred between codes.

The recent marriage of NASTRAN (finite element solver) and PATRAN (finite element pre-/post-processor) under MacNeal Schwendler has the potential to eliminate many of the cumbersome interface problems that the structural analyst faces daily. With the release of version 69.1 of MSC/NASTRAN and version 6.0 of MSC/PATRAN, MacNeal Schwendler has made an effort to make the interface between the two products more seamless and reliable, which has freed the analyst from having to reenter data that was lost or transferred incorrectly between the codes. However, this union currently lacks a complete set of tools for performing finite element model correlation to modal survey test data. This can be a serious shortcoming to an analyst who needs to correlate his models. Normally, as an analyst develops a finite element model (FEM) in PATRAN, he organizes the model using detailed group names, detailed element property names, detailed material property names, and detailed load case names. The information is retained as comment cards in NASTRAN during the analysis. However, when the FEM is exported for correlation to a separate code, like Dynaview or IDEAS, the detailed documentation is essentially lost. The correlation process is repetitive, usually requiring numerous imports/exports back and forth between the pre-/post-processor, the solver and the correlation software. To date this has driven the PATRAN/NASTRAN-based analyst to be a master bookkeeper, to keep versions of models organized on different machines and in different codes. This bookkeeping can consume a sizable portion of an analyst's time, and would be unnecessary if a correlation tool existed inside the PATRAN/NASTRAN environment.

NASA Langley's Aerospace Mechanical Systems Division's answer to this efficiency problem is a customized PATRAN Command Language (PCL) code, "Test - Analysis Correlation Tools" (TACT), described in this document. The code provides a basic yet complete set of tools for correlation totally inside the PATRAN/NASTRAN environment. References used in the development of this code are cited in section 9.

1.2•Features

With this initial release of TACT, the following basic functionalities are now available inside MSC/PATRAN:

- **Step-by-Step Menu Structure** guides analysts unfamiliar with the correlation process through the necessary steps.
- **Pre-Test Analysis** which enables the analyst to choose accelerometer locations and orientations that will adequately capture the modal information during testing.
- **Create/Modify ASET** tool allows the analyst to manage several different candidate accelerometer sets during Pre-Test Analysis.
- **Create/Modify Stick Model** tool helps the analyst to define a "stick model" which simply "connects the dots" between accelerometers for easy test result visualization.
- **Export Analysis Data** including accelerometer locations, "stick model", reduced analytical mass matrix, and eigenvalue/vector results to a single Universal File Format (UFF) file, which can be imported into the major test manager software codes, such as IDEAS or Star.
- **Import Test Results** as a single UFF file for animation and correlation calculation in PATRAN and NASTRAN. If the "Auto-transform" toggle is selected, the code automatically corrects for test data that might be in different units and orientation than the analysis model.
- **Correlation Calculator** automatically calculates frequency percent differences and mass-normalized cross-orthogonality using ASET1 cards, DMI cards, and DMAP in NASTRAN.
- **Mode Pairs** tool cleanly displays mode pair results and has an **"Auto-Pair"** capability where the code calculates correlated mode pairs based on user-definable frequency and diagonal and off-diagonal cross-orthogonality matrix results.
- **Mode Pair Reports** are optionally exported text files containing all mode pair results which can be easily imported into test report or correlation report documents.
- **Animation** tool animates "stick model" analysis and test results based on mode pairs or on-the-fly user selections.
- **5 Animation Results Viewing Methods** including Analysis Only, Test Only, Analysis and Test overlaid, Analysis and Test adjacent, and Analysis and Test differenced.

This set of features provides an initial core set of tools that makes it possible for the analyst to perform a FEM correlation effort entirely inside the PATRAN/NASTRAN environment.

1.3•Requirements

The following list details the system and PATRAN environment requirements for proper execution of TACT.

- **SGI Irix 5.3/6.2 environment.** TACT was tested exclusively in a SGI Irix 5.3/6.2 environment. The PCL does execute commands to verify file permissions, change directories, and create and delete scratch files that may be unique to that environment. Testing and customization for other environments is not planned, although modification to the source would be minimal should other users wish to do this for their particular environments.
- **Analysis Manager should be enabled; NASTRAN v68.2 or later required.** TACT automatically submits NASTRAN (v68.2 or later required) jobs using MSC's Analysis Manger by default. If Analysis Manager is not correctly installed and the default is left on, the PCL will have errors. Users not able or not wishing to use Analysis Manager should make sure that the "Submit Job Now" toggle is deselected on the forms that submit NASTRAN jobs. The prepared NASTRAN deck can then be submitted separately by the user and results can be imported with no further adjustments.
- **PATRAN must be executed from the directory where the database is located.** There is a tremendous amount of file input/output involved in the normal execution of TACT. To prevent the user from having to input file names continuously throughout execution of TACT, a directory structure and file naming convention are used to organize TACT files. For TACT to execute correctly, the user must enter PATRAN from the directory where the database is located.
- **Node 100,000,000 must not exist in the database.** TACT uses Node 100,000,000 to control viewport focus during mode shape animation. The FEM should not contain this node number, since TACT needs to have the ability to create and delete this node. The user will periodically see the message below in the history window; this message does not indicate an error, and does not require any special action by the user.
  $# 1 FEM entity does not exist or is still associated and cannot be deleted: Node 100000000
- **Test accelerometer locations and FEM nodal locations must be coincident.** During normal operation of TACT, the user will define a node - accelerometer mapping table. When test results are imported, TACT assumes that the accelerometers and nodes paired in this table are in exactly the same location. The program is tolerant of small discrepancies; however, if there are large distances between a nodal location and the actual position of the accelerometer, TACT's representation of the test article will be inaccurate. This requirement is normally not an issue since it is good modeling/correlation practice for the analyst to place a node more-or-less exactly at each accelerometer location.

1.4•Installation

Since TACT is merely PCL, a PATRAN user or system administrator can follow normal PCL procedures for installing the code. Basic instructions are provided below.

It is recommended that this PCL be recompiled on the host system prior to installation. There are 14 PCL files that make up tact. These files, along with their corresponding form in TACT, are listed in the table below.

TACT PCL File	Version	Rev. Date	Corresponding TACT Module
tact.pcl	1.0	1/6/97	Main TACT menu
calc_base.pcl	1.4	10/6/98	‘Run FullFEM Job’
aset_mgr.pcl	1.5	1/8/99	‘Create/Modify ASET’
aset_field.pcl	1.2	1/8/99	Creates, modifies, and queries FEM fields in the database.
stick_mgr.pcl	1.3	1/8/99	‘Create/Modify Stick Model’
calc_aset.pcl	1.5	10/6/98	‘Run FullFEM/ASET Job’
export_aset.pcl	1.4	10/6/98	‘Export ASET UFF’
import_test.pcl	1.2	7/14/97	‘Import Test UFF’
calc_test.pcl	1.5	10/6/98	‘Run ASET/Test Job’
mode_mgr.pcl	1.0	3/7/97	‘Mode Pairs & Correlation’ file management
mode_results.pcl	1.3	7/14/97	‘Mode Pairs & Correlation’ results
anim_mgr.pcl	1.1	3/26/97	‘Animated Mode Shapes’
get_file.pcl	1.0	2/21/97	Select BDF file form used by all ‘Run XXX Job’ forms
draw.pcl	1.1	7/14/97	Draws accelerometer and stick model ‘markers’ to current viewport

Before compiling, the user needs to edit the tact.pcl file and modify the hardcoded location of the TACT helpfiles. If this is not done, everything except the TACT helpfiles should work normally. To compile these files into a single PCL library, the user or system administrator needs to execute the Makefile which is listed below. Note that the first line in the Makefile needs to be customized before execution; PCL_DIR should be changed to the location of the selected PCL directory. If the installation is being performed for/by a single user, then the location is normally a directory called '~/p3_pcl'; if the installation is being performed for a site then the directory is normally 'P3_HOME/p3_pcl'. Installers should customize this line as appropriate.

```
# Name of the target pcl library
PclLibrary = PCL_DIR/lib/tact.plb
#
# List of .pob files that go into the library
# Each of these files should have a corresponding .pcl file
PclObjects = \
        tact.pob \
        draw.pob \
        get_file.pob \
        aset_mgr.pob \
        aset_field.pob \
        stick_mgr.pob \
        mode_mgr.pob \
        mode_results.pob \
        anim_mgr.pob \
        calc_base.pob \
        calc_aset.pob \
        calc_test.pob \
        export_aset.pob \
        import_test.pob
#
# Location of include files.
IPATH = -I /patran/customization
#
# Script for invoking the standalone pcl compiler
PCLCOMP = /patran/customization/Pclcomp
#
# Command for compiling a single preprocessed pcl source file
COMPILE = $(PCLCOMP) $(PCFLAGS) -pob $*.CPP
#
# Possible locations for finding the executable for cpp
CPPLIST = /usr/lang/cpp /usr/ccs/lib/cpp /lib/cpp /usr/lib/cpp
#
# cpp arguments for preprocessing a single pcl source file
CPPARGS = $(IPATH) -C $*.pcl >$*.CPP
#
```

```
# Define the possible file suffixes
.SUFFIXES: .pcl .pob .plb
#
# Make sure that the bourne shell is used to invoke subcommands
SHELL = /bin/sh
#
# Define a rule for converting a .pcl source file to a .pob object.
# This rule is somewhat ugly because 1) it attempts to intelligently
# locate the cpp executable given that it often is not on the default
# search path and 2) we need to make sure that the .pob file gets
# deleted if the compilation fails!  We use "@" carefully so as to not
# clutter the screen while make is running.
.pcl.pob:
@  rm -f $*.ERROR
@  CPP='' ; \
  for i in $(CPPLIST) ; do \
     if [ -f $$i ] ; then \
          CPP="$$i" ; \
     fi ;  \
  done ; \
  echo "$$CPP $(CPPARGS)" ; \
  $$CPP $(CPPARGS)
@echo $(COMPILE)
-@ $(COMPILE) ; \
  if [ $$? -ne 0 ] ; then \
     rm -rf $*.pob ; \
     touch $*.ERROR ; \
  else  \
     exit 0 ; \

  fi
rm -f $*.CPP
@  echo
@  if [ -f $*.ERROR ] ; then \
     rm -f $*.ERROR ; \
     exit 1 ; \
  else  \
     exit 0 ; \
  fi
#
# Merge all .pobs into the target
$(PclLibrary): $(PclObjects)
$(PCLCOMP) $(PCFLAGS) -m $@ $(PclObjects)
#
# Finally, define a "clean" rule
```

```
clean:
rm -f $(PclObjects) $(PclLibrary)
```

Once compiled, the ‘p3epilogue.pcl’ file, either in a user’s directory or in the ‘patran3’ directory for a site installation, needs to be modified by adding the lines below. Once again, PCL_DIR needs to be changed to reflect the location of the newly compiled TACT library.

```
/* Load the TACT library */
!!library PCL_DIR/lib/tact.plb
ui_exec_function( "tact", "display")
```

When the user executes PATRAN after the process has been completed, TACT appears as a new selection on the main PATRAN menubar.

2•Pre-Test Modules

2.1•Pre-Test Process

The successful process of correlating a FEM to modal survey test data actually begins long before the test ever takes place. The analyst will never be successful in achieving correlation of the FEM to the test data if steps are not taken to make sure that the test data is adequate for the analyst's need. It is absolutely critical that the analyst and the test engineer work together to define a set of accelerometers for the test that are physically accessible yet analytically adequate to capture the necessary test results.

Selecting adequate accelerometer locations is partially an art. The first step is to develop a finite element model of the test article which the analyst believes accurately describes the structure's behavior. The analyst must then identify the modes of interest for test verification. Once these modes are identified, the analyst should study the mode shapes of the math model. Good accelerometer locations will have large relative motion in those modes that the test is designed to capture. An illustrative example is that of a (2D) simply supported beam. Suppose the modal survey was to capture both the first and second modes of the beam. Placing one triaxial accelerometer in the center of the span would capture the first mode. However, this location does not move in the second mode; at least one additional accelerometer located at either one quarter or three quarters of the span are needed to capture this mode.

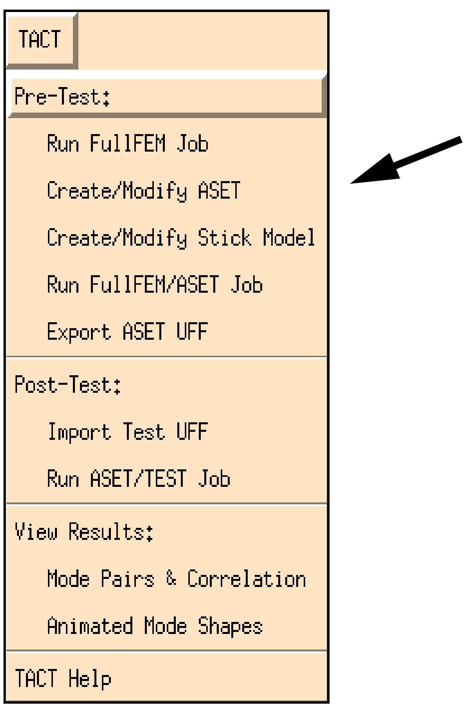
There are many ways to analytically evaluate a candidate set of accelerometers to see if they will successfully capture the test modes of interest. In TACT, the modal results are calculated first using the entire FEM, and then recomputed using mass condensation at the selected DOF of the candidate accelerometer GRIDs. The mass condensation calculation is performed in MSC/NASTRAN by placing the accelerometer DOF on ASET1 cards.The cross-orthogonality calculation between full FEM eigenvectors and reduced FEM results is below:

$$\left[\Phi_{FullFEM}\right]^T \left[M\right] \left[\Phi_{ASET}\right] = \left[\delta_x\right]$$

where Φ, in both cases, contains mass-normalized eigenvectors, M is the mass matrix, and δ_x is the cross-orthogonality matrix. If $\Phi_{FULLFEM}$ and Φ_{ASET} represent the same mode shapes, then δ_x will approach the identity matrix. In NASTRAN, DMAP is used to make this cross-orthogonality calculation on full FEM (G-set) sized matrices. This accelerometer set evaluation procedure will normally be used several times in the Pre-Test process, while the analyst struggles to minimize the number of accelerometers required to adequately capture the necessary modes.

Once an adequate set of accelerometers has been identified, the test engineer will normally want the analyst to provide him with the predicted mode shapes. This first requires that the analyst define the accelerometer connectivity by simply connecting-the-dots between accelerometers to make a “stick model” that looks like a skeleton of the actual structure; this “stick model” is used strictly for visualization of modal results. TACT then exports the accelerometer locations, connectivity, and modal results information in Universal File Format (UFF), which is a common import/export format for test packages.

The next sections will describe each of the 5 modules in TACT that aid the analyst during Pre-Test planning. These modules are shown on the TACT menu below, and include Run FullFEM Job, Create/Modify ASET, Create/Modify Stick Model, Run FullFEM/ASET Job, and Export ASET UFF.

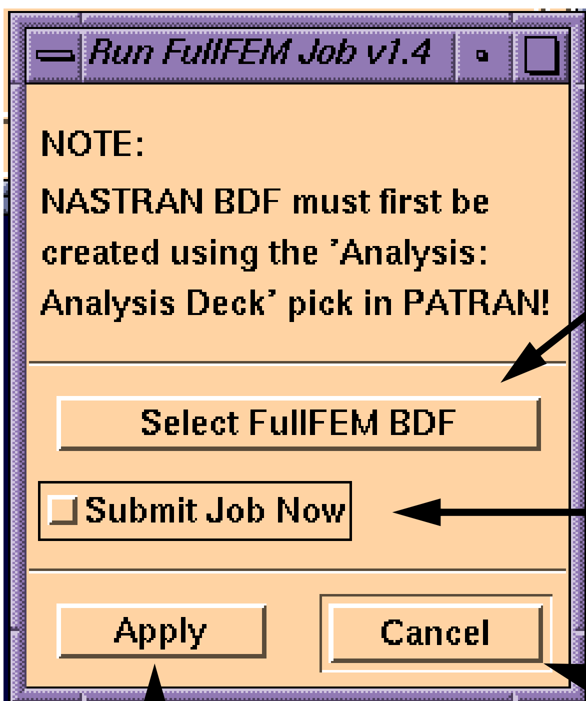


Pre-Test
TACT
Modules

2.2•Run FullFEM Job

After the analyst has created and is satisfied with the FEM, the first step in the Pre-Test process is to “baseline” the full finite element model. Prior to entering the TACT menu, the user must create a NASTRAN deck by going to the Analysis form and setting the method to ‘Analysis Deck’. The analyst should create a modal analysis job using whatever settings and parameters he/she would normally use. After this deck is created, the analyst is ready to use TACT.

The first selection under Pre-Test in TACT is ‘Run FullFEM Job’; upon selection, the form below is displayed. Actions initiated by the user on the form are briefly described below.



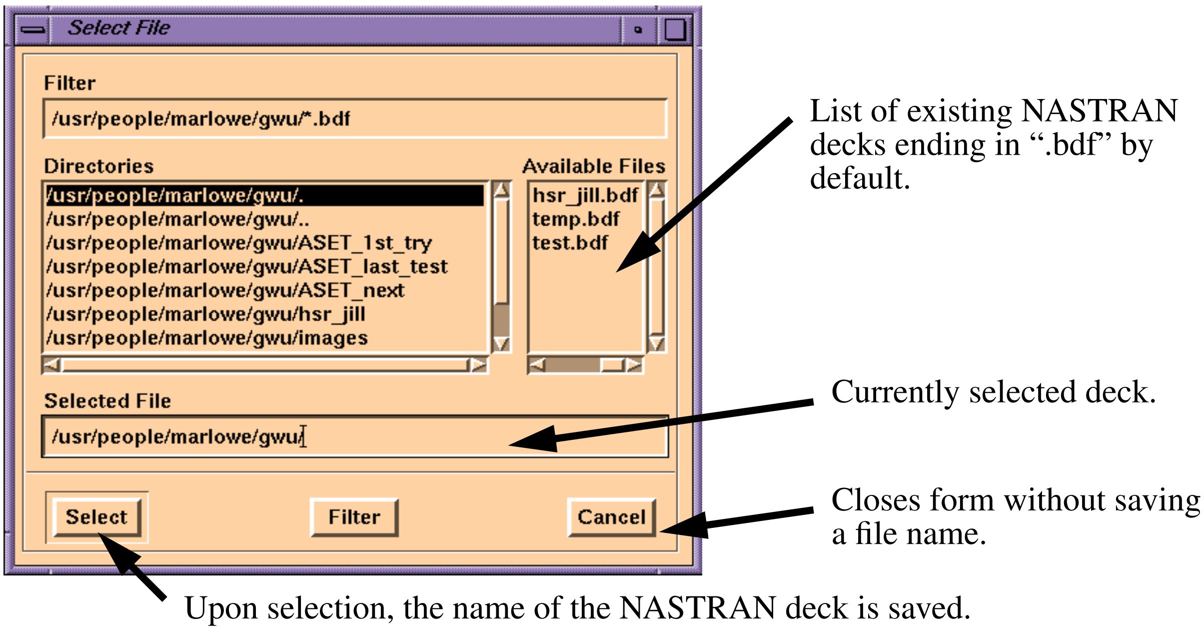
Upon selection, the ‘Select FullFEM BDF’ button displays a form where the user can select the NASTRAN deck created in the PATRAN Analysis form.

Toggles on(Default)/off the automatic submission of the NASTRAN job using Analysis Manager.

Closes the form without executing any commands.

Upon selection, ‘Apply’ creates a directory where the full FEM results will be stored, modifies a copy of the selected BDF to include DMAP that will punch the full FEM results to DMI cards for inclusion in later NASTRAN analyses, and submits the NASTRAN job if the ‘Submit Job Now’ toggle is on.

The ‘Select File’ form and actions are shown below.



When the analyst selects apply on the ‘Run FullFEM Job’ form, the following actions are performed by TACT:

- A directory for holding full FEM results is created if it does not already exist.
- The selected NASTRAN deck is copied into this directory.
- The copy of the deck is modified to include the following DMAP:

```
$----------------------------------------------------------------------------------------------------------
$A1- ALTER INSERTED BY TACT TO STORE EIGENVECTORS TO DMI Cards in Punch file
$
COMPILE SEMODES SOUIN=MSCSOU NOREF NOLIST
$ First, dump out full FEM eigenvalues
ALTER 'CALL SUPER3'
LAMX, ,LAMA/LMAT/-1$
EQUIVX LMAT/FULLEIG/-1$
$ Then, dump out full FEM eigenvectors
EQUIVX PHG/PHGF/-1$
MATPCH FULLEIG,PHGF,,,//-18 $
```

```
$
$ END OF ALTER
$-------------------------------------------------------------------------------------------------------------------
```

- If the ‘Submit Job Now’ toggle is on, the NASTRAN job is automatically submitted using Analysis Manager.

The DMAP causes the job to punch two matrices to DMI cards. The matrices are FULLEIG, which is essentially the LAMA matrix in NASTRAN that contains the eigenvalue information, and PHGF, which is the PHG matrix for the full FEM. These matrices will be read in on later jobs, and additional DMAP will be used to compare results for a particular accelerometer set to these full FEM results.

2.3•Create/Modify ASET

After the full FEM has been baselined, the analyst is ready to define sets of accelerometers, which are abbreviated in TACT as ‘ASETs’. The ‘Create/Modify ASET’ form is designed to facilitate the management of multiple candidate sets while the analyst is performing trade studies.

ASETs are managed by TACT using PATRAN groups and fields. Groups are used to store finite element node numbers representing accelerometer sites, and curves (PATRAN parametric cubic geometry) which will be used to store accelerometer connectivity data. PATRAN FEM fields are used to store accelerometer number and degree-of-freedom information. Each nodal entry in a FEM field contains the accelerometer number concatonated with a 3 digit code, where each digit is either a “1” (indicating that DOF is measured) or a “0” (indicating that DOF is discarded) for each of the X, Y, Z DOFs. FEM field entries are “decoded” by the ‘aset_field’ subroutines into the accelerometer numbers and NASTRAN-style DOF markers that the user actually sees (i.e., “13” indicates XZ DOFs). All groups and fields created by TACT begin with the prefix “ASET_”. These groups and fields should not be modified by the user.

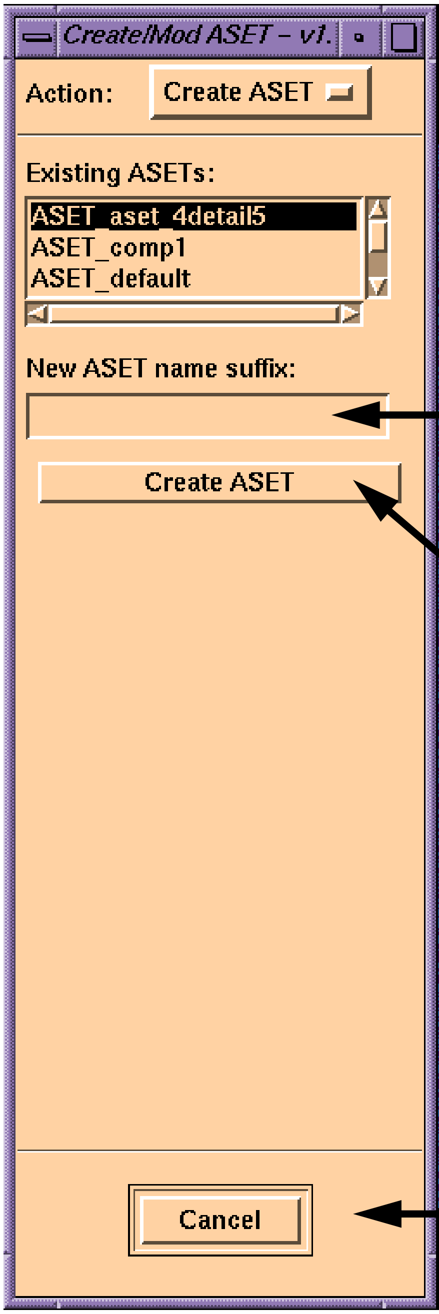
By default, a single empty ASET group exists before the user enters TACT for the first time; this group is called “ASET_default” and it will always exist (even if the user tries to delete it, it is automatically recreated).

There are five actions available to the analyst on the ‘Create/Modify ASET’ form; these actions and the corresponding selections on the form are discussed in the sections that follow.

All commands that create/modify/delete groups and fields are recorded to the session file during a TACT session. Before replaying a session file, make sure that all groups and fields that were created during that session are deleted, so that errors will not occur when the actions in the session file try to create the items again.

2.3.1•Action: Create ASET

The 'Create ASET' action is used solely to create an empty new ASET group name. The 'Create/ Modify ASET' form with the 'Create ASET' action selected is shown below.



Action set to 'Create ASET'

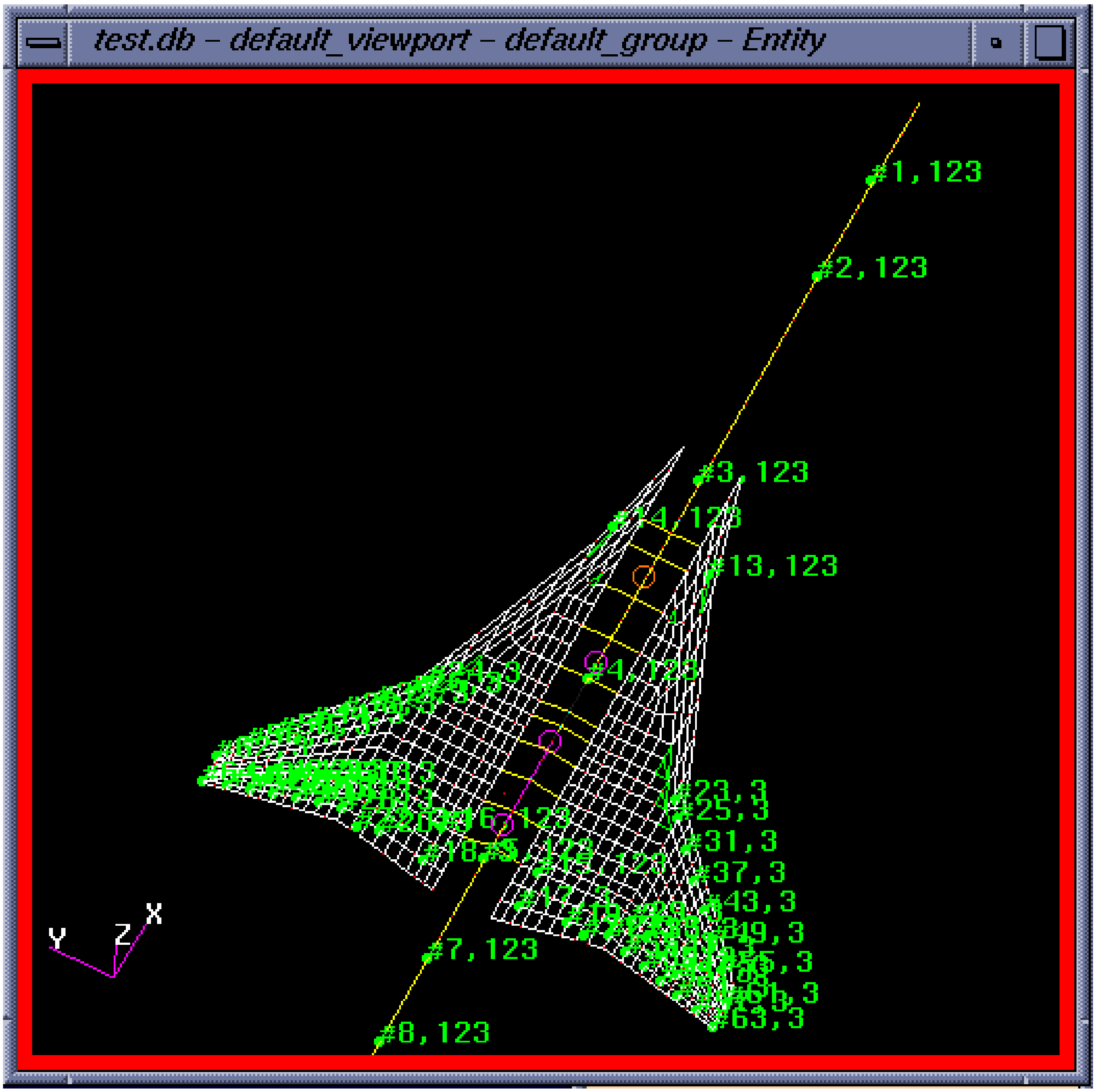
Listbox showing existing ASETs. Selecting an ASET shows the accelerometer locations and DOF in the current viewport; a typical viewport display is shown on the next page.

Data box for text input only; user should enter the *suffix only* for the new ASET. For example, entering "my_aset" will create the group and field "ASET_my_aset" in PATRAN. The created ASET will be empty.

Upon selection, a new ASET is created by appending the text in the above data box to "ASET_". Selection creates a new empty group and field. If either the group or field already exist the request is aborted.

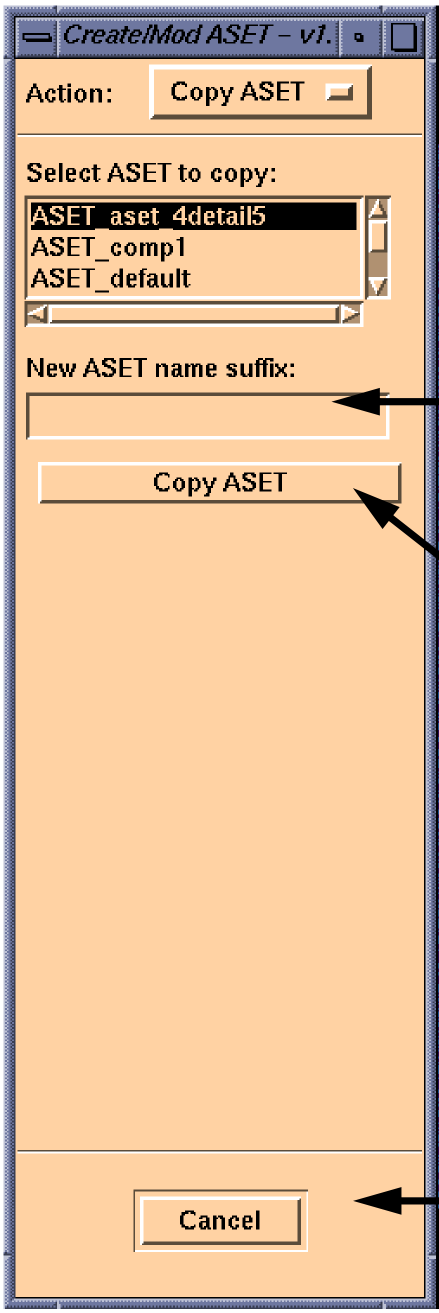
Closes the 'Create/Modify ASET' form.

The PATRAN viewport shown below shows a full FEM with the ASET markers displayed. Each green marker shows the accelerometer number and which DOF (1, 2 or 3) are to be measured at that particular accelerometer location.



2.3.2•Action: Copy ASET

The ‘Copy ASET’ action allows the user to copy all of the nodes/curves of an existing ASET group into a new ASET name. The form is shown below.



Action set to ‘Copy ASET”

Listbox showing existing ASETs. Selecting an ASET shows the accelerometer locations and DOF in the current viewport; a typical viewport display is shown on the next page.

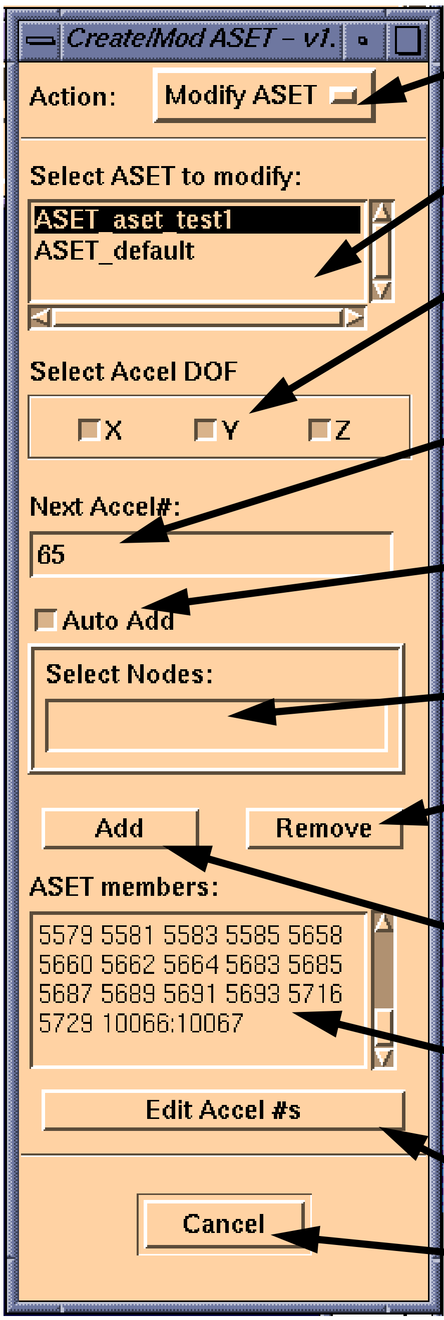
Data box for text input only; user should enter the *suffix only* for the new ASET. For example, entering “my_aset” will create the group and field “ASET_my_aset” in PATRAN. The created ASET will be empty.

Upon selection, a new ASET is created by appending the text in the above data box to “ASET_”. Selection creates a new group and field which are identical to the ASET selected in the above listbox. The application will abort if either the group or field already exist.

Closes the ‘Create/Modify ASET’ form.

2.3.3•Action: Modify ASET

The ‘Modify ASET’ action is the workhorse of the ‘Create/Modify ASET’ form. In this form, nodes and corresponding DOF are added or removed from the ASET. The form and actions available to the user are described below.



Action set to ‘Modify ASET’

Listbox showing existing ASETs. Selecting an ASET shows the accelerometer locations and DOF in the current viewport, and closes the ‘Edit Accel #s’ form if it is open.

Toggles indicating which DOF the Add/Remove actions should affect. All toggles are on by default. The DOF corresponding to a nodal location are stored in field by the same name as the ASET.

The accelerometer # to be assigned to the next node that is added to the ASET. This defaults to the maximum current accelerometer number + 1.

When selected, any node selected is automatically added to the ASET with whatever DOF toggles are selected.

Select data box that allows the user to select Nodes (either by selecting in the viewport or typing) for addition or removal from the ASET.

Upon selection, the DOF indicated by the ‘on’ DOF toggles for the nodes listed in the select data box are removed from the ASET.

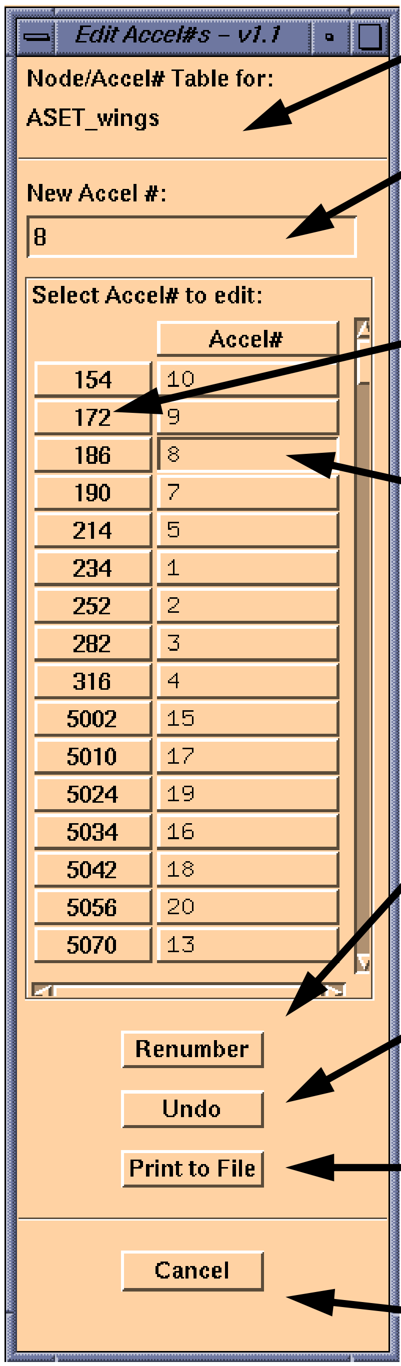
Upon selection (or if Auto Add is selected), the DOF indicated by the ‘on’ DOF toggles for the nodes listed in the select data box are added to the ASET.

Listbox shows nodes that are members of the ASET; to show DOF information, set the form action to ‘Show ASET’.

Upon selection, the ‘Edit Accel #s’ form is displayed

Closes the ‘Create/Modify ASET’ form.

Upon selection of the ‘Edit Accel #s’ button, the form below is displayed which allows the user to modify the node/accelerometer mapping.



Label indicating which Node/Accelerometer table is currently displayed.

Databox for entering a new accelerometer number corresponding to the selected node/accel# in the table below. The default value is the current accelerometer #. Valid input is a single input between 1 and 100,000.

The nodes in the selected ASET are listed down the left column. Node numbers are not selectable.

Accelerometer numbers corresponding to each node. Selection of an accelerometer number changes the value in the databox above to the currently selected accelerometer number, and also causes the accelerometer marker to be highlighted in orange in the viewport.

Upon selection, the accelerometer numbers are renumbered to correspond to sequential ascending node numbers.

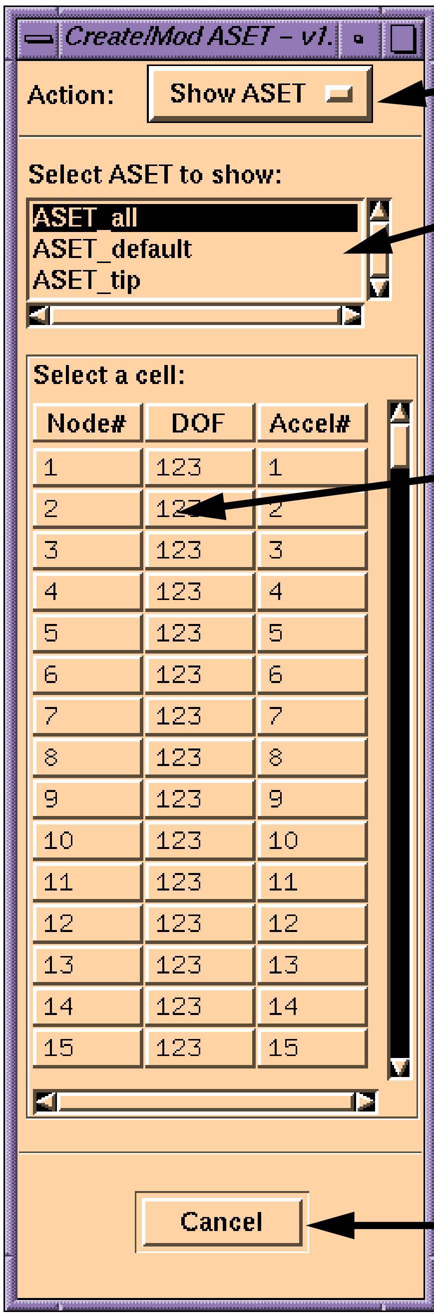
Upon selection, the last modification to the accelerometer numbers only is reversed to the previous value. If the last action was ‘Renumber’, then all accelerometer numbers are reversed.

Upon selection, the file ‘TXT_REPORT.aset_map’ is generated in the ASET’s directory. This ascii file contains a node#/accelerometer#/DOF table which is easily imported into word processing or spreadsheet software.

Closes this form, and updates the ‘Create/Modify ASET’ form to reflect any changes.

2.3.4•Action: Show ASET

The ‘Show ASET’ action allows a user to view a node/DOF table for a particular ASET. The form and actions available are described below.



Action set to ‘Show ASET’

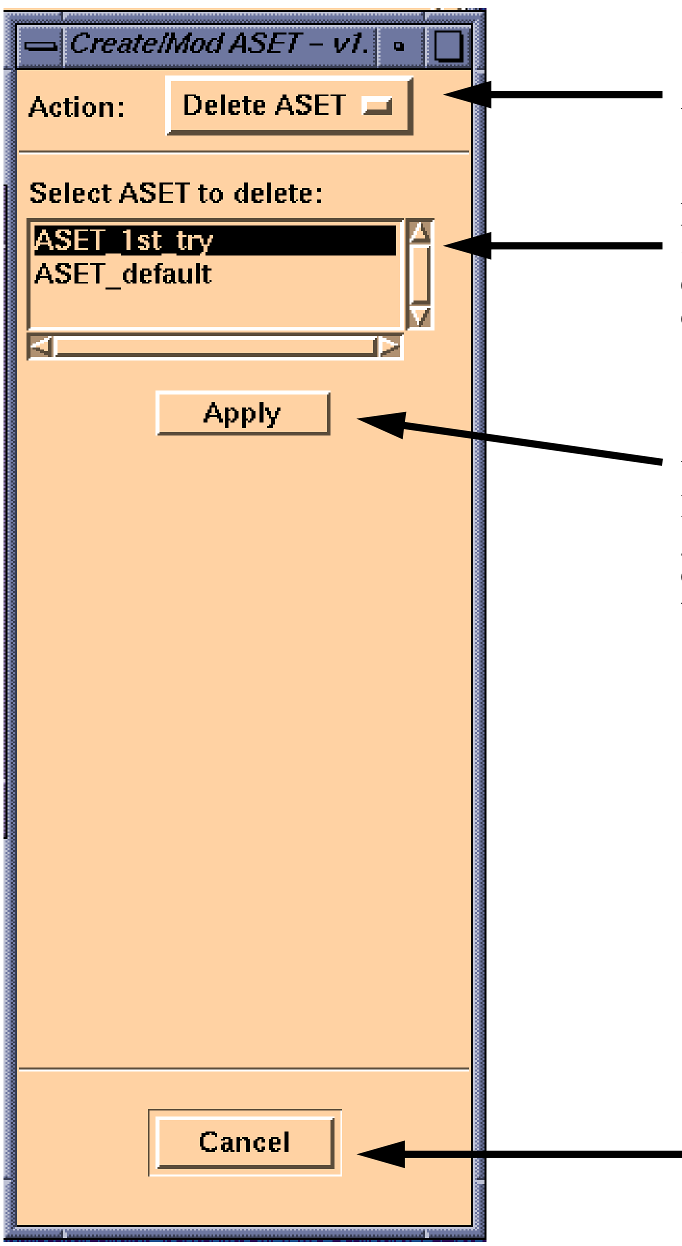
Listbox showing existing ASETs.
Selecting an ASET shows the accelerometer locations and DOF in the current viewport.

Spreadsheet which shows the nodes that are members of the ASET and the corresponding DOF and accelerometer numbers. A single cell or a range of cells may be selected from this spreadsheet; the corresponding accelerometer markers in the viewport will be highlighted in orange.

Closes the ‘Create/Modify ASET’ form.

2.3.5•Action: Delete ASET

The ‘Delete ASET’ action deletes the PATRAN group and field associated with the selected ASET. Any curves contained in the group are deleted; nodes associated with the group are not deleted. The form and actions are shown below.



Action set to ‘Delete ASET’

Listbox showing existing ASETs. Selecting an ASET shows the accelerometer locations and DOF in the current viewport.

Upon selection, the ASET selected in the listbox above is deleted (i.e., the PATRAN group, the PATRAN field, and any curves contained in the group are deleted from the database).

Closes the ‘Create/Modify ASET’ form.

2.4•Create/Modify Stick Model

After an ASET has been created using ‘Create/Modify ASET’, the user is ready to define the connectivity between the accelerometers in a ‘stick model’. This ‘stick model’ looks like a skeleton model of the full FEM, and is used strictly for visualizing reduced FEM modal results and modal test results. The ‘Create/Modify Stick Model’ form allows an analyst to quickly “connect the dots” between accelerometers to create/modify the stick model.

Single elements or “sticks” in a stick model in TACT are represented using a parametric cubic curve. The curve is merely a bookkeeper; after the stick element is created, TACT uses the curve end point XYZ information to determine which accelerometers the stick connects.

The ‘Create/Modify Stick Model’ form has three actions: Add ‘Sticks’, Remove ‘Sticks’, and Show ‘Sticks’. In order for a user to be able to remove a curve from an ASET, the curve must be posted to the current viewport. For this reason, when the user exits the ‘Create/Modify Stick Model’ form, a warning message is posted that informs the user that the current group may have changed. This is, of course, not serious, but it can be annoying to a user to have the current group changed and not know it.

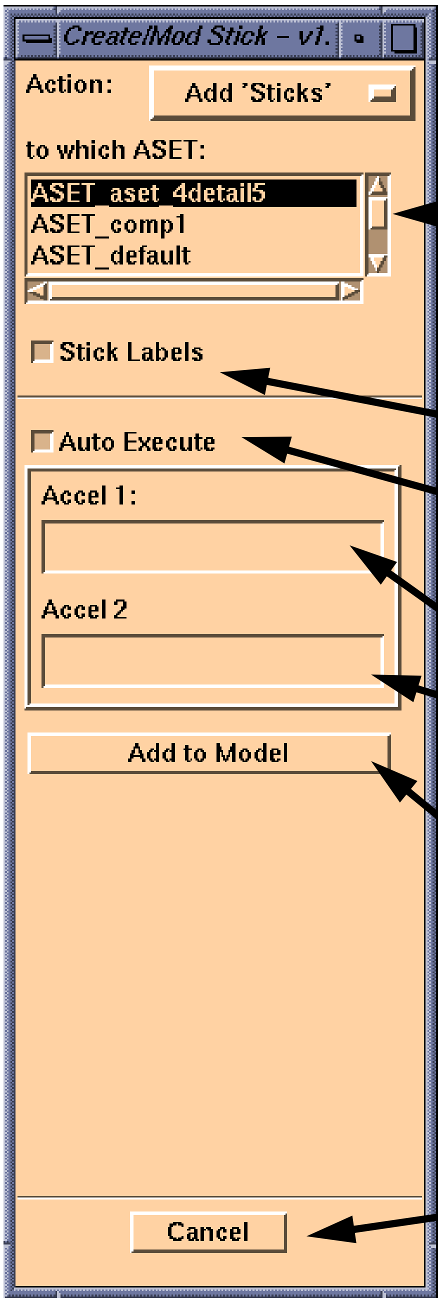
With the first release, if the user wanted to view just the stick model without the full FEM in the viewport, he would have to go to the Group/Post form and post just the ASET group of interest to the viewport. In the next major release, this type of display should be available from the ‘Create/Modify Stick Model’ form.

The actions on the ‘Create/Modify Stick Model’ form and their corresponding selections are discussed in the sections that follow.

All commands that create/modify/delete curves the associated impact on groups are recorded to the session file during a TACT session. When replaying the session file, keep in mind that if curves created during the original session still exist in the database, you will be prompted to allow duplicate curves to exist. The user should be cautious when replaying session files and should carefully interrogate the resulting curves, groups, and fields in the database before proceeding.

2.4.1•Action: Add ‘Sticks’

The ‘Add Sticks’ action allows the analyst to quickly “connect the dots” between accelerometer locations to created the skeleton model for results visualization. The form is shown below and actions are discussed.



Action set to ‘Add Sticks’.

Listbox showing existing ASETs. Selecting an ASET shows the accelerometer locations, DOF, and stick model in the current viewport; a typical viewport display is shown on the next page.

Toggle to turn on(default)/off curve labels.

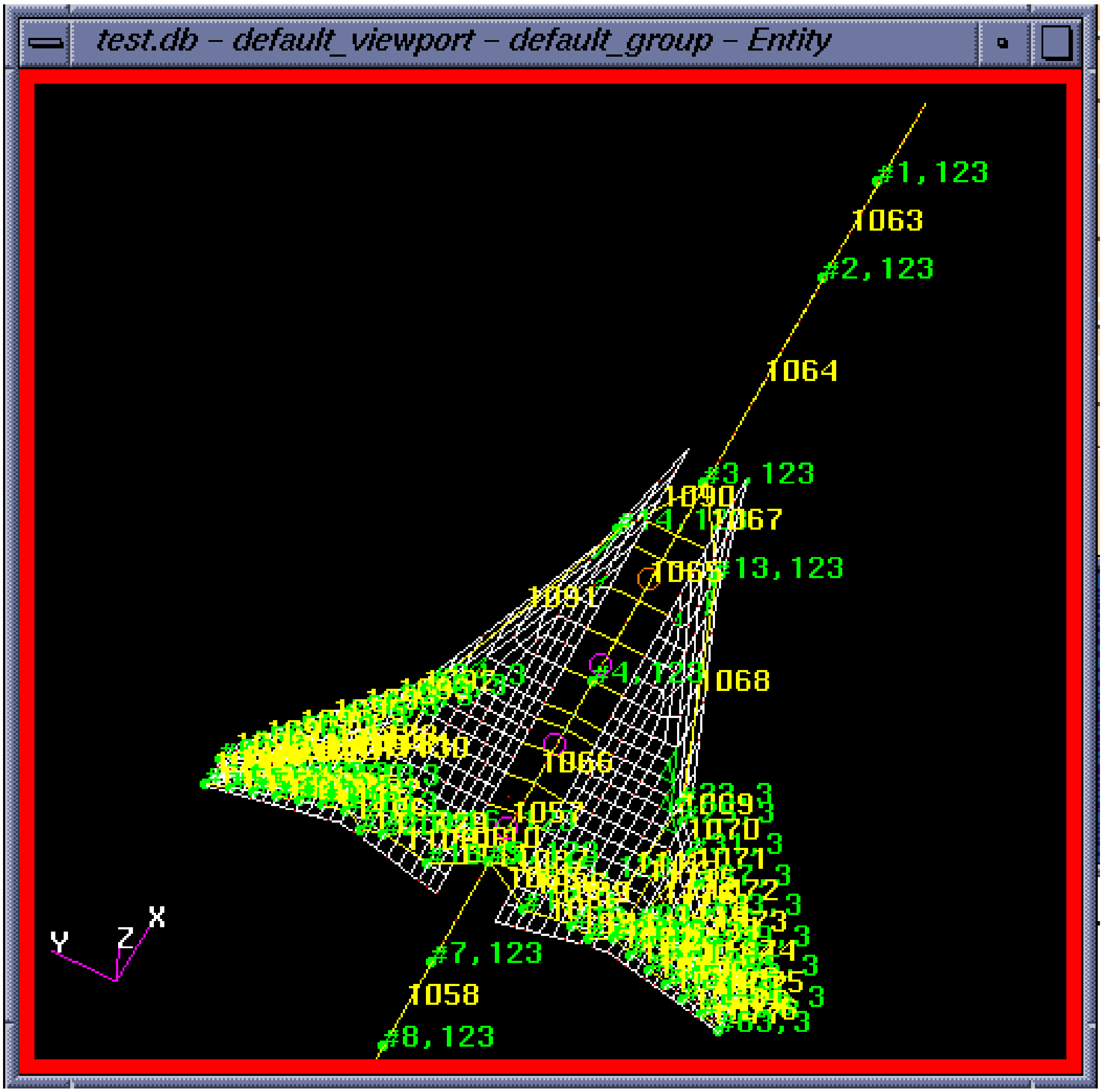
When Auto Execute toggle is selected, sticks are automatically added to ASET as soon as the select data boxes below are populated.

Select data boxes that allow the user to select nodes that are in the ASET to define end point 1 and end point 2 of the stick element (curve).

When AutoExecute is not selected, selection of ‘Add to Model’ creates the stick element.

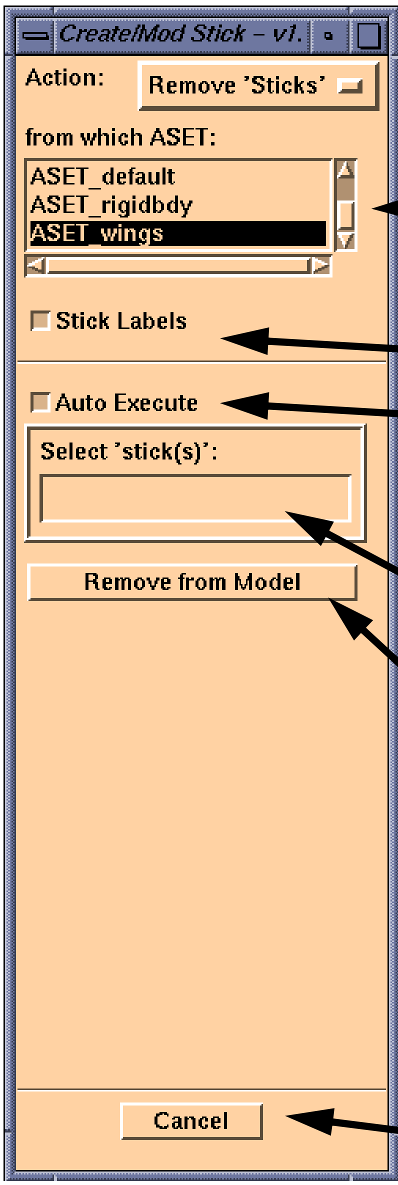
Closes the ‘Create/Modify Stick Model’ form.

As “stick elements” are added for the stick model of a particular ASET, they are posted to the current viewport. Stick element labels are on, by default, and are posted in yellow as shown in the typical viewport display below.



2.4.2•Action: Remove 'Sticks'

The 'Remove Sticks' action allows the analyst to delete stick elements from the stick model of the selected ASET. When the user selects the 'Remove Sticks' action, the currently selected ASET is posted to the viewport; upon exiting the form, TACT issues a warning message that the current group and/or posted groups may have changed. The form is shown below and actions are discussed.



Action set to 'Remove Sticks'.

Listbox showing existing ASETs. Selecting an ASET shows the accelerometer locations, DOF, and stick model in the current viewport.

Toggle to turn on(default)/off curve labels.

When Auto Execute toggle is selected, sticks are automatically deleted from the selected ASET as soon as the select data box below is populated.

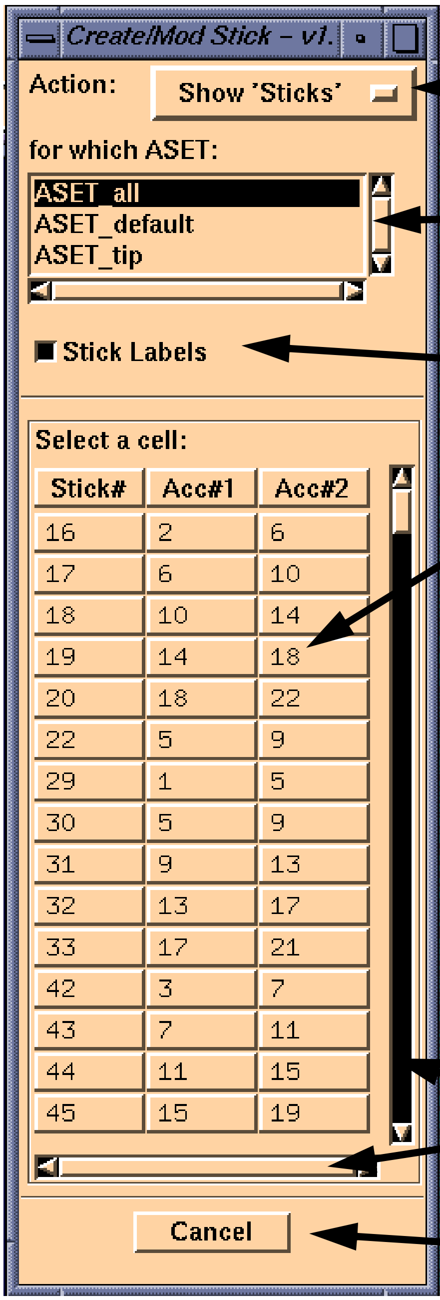
Select data box that allows the user to select curves that are in the ASET.

When AutoExecute is not selected, selection of 'Remove from Model' deletes the selected curve/stick element.

Closes the 'Create/Modify Stick Model' form.

2.4.3•Action: Show ‘Sticks’

The Show ‘Sticks’ action displays the connectivity data (in accelerometer numbers) for each ‘stick’ in the stick model in tablular form. No changes to the data can be made from this form.



Action set to ‘Show Sticks’.

Listbox showing existing ASETs. Selecting an ASET shows the accelerometer locations, DOF, and stick model in the current viewport.

Toggle to turn on(default)/off curve labels.

Connectivity table showing stick #s (which are also curve labels) versus the associated accelerometer #1 and accelerometer #2 for that ‘stick’. Selection of data in the ‘Stick#’ column causes the selected sticks to be hightlighted in orange in the viewport. Selection of data in the accelerometer columns causes the selected accelerometers to be highlighted in orange in the viewport.

Data may not be modified from this form.

Scroll bars shift right/left and up/down to allow viewing of all data.

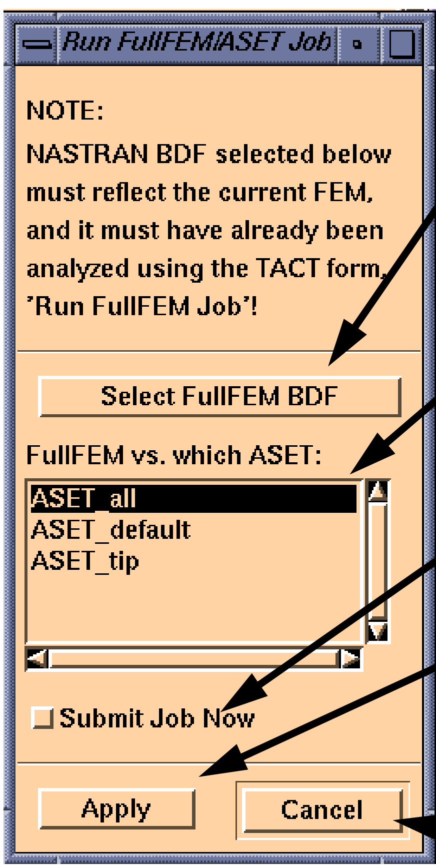
Closes the ‘Create/Modify Stick Model’ form.

2.5•Run FullFEM/ASET Job

After the analyst has created an ASET and a stick model, the next step in the Pre-Test process is to analytically determine the adequacy of that ASET for capturing the desired modes during the modal survey test. The ‘Run FullFEM/ASET Job’ form prepares and submits a NASTRAN deck that calculates frequency differences and a cross-orthogonality matrix between the full FEM results (which were created under ‘Run FullFEM Job’) and the ASET results.

Prior to selecting ‘Apply’ on the ‘Run FullFEM/ASET Job’ form, the user must have created and analyzed the full FEM using ‘Run FullFEM Job’. If this form was not used to create/run the full FEM deck, then the file containing the full FEM results as DMI entries will not exist, and TACT will return an error to the user.

Upon selecting ‘Run FullFEM/ASET Job’ from the TACT menu, the form below is displayed. Actions initiated by the user on the form are briefly described below.



Upon selection, the ‘Select FullFEM BDF’ button displays the ‘Select File’ form where the user can select the NASTRAN deck created in the PATRAN Analysis form.

Listbox showing existing ASETs. Selecting an ASET shows the accelerometer locations and DOF in the current viewport.

Toggles on(Default)/off the automatic submission of the NASTRAN job using Analysis Manager.

Upon selection, ‘Apply’ creates a directory where the ASET results will be stored, modifies a copy of the selected BDF to include DMAP that will calculate frequency differences and the cross-orthogonality between the full FEM and ASET results. Job is automatically submitted if the ‘Submit Job Now’ toggle is on.

Closes the form without executing any commands.

When the analyst selects ‘Apply’ on the ‘Run FullFEM/ASET Job’ form, the following actions are performed by TACT:

- A directory for holding that ASET’s results is created if it does not already exist.
- The selected NASTRAN deck is copied into this directory.
- The copy of the deck is modified to include the DMAP below (DMAP is customized for the selected ASET, as opposed to the dummy ‘ASET_1st_try’ in the example DMAP).

```
$----------------------------------------------------------------------------------------------------------------
$A2- ASSIGN STATEMENT INSERTED BY TACT
$   FILE W/ STORED FREQ DELTAS & X-ORTHOG MATRICES
ASSIGN OUTPUT4 = ‘ASET_1st_try.f15’, UNIT = 15, DELETE, FORM=FORMATTED
$   FILE W/ STORED FREQS & REDUCED EIGENVECTORS
ASSIGN OUTPUT4 = ‘ASET_1st_try.f16’, UNIT = 16, DELETE, FORM=FORMATTED
$----------------------------------------------------------------------------------------------------------------
$ Direct Text Input for File Management Section
$ Normal Modes Analysis, Database
SOL 103
TIME 1000
$ Direct Text Input for Executive Control
$----------------------------------------------------------------------------------------------------------------
$A2- ALTER INSERTED BY TACT TO CALCULATE X-ORTHOG & FREQ DELTAS, & DUMP
REDUCED EIGS
$
COMPILE SEMODES SOUIN=MSCSOU NOREF NOLIST
ALTER ’CALL SUPER3’
$ First, read in full FEM eigenvalues
DMIIN DMI,DMINDX/FULLEIG,PHGF,,,,,,,/ $
LAMX, ,LAMA/ASETEIG/-1$
$ Calculate frequency percent differences
ADD ASETEIG,FULLEIG/EIGDELTA/1./-1./0 $
ADD EIGDELTA,FULLEIG/PCNTDIFF/1./1./2 $
$ Write out full FEM, ASET eignevalues + percent differences
MATPRN PCNTDIFF,,,, // $
OUTPUT4 FULLEIG,,,,//0/15/0/  $ Full FEM eigenvalues
OUTPUT4 ASETEIG,,,,//0/15/0/  $ ASET FEM eigenvalues
OUTPUT4 PCNTDIFF,,,,//0/15/0/ $ Percent diff between
$ Then, read in full FEM eigenvectors and calculate cross-orthog
SMPYAD PHGF,MGG,PHG,,,/OCHK/3/1/1/1/1/0/0 $
$ Write out cross-orthogonality matrix
MATPRN OCHK,,,, // $
OUTPUT4 OCHK,,,,//0/15/0/ $
$ Transform A-set eigenvectors to basic coord system
UMERGE1 USET,PHA,,,/PHAG/’G’/’A’/’O’/1$
```

VECPLOT PHAG,BGPDTS,EQEXINS,CSTMS,CASES,,,/PHAGBSC/0/0/1
UPARTN USET,PHAGBSC/PHAABSC,PHAOBSC,,/'G'/'A'/'O'/1$
$ Write out eigenvalues, eigenvectors + mass
OUTPUT4 ASETEIG,,,,//0/16/0/ $ ASET FEM eigenvalues
OUTPUT4 PHAABSC,,,,//0/16/0/ $
OUTPUT4 MAA,,,,//0/16/0/ $
$
$ END OF ALTER
$
$---

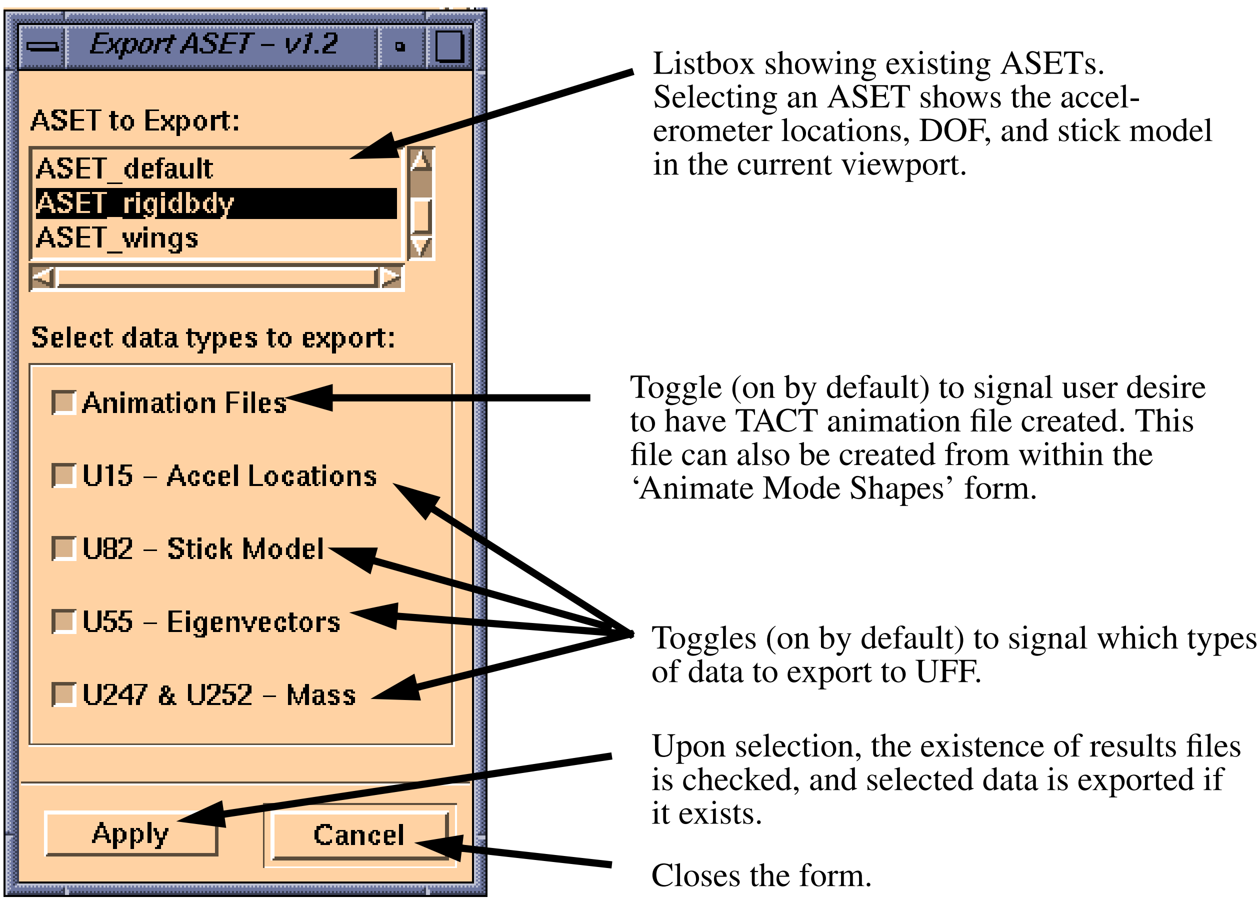
- ASET1 cards are added to the bulk data deck which represent the accelerometer DOF.
- If the 'Submit Job Now' toggle is on, the NASTRAN job is automatically submitted using Analysis Manager.

The DMAP performs the frequency difference and cross-orthogonality matrix calculations, and writes these results to an OUTPUT4 file ending with a ".f15" suffix. The reduced mass matrix and the ASET eigenvalues and eigenvectors are written to an OUTPUT4 file ending with a ".f16" suffix. The correlation results can be viewed easily by selecting 'Mode Pairs & Correlation' under the 'View Results:' section of the TACT main menu. ASET mode shape animations can be viewed by selecting 'Animate Mode Shapes' under the 'View Results:' section of TACT. These two modules will be discussed following the presentation of Post-Test modules.

Once the analyst and test engineer have settled on the accelerometer DOF and locations, the analyst is ready to export the analytical predictions to the test engineer.

2.6•Export ASET UFF

The 'Export ASET UFF' form exports ASET models and results to a UFF file ending in a ".UFF" suffix for the test engineer, and it also prepares a file called 'anim.aset' which TACT uses for animating stick model results. The form and actions available are described below.



Upon selecting 'Apply', TACT performs the following actions:

- Backs up the ".UFF" file if it already exists in the ASET's directory.
- If either of 'Animation Files' or 'U55 - Eigenvectors' is toggled on, then TACT checks to see if the ".f16" results file exists from the 'Run FullFEM/ASET Job' process. If the file does not exists, TACT issues an error.
- The UFF file is written (assuming one of the UFF data types were selected) to the ASET's directory; TACT automatically assigns the user-defined accelerometer numbers which are

extracted from the ASET's corresponding FEM field.

- The file 'anim.aset' is written and contains the accelerometer locations and modal results in a format that is quick for PATRAN to process during an animation; a corresponding file called 'anim.test' will be created when test results are imported.

After the analytical predictions have been read into the test engineers software, it will be possible for the test engineer and the analysts to make some quick preliminary assessments about the test results in real time. After the test has concluded, the test engineer will post process the modal survey results, and export a UFF file. Then the Post-Test correlation activities begin for the analyst.

3•Post-Test Modules

3.1•Post-Test Process

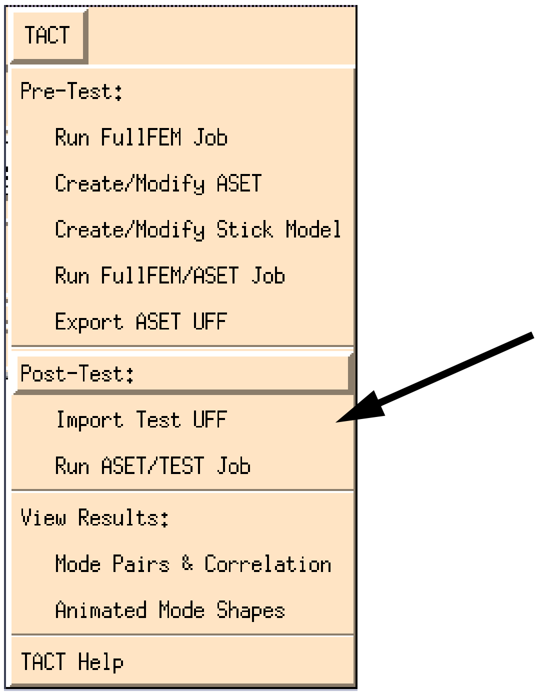
Once the modal survey has been completed, the test engineer will post process the results, and deliver the results to the analyst. Assuming the test results are believed to be valid, the analyst then begins the process of modifying the FEM so that the analytical results match the test results. Normally, changes to the FEM are made incrementally, and the effect of a particular FEM modification on the correlation is evaluated after each change.

There are several criteria available for determining the adequacy of correlation during the FEM updating and assessment activity. Normally, simple frequency deltas or percent differences are used to assess eigenvalues, and the allowable percent difference for a particular mode is normally smaller for the primary modes and higher for higher order modes. To assess mode shapes, a cross-orthogonality criteria or Modal Assurance Criteria (MAC) are common choices to determine how well the finite element model predictions matched the test data. With this initial release of TACT, only frequency percent differences and cross-orthogonality check are implemented. The cross-orthogonality calculation between the test eigenvectors and reduced FEM results is below:

$$\left[\Phi_{TEST}\right]^T \left[M_{ASET}\right] \left[\Phi_{ASET}\right] = \left[\delta_x\right]$$

where Φ, in both cases, contains analysis mass-normalized eigenvectors, M_{ASET} is the analytical mass matrix, and δ_x is the cross-orthogonality matrix. If Φ_{TEST} and Φ_{ASET} represent the same mode shapes, then δ_x will approach the identity matrix. TACT makes this calculation in NASTRAN (using DMAP) on reduced FEM (A-set) sized matrices.

The next sections will describe the 2 modules in TACT that aid the analyst during Post-Test evaluation. These modules are shown on the TACT menu below.



Post-Test
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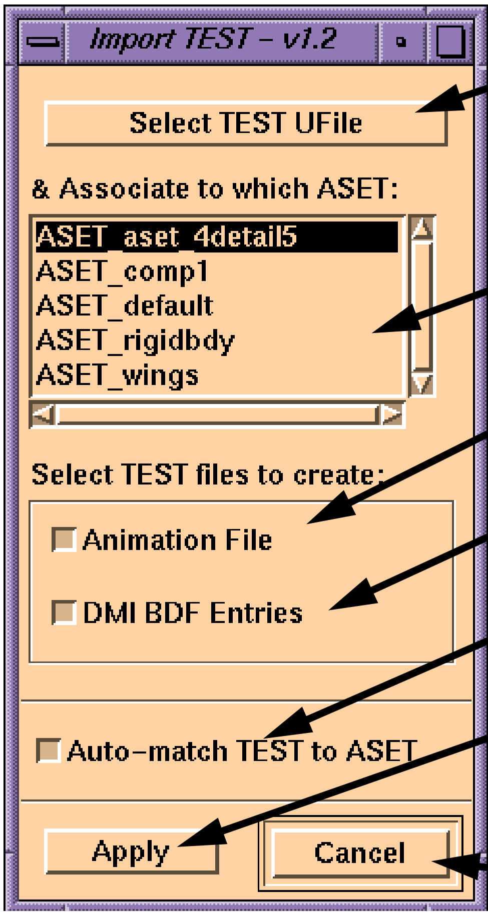
Modules

3.2•Import Test UFF

The 'Import Test UFF' form imports test results (U15, U82, U55) in a UFF file ending in a ".UFF" suffix. If selected, it then creates "anim.test", the animation file used by TACT, and "test.dmi", the results converted to DMI NASTRAN card entries for use in later NASTRAN analyses. The form and actions available are described below.



Upon selection, the 'Select TEST UFile' button displays the 'Select File' form.

Listbox showing existing ASETs. Selecting an ASET shows the accelerometer locations, DOF, and stick model in the current viewport.

Toggle indicating whether "anim.test", a file used by TACT for mode shape animation, should be created (on by default).

Toggle indicating whether DMI cards containing test results should be created.

Toggle indicating whether test data should automatically be transformed to match the analysis model.

Upon selection, TACT reads in test results, makes sure that the test data is in the same coordinate system and orientation as the analysis model, and exports the selected files.

Closes the form.

Upon selecting 'Apply', TACT performs the following actions:

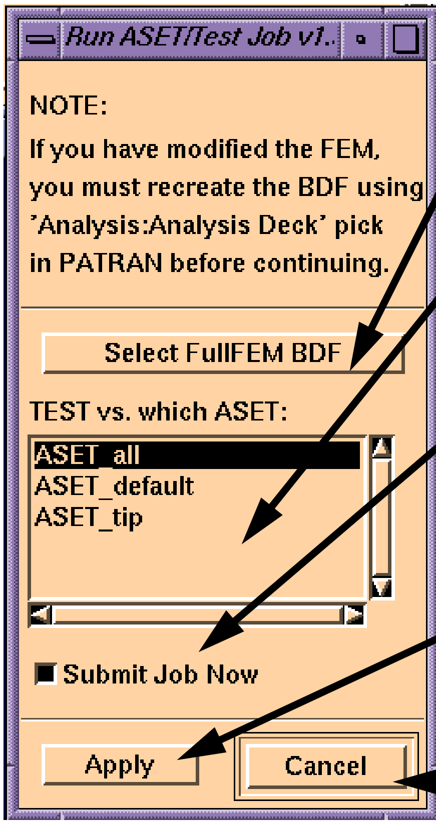
- Opens the file selected on the 'Select File' form, and verifies that it is a UFF file.
- Checks to make sure that the directory for the selected ASET exists.
- Looks up the node # - accelerometer # mapping from the FEM field. If the accelerometer numbers were changed by the test engineer, then the analyst needs to bo back into 'Create/ Modify ASET' and update the accelerometer numbers prior to importing test results.

- The test results are then reordered so that they are in the same order as the analysis results.
- If the 'Auto-match' toggle is selected, the test results are then scaled so that the units are the same between the test and analysis results. Scaling is performed based on the distance from the origin to the first accelerometer/node pair in the ASET's FEM field (TACT verifies that this pair is not located at the origin first).
- If the 'Auto-match' toggle is selected, the test results are then rotated/translated so that the test results are aligned with the analysis results; this step is included in case test data was recorded in a different coordinate system from the analysis data. The translation/rotation is performed based on analysis and test "lines" that run between the first two accelerometer/node pairs in the ASET's FEM field. The "lines" are translated so that the first endpoint is on the origin. Then the analysis "line" is rotated so that it s aligned with the X axis; these angles are stored so that the "line" can be rotated back to it's original position. Next the test "line" is rotated to align with the X axis, and then all geometry is rotated back and translated back to its original position.
- If the 'Animation File' toggle is selected, the file 'anim.test' is written. This file contains the accelerometer locations and modal results in a format that is quick for PATRAN to process during an animation; a corresponding file called 'anim.aset' was created when analysis results were exported.
- If the 'DMI BDF Entries' toggle is selected, the file 'test.dmi' is written. This file contains test eigenvalue and eigenvector results on DMI bulk data card entries for use in NASTRAN correlation calculation runs.

3.3•Run ASET/Test Job

After the analyst has imported the test results, the next step in the Post-Test process is to calculate the correlation between the test results and the current FEM. Each time the analyst modifies the FEM to improve correlation, he needs to recreate the NASTRAN deck using the Analysis form in PATRAN, and then bring up the 'Run ASET/Test Job' form in TACT. The 'Run ASET/Test Job' form prepares and submits a NASTRAN deck that calculates frequency differences and a cross-orthogonality matrix between the test and the ASET results. This step in the Post-Test process is repeated numerous times until acceptable correlation for the modes of interest are achieved.

Prior to selecting 'Apply' on the 'Run ASET/Test Job' form, the user must have recreated the NASTRAN deck if any changes to the FEM were made. If this BDF is not updated, then changes to the model will not be included in the NASTRAN analysis. Upon selecting 'Run ASET/Test Job' from the TACT menu, the form below is displayed. Actions initiated by the user on the form are briefly described below.



Upon selection, the 'Select FullFEM BDF' button displays the 'Select File' form where the user can select the NASTRAN deck created in the PATRAN Analysis form.

Listbox showing existing ASETs. Selecting an ASET shows the accelerometer locations and DOF in the current viewport.

Toggles on(Default)/off the automatic submission of the NASTRAN job using Analysis Manager.

Upon selection, 'Apply' modifies a copy of the selected BDF to include DMAP that will calculate frequency differences and the cross-orthogonality between the test and ASET results. The job is automatically submitted if the 'Submit Job Now' toggle is on.

Closes the form without executing any commands.

On 'Apply', the following actions are performed by TACT:

- A directory for holding that ASET's results is created if it does not already exist.
- The selected NASTRAN deck is copied into this directory.
- The copy of the deck is modified to include the DMAP below (customized for the selected ASET, as opposed to the dummy 'ASET_1st_try' in the example DMAP).

```
$-----------------------------------------------------------------------------------------------------------
$A3- ASSIGN STATEMENT INSERTED BY TACT
$   FILE W/ STORED FREQS & REDUCED EIGENVECTORS & REDUCED MASS
ASSIGN OUTPUT4 = 'ASET_1st_try.f16', UNIT = 16, DELETE, FORM=FORMATTED
$   FILE W/ STORED FREQ DELTAS & X-ORTHOG MATRICES
ASSIGN OUTPUT4 = 'ASET_1st_try.f17', UNIT = 17, DELETE, FORM=FORMATTED
$-----------------------------------------------------------------------------------------------------------
$ Normal Modes Analysis, Database
```

```
SOL 103
TIME 1000
$-------------------------------------------------------------------------------------------------------------
$A3- ALTER INSERTED BY TACT TO CALCULATE X-ORTHOG & FREQ DELTAS, & DUMP
REDUCED EIGS
$
COMPILE SEMODES SOUIN=MSCSOU NOREF NOLIST
$ First, read in test eigenvalues and  test FEM eigenvectors and calculate frequency deltas
ALTER 'CALL SUPER3'
$ First, read in Test eigenvalues + eigenvectors
DMIIN DMI,DMINDX/TESTEIG,PHT,,,,,,,/ $
LAMX, ,LAMA/ASETEIG/-1$
$ Calculate frequency percent differences
ADD ASETEIG,TESTEIG/EIGDELTA/1./-1./0 $
ADD EIGDELTA,TESTEIG/PCNTDIFF/1./1./2 $
$ Write out Test, ASET eignevalues + percent differences
MATPRN PCNTDIFF,,,, // $
OUTPUT4 TESTEIG,,,,//0/17/0/  $ Test eigenvalues
OUTPUT4 ASETEIG,,,,//0/17/0/  $ ASET FEM eigenvalues
OUTPUT4 PCNTDIFF,,,,//0/17/0/ $ Percent diff between
$ Then, calculate cross-orthog
SMPYAD PHT,MAA,PHT,,,/MSF2/3/1/1/1/1/0/0  $ CALCULATE MODAL SCALE FACTORS
DIAGONAL MSF2/MSF/'SQUARE'/0.5 $
TRNSP PHT/PHTT $
SOLVE MSF,PHTT/PTNT/0$ FORM MASS NORMALIZED TEST EIGENVECTORS
TRNSP PTNT/PHTN $
SMPYAD PHTN,MAA,PHA,,,/OCHK/3/1/1/1/1/0/0 $CALCULATE X-ORTHOG"
$ Write out cross-orthogonality matrix
MATPRN OCHK,,,, // $
OUTPUT4 OCHK,,,,//0/17/0/ $
$ Transform A-set eigenvectors to basic coord system
UMERGE1 USET,PHA,,,/PHAG/'G'/'A'/'O'/1$
VECPLOT PHAG,BGPDTS,EQEXINS,CSTMS,CASES,,,/PHAGBSC/0/0/1
UPARTN USET,PHAGBSC/PHAABSC,PHAOBSC,,/'G'/'A'/'O'/1$
$ Write out eigenvalues, eigenvectors + mass
OUTPUT4 ASETEIG,,,,//0/16/0/  $ ASET FEM eigenvalues
OUTPUT4 PHAABSC,,,,//0/16/0/ $
OUTPUT4 MAA,,,,//0/16/0/ $
$
$ END OF ALTER
$
$---------------------------------------------------------------------------")
```

- ASET1 cards are added to the bulk data deck which represent the accelerometer DOF.

- DMI cards containing the test results are added to the bulk data deck.
- If the 'Submit Job Now' toggle is on, the NASTRAN job is automatically submitted using Analysis Manager.

The DMAP performs the frequency difference and cross-orthogonality matrix calculations, and writes these results to an OUTPUT4 file ending with a ".f17" suffix. The reduced analytical mass matrix and the ASET eigenvalues and eigenvectors are written to an OUTPUT4 file ending with a ".f16" suffix. The correlation results can be viewed easily by selecting 'Mode Pairs & Correlation' under the 'View Results:' section of the TACT main menu. ASET and test mode shape animations can be viewed by selecting 'Animate Mode Shapes' under the 'View Results:' section of TACT. These two modules will be discussed in the next section.

4•'View Results' Modules

4.1•Results Post-processing

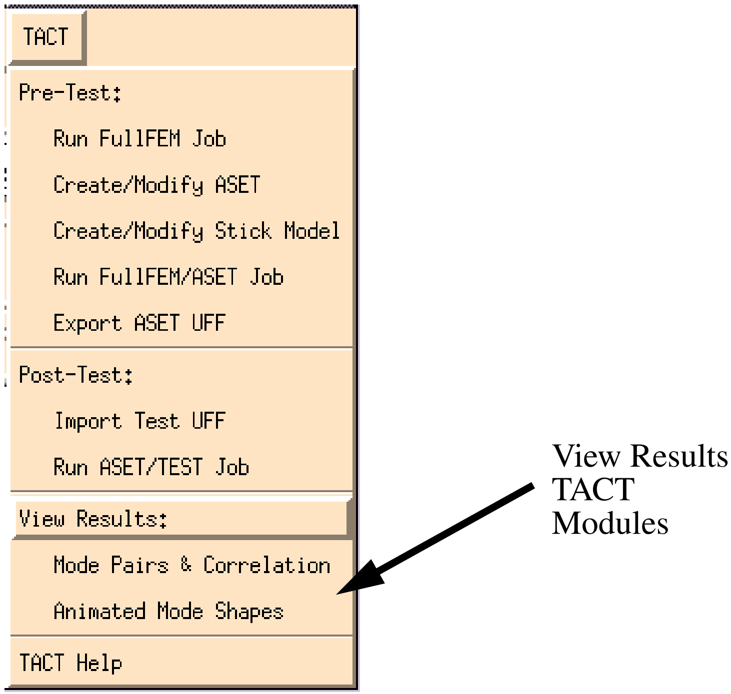
Any time the analyst wishes to review modal results where the ASET model results are compared to either the full FEM or test results, the same basic capabilities are needed. These results post-processing features are provided in the 'View Results' section of TACT.

There are two aspects to reviewing results during a correlation activity. The first is actually viewing and post-processing the frequency percent difference and cross-orthogonality calculations. By default, NASTRAN assumes that the modes in the DMI entries for either the full FEM or the test results are ordered so that they pair sequentially with the calculated reduced FEM results. This may not be true, and TACT provides the user with the ability to manipulate mode pairs. TACT also has an 'Auto Pair' capability, which calculates which modes form likely mode pairs based on user defined thresholds.

The second part of reviewing modal results is to actually view the animated mode shapes. TACT currently offers five different ways of displaying animated mode shape results, which include analysis and test results side-by-side, analysis and test results overlaid and an animation of the difference between analysis and test results. All animation parameters can be modified during an animation or while stepping through an animation.

In the first several iterations of trying to determine where the finite element model should be changed or updated to better reflect test data, most analysts use visual inspection of the mode shapes in conjunction with the correlation calculations. The two 'View Results' modules in TACT are intended to provide a set of core tools for performing this function. Once the analyst understands which parameters in his FEM are driving the behavior of certain modes, a sensitivity or optimization analysis (minimize the difference between a test and analysis mode shape by varying some parameter, such as a plate thickness or spring stiffness) might be used to fine tune the correlation. This advanced functionality is on the list of desired features for future releases of TACT.

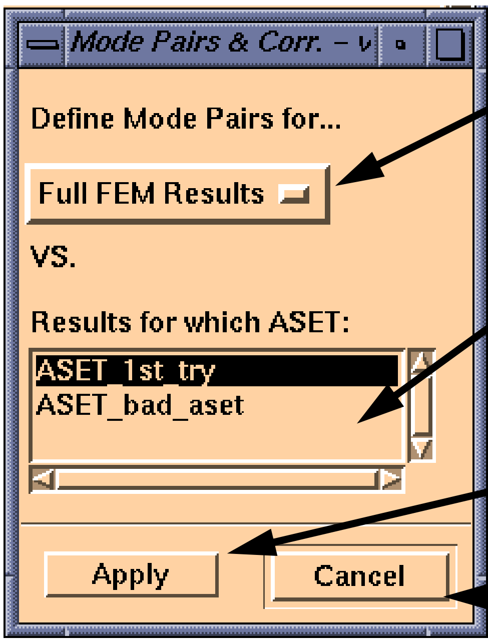
The next sections will describe the two ‘View Results’ modules which are shown on the TACT menu below.



4.2•Mode Pairs & Correlation

The 'Mode Pairs & Correlation' form in TACT provides the user with a single place to manipulate mode pairs and view the effect on the frequency percent differences and cross-orthogonality matrix.

After selecting 'Mode Pairs & Correlation' from the TACT menu, the form below appears; this is where the user defines what results sets he/she wishes to work with. Actions on the form are described below.



Action button which toggles between 'Full FEM Results' and 'Test Results'.

Listbox showing existing ASETs that also have a results file of the type selected above. 'Full FEM Results' results files end in a ".f15" suffix and 'Test Results' files end in a ".f17". Selecting an ASET shows the accelerometer locations, DOF, and stick model in the current viewport.

Upon selection, TACT reads in the results file and the appropriate "mode_pairs" file and displays the results on another form.

Closes this form.

Upon selecting the 'Apply' button, TACT performs the following actions:

- The selected OUTPUT4 results file is read in. If the action is set to 'Full FEM Results', then the results file will end in a ".f15" suffix; if the action is 'Test Results' then the file ends in a ".f17" suffix.
- The appropriate mode pair file is read in. If the action is set to 'Full FEM Results', then the mode pair file will end in a ".full.mode_pairs" suffix; if the action is 'Test Results' then the file ends in a ".test.mode_pairs" suffix. If the file does not exist, then it is created with sequentially created mode pairs.

Once the results have been read in, the results are displayed on the 'Mode Pairs & Correlation - Review Results' form, which is discussed in the following sections.

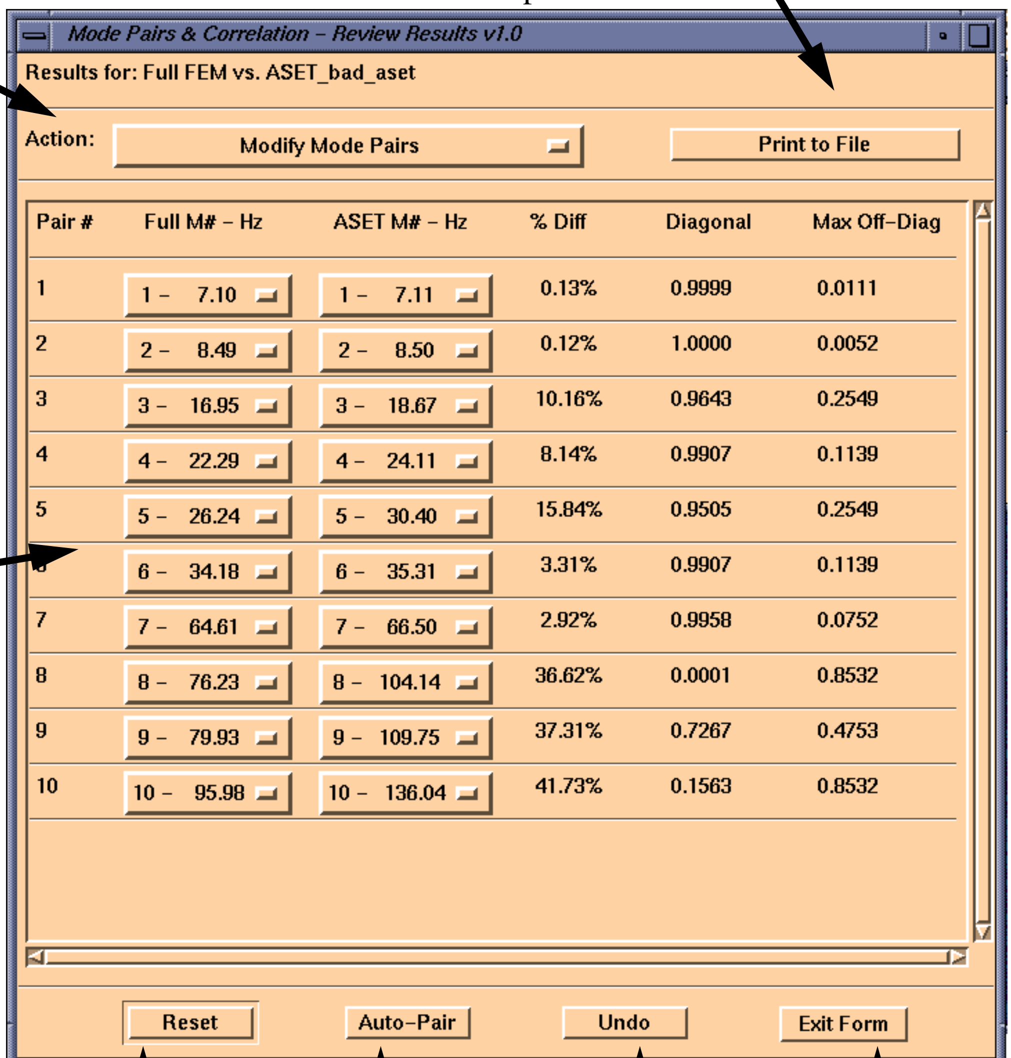
4.2.1•Action: 'Modify Mode Pairs'

When the 'Mode Pairs & Correlation - Review Results' form is displayed, the action is initially set to 'Modify Mode Pairs'. The form and user selections are described below.

Generates a text report of this form.

Action set to 'Modify Mode Pairs'

Any mode may be selected and paired with any opposing mode.


Mode Pairs & Correlation – Review Results v1.0

Results for: Full FEM vs. ASET_bad_aset

Action: Modify Mode Pairs   Print to File

Pair #	Full M# – Hz	ASET M# – Hz	% Diff	Diagonal	Max Off–Diag
1	1 – 7.10	1 – 7.11	0.13%	0.9999	0.0111
2	2 – 8.49	2 – 8.50	0.12%	1.0000	0.0052
3	3 – 16.95	3 – 18.67	10.16%	0.9643	0.2549
4	4 – 22.29	4 – 24.11	8.14%	0.9907	0.1139
5	5 – 26.24	5 – 30.40	15.84%	0.9505	0.2549
6	6 – 34.18	6 – 35.31	3.31%	0.9907	0.1139
7	7 – 64.61	7 – 66.50	2.92%	0.9958	0.0752
8	8 – 76.23	8 – 104.14	36.62%	0.0001	0.8532
9	9 – 79.93	9 – 109.75	37.31%	0.7267	0.4753
10	10 – 95.98	10 – 136.04	41.73%	0.1563	0.8532

Reset   Auto–Pair   Undo   Exit Form

Resets mode pairs to sequential pairing.

Auto-pairs modes.

1-step 'Undo'.

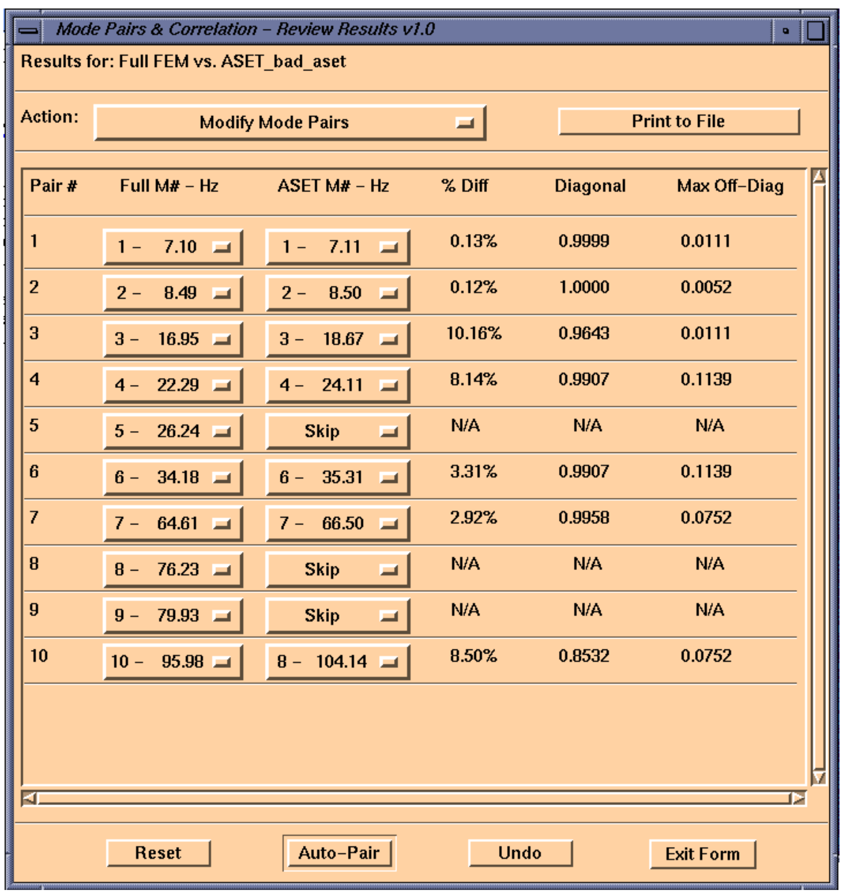
Closes this form.

This form has the following features:

- The analyst quickly sees a summary of the relevant cross-orthogonality and frequency percent difference results for the current mode pairing.

- The user can modify the mode pairs individually by selecting individual modes.
- The user can use the ‘Auto-Pair’ function to have TACT calculate the best mode pairings based on user-defined thresholds which are shown later in this chapter.
- The user can ‘Reset’ the mode pairs to the original sequential pairings at any time.
- A 1-step ‘Undo’ capability has been implemented for this form; this is in case of accidental selection of the ‘Reset’ or ‘Auto-Pair’ buttons.
- Any modification of the mode pairs at any time causes TACT to update the mode pairs file.
- A text report can be printed to a file called ‘TXT_REPORT.xxxx.mpair_list’, where ’xxxx’ is replaced by either ‘full’ or ‘test’ depending on the result being viewed. This file is easily imported into spreadsheet or word processing software for inclusion in formal documentation.

The form is shown again below; the mode pairs have now been modified by selecting the ‘Auto-Pair’ button. In this example, the ASET did not capture full FEM modes 8,9.

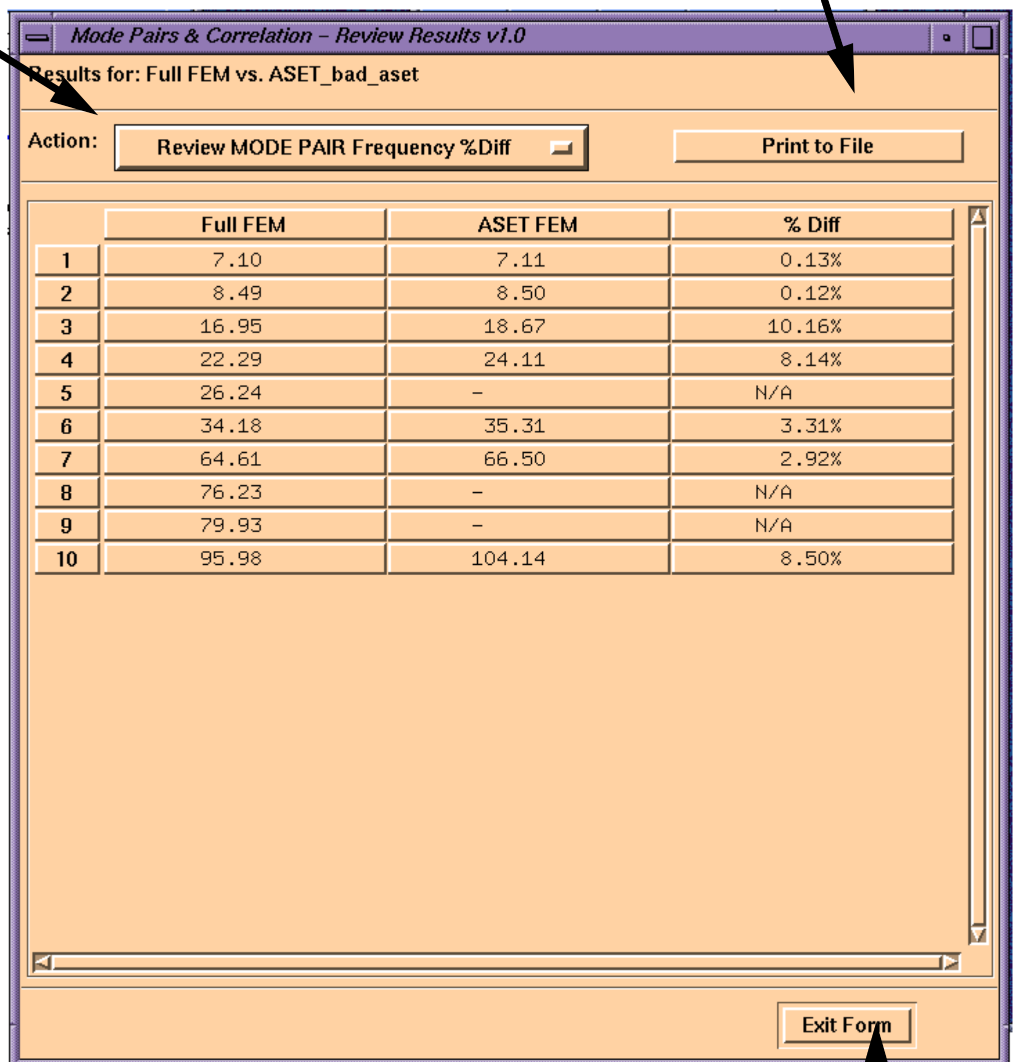


4.2.2•Action: ‘Review MODE PAIR Frequency %Diff’

The ‘Review MODE PAIR Frequency %Diff’ action displays a table of percent differences between modal frequencies based on the current mode pairs. The form and user selections are described below.

Generates a text report of this form.

Action set to ‘Review MODE PAIR Frequency %Diff’



	Full FEM	ASET FEM	% Diff
1	7.10	7.11	0.13%
2	8.49	8.50	0.12%
3	16.95	18.67	10.16%
4	22.29	24.11	8.14%
5	26.24	-	N/A
6	34.18	35.31	3.31%
7	64.61	66.50	2.92%
8	76.23	-	N/A
9	79.93	-	N/A
10	95.98	104.14	8.50%

Closes this form.

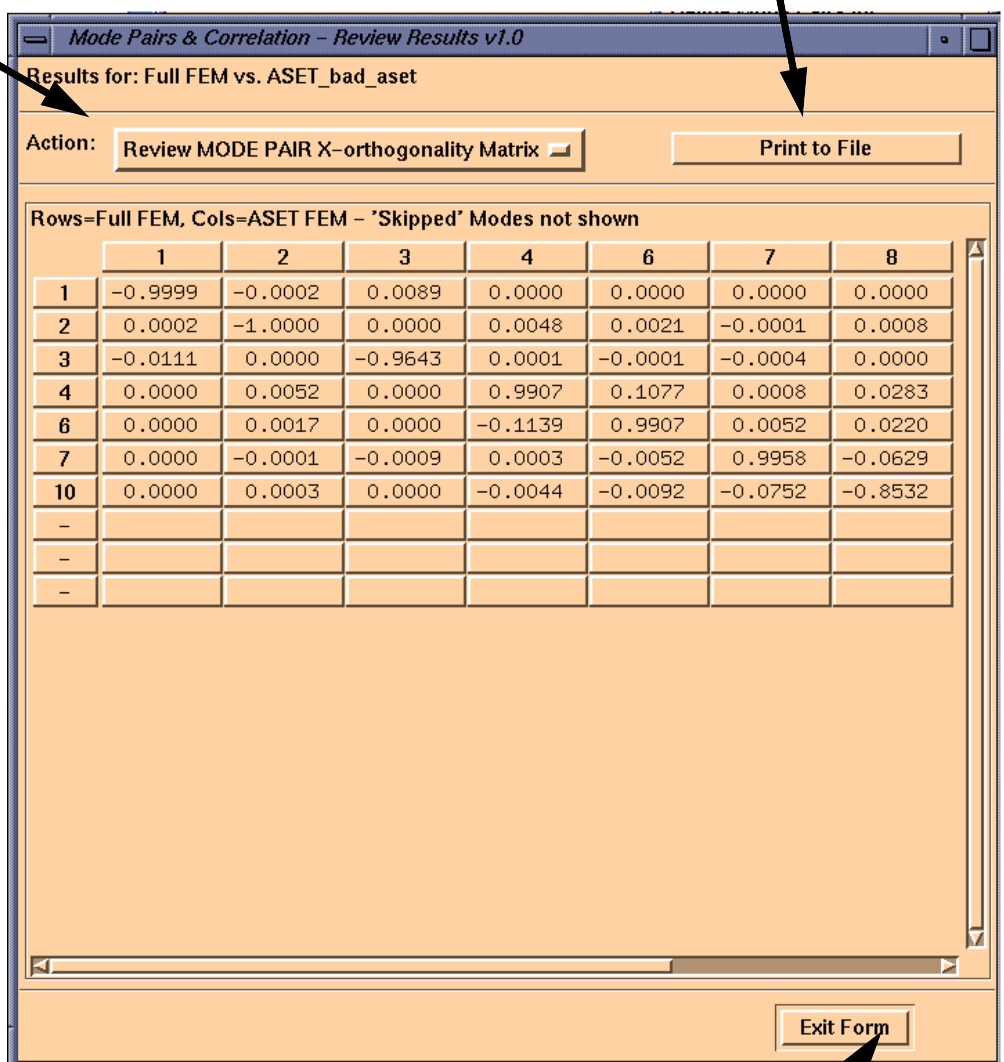
A text report can be printed to a file called ‘TXT_REPORT.xxxx.mpair_freq’, where ’xxxx’ is replaced by either ‘full’ or ‘test’ depending on the result being viewed.

4.2.3•Action: ‘Review MODE PAIR X-orthogonality Matrix’

The ‘Review MODE PAIR X-orthogonality Matrix’ action displays the cross-orthogonality matrix based on the current mode pairs. Rows and columns of the original cross-orthogonality matrix that correspond to modes not selected in the current mode pairs are eliminated. The form and user selections are described below.

Generates a text report of this form.

Action set to ‘Review MODE PAIR X-orthogonality Matrix’


Mode Pairs & Correlation – Review Results v1.0

Results for: Full FEM vs. ASET_bad_aset

Action: Review MODE PAIR X–orthogonality Matrix

Print to File

Rows=Full FEM, Cols=ASET FEM – 'Skipped' Modes not shown

	1	2	3	4	6	7	8
1	-0.9999	-0.0002	0.0089	0.0000	0.0000	0.0000	0.0000
2	0.0002	-1.0000	0.0000	0.0048	0.0021	-0.0001	0.0008
3	-0.0111	0.0000	-0.9643	0.0001	-0.0001	-0.0004	0.0000
4	0.0000	0.0052	0.0000	0.9907	0.1077	0.0008	0.0283
6	0.0000	0.0017	0.0000	-0.1139	0.9907	0.0052	0.0220
7	0.0000	-0.0001	-0.0009	0.0003	-0.0052	0.9958	-0.0629
10	0.0000	0.0003	0.0000	-0.0044	-0.0092	-0.0752	-0.8532
–							
–							
–							

Exit Form

Closes this form.

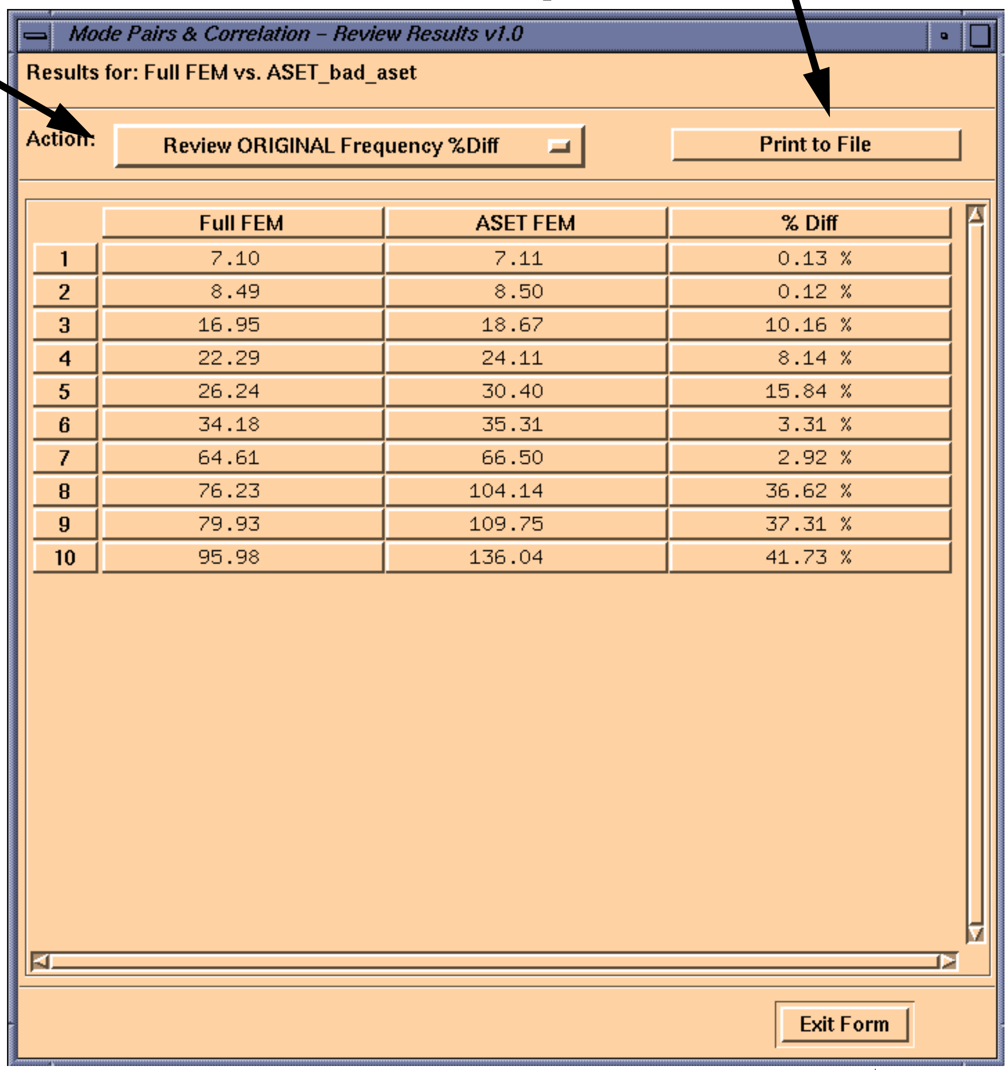
A text report can be printed to a file called ‘TXT_REPORT.xxxx.mpair_ochk’, where ’xxxx’ is replaced by either ‘full’ or ‘test’ depending on the result being viewed.

4.2.4•Action: ‘Review ORIGINAL Frequency %Diff’

The ‘Review ORIGINAL Frequency %Diff’ action displays a table of percent differences between modal frequencies based on the original sequential mode pairs. The form and user selections are described below.

Generates a text report of this form.

Action set to ‘Review ORIGINAL Frequency %Diff’



Mode Pairs & Correlation – Review Results v1.0

Results for: Full FEM vs. ASET_bad_aset

Action: Review ORIGINAL Frequency %Diff

Print to File

	Full FEM	ASET FEM	% Diff
1	7.10	7.11	0.13 %
2	8.49	8.50	0.12 %
3	16.95	18.67	10.16 %
4	22.29	24.11	8.14 %
5	26.24	30.40	15.84 %
6	34.18	35.31	3.31 %
7	64.61	66.50	2.92 %
8	76.23	104.14	36.62 %
9	79.93	109.75	37.31 %
10	95.98	136.04	41.73 %

Exit Form

Closes this form.

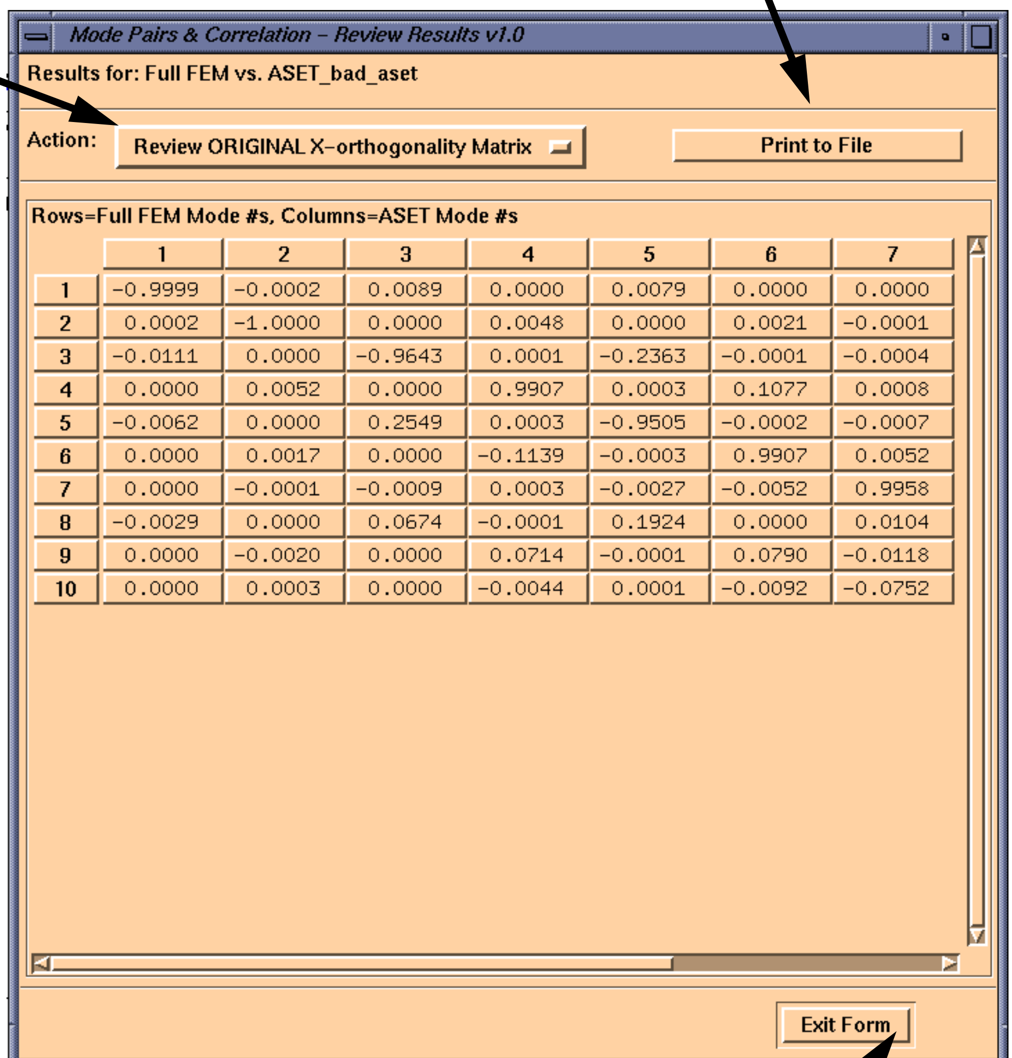
A text report can be printed to a file called ‘TXT_REPORT.xxxx.orig_freq’, where ’xxxx’ is replaced by either ‘full’ or ‘test’ depending on the result being viewed.

4.2.5•Action: ‘Review ORIGINAL X-orthogonality Matrix’

The ‘Review ORIGINAL X-orthogonality Matrix’ action displays the cross-orthogonality matrix based on the original sequential mode pairs. This matrix is identical to the OCHK matrix printed out in the NASTRAN “.f06” file from the ‘Run ASET/Test Job’ analysis. The form and user selections are described below.

Generates a text report of this form.

Action set to ‘Review ORIGINAL X-orthogonality Matrix’



	1	2	3	4	5	6	7
1	-0.9999	-0.0002	0.0089	0.0000	0.0079	0.0000	0.0000
2	0.0002	-1.0000	0.0000	0.0048	0.0000	0.0021	-0.0001
3	-0.0111	0.0000	-0.9643	0.0001	-0.2363	-0.0001	-0.0004
4	0.0000	0.0052	0.0000	0.9907	0.0003	0.1077	0.0008
5	-0.0062	0.0000	0.2549	0.0003	-0.9505	-0.0002	-0.0007
6	0.0000	0.0017	0.0000	-0.1139	-0.0003	0.9907	0.0052
7	0.0000	-0.0001	-0.0009	0.0003	-0.0027	-0.0052	0.9958
8	-0.0029	0.0000	0.0674	-0.0001	0.1924	0.0000	0.0104
9	0.0000	-0.0020	0.0000	0.0714	-0.0001	0.0790	-0.0118
10	0.0000	0.0003	0.0000	-0.0044	0.0001	-0.0092	-0.0752

Closes this form.

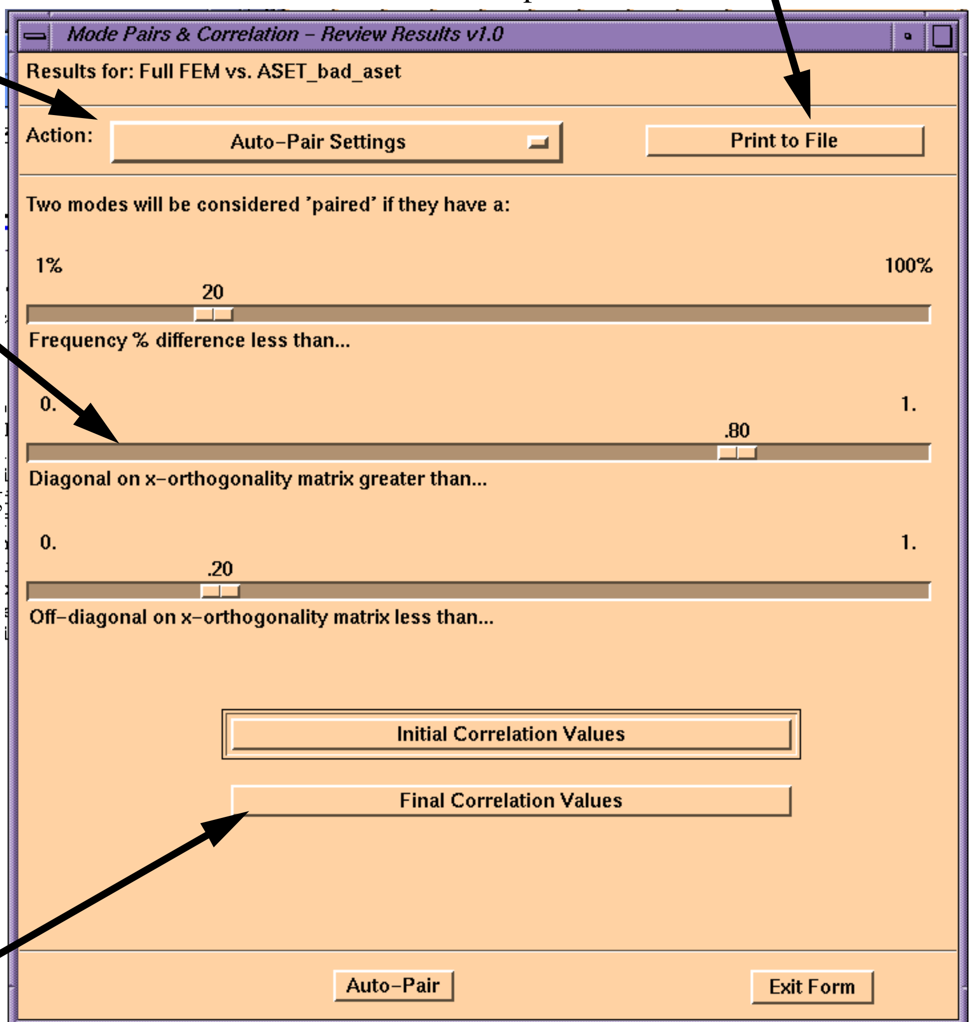
A text report can be printed to a file called ‘TXT_REPORT.xxxx.orig_ochk’, where ’xxxx’ is replaced by either ‘full’ or ‘test’ depending on the result being viewed.

4.2.6•Action: 'Auto-Pair Settings'

The 'Auto-Pair Settings' action allows the analyst to control the way TACT determines which modes should be paired. The form and user selections are shown below.

Generates a text report of this form.

Action set to 'Auto-Pair Settings'



Slide settings for frequency percent difference, diagonal terms, and off-diagonal terms of the cross-orthogonality matrix to use when assessing candidate mode pairs.

Two pre-set combinations of the slide toggles; Initial correlation sets slides to 20%, .80 diagonal, .20 off-diagonal, and Final correlation sets slides to 5%, .95 diagonal, and .05 off-diagonal.

Auto-pairs modes.

Closes this form.

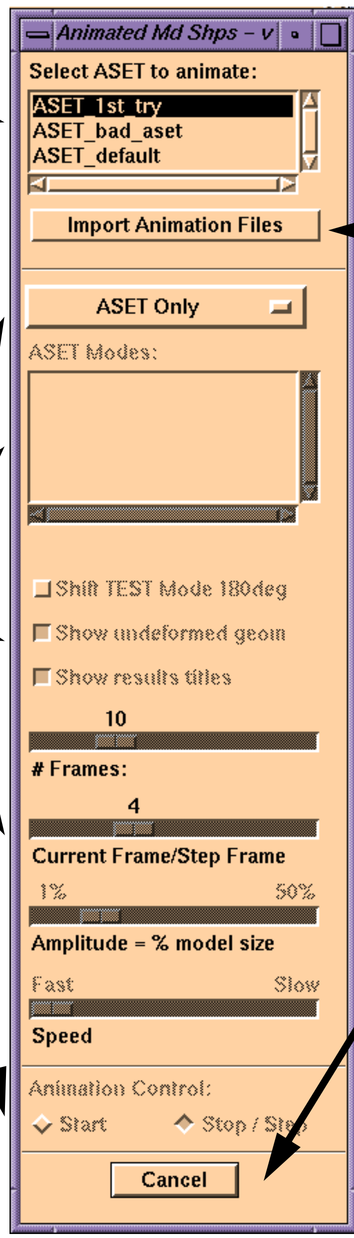
When the ‘Auto-Pair’ button is selected, TACT scans all the modes to determine the best pairs. TACT works on either the full FEM or test modes, and scans the ASET modes to find the ASET mode with the largest corresponding cross-orthogonality matrix value. TACT then checks to make sure this value is above the ‘Diagonal on x-orthogonality matrix’ setting. Then TACT checks the frequency percent difference for this pair, and makes sure that it is less than the ‘Frequency % difference’ setting. An initial mode pairing is made for all full FEM or test modes based on these two criteria. Then, TACT checks the off-diagonal terms of the cross-orthogonality matrix for those ASET modes that are included in the initial mode pairing, and makes sure that the maximum off-diagonal is less than the ‘Off-diagonal on x-orthogonality matrix’ setting. Finally, the ‘Modify Mode Pairs’, ‘MODE PAIR Frequency %Diff’, and ‘MODE PAIR X-orthogonality Matrix’ forms are updated to reflect the new mode pairs, and the “.xxxx.mode_pairs” file is updated.

A text report can be printed to a file called ‘TXT_REPORT.xxxx.auto_pair’, where ’xxxx’ is replaced by either ‘full’ or ‘test’ depending on the result being viewed.

4.3•Animated Mode Shapes

The ‘Animated Mode Shapes’ function in TACT uses a separate viewport (named “Stick Model Animation”) and a single form for controlling animations. Upon entering the ‘Animated Mode Shapes’ form, the user can select which ASET to animate, and the stick model and DOF markers for that ASET are updated in the Animation viewport. The form and the viewport at this point are shown below.

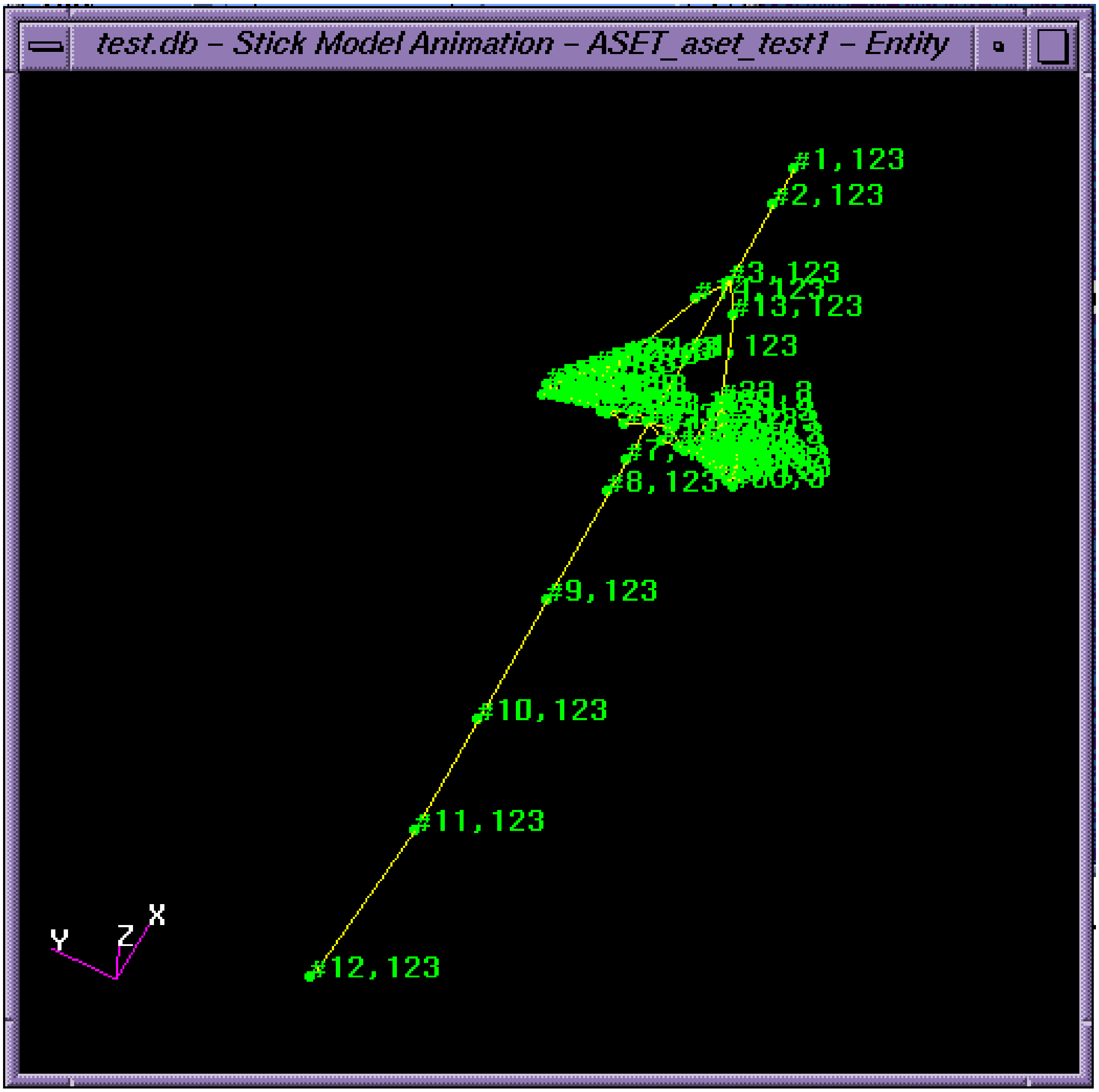
List box showing existing ASETs. Selecting an ASET shows the accelerometer locations, DOF, and stick model in the ‘Stick Model Animation’ viewport.



Upon selection, TACT reads animation data from the files ‘anim.aset’ and ‘anim.test’ for the selected ASET. TACT then determines which viewing methods are available based on the data read in, and the animation widgets are enabled.

All animation widgets are disabled until the user selects the ‘Import Animation Files’ button and the animation files ‘anim.aset’ and/or ‘anim.test’ have been successfully read in.

Closes this form and deletes the “Stick Model Animation” viewport. The dummy node 100000000, which is used during ‘ASET/Test Adjacent’ results viewing, is also deleted.


test.db – Stick Model Animation – ASET_aset_test1 – Entity
#1,123
#2,123
#3,123
#13,123
#9,123
#10,123
#11,123
#12,123
Y
Z
X

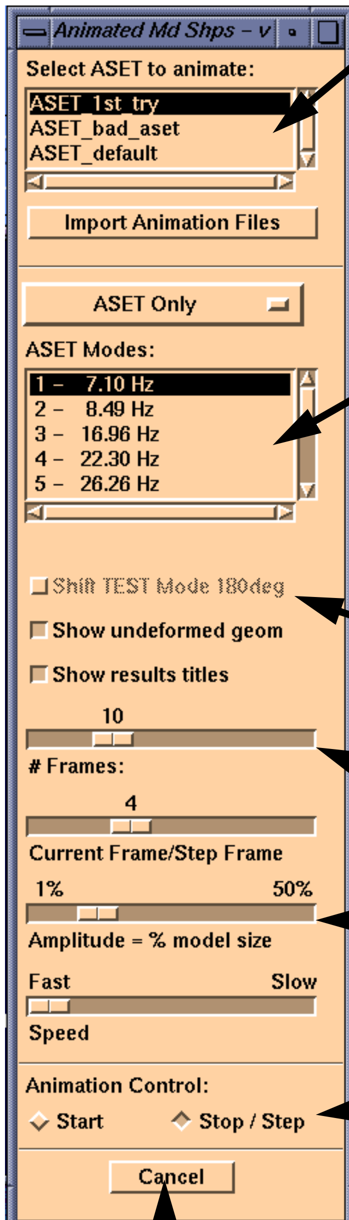
When the user selects the ‘Import Animation Files’ button, TACT performs the following actions:

- If the file, ‘anim.aset’ is found in the selected ASET’s directory, the file is read in. If this file was not found, then the code checks to see if the ‘.f16’ file exists; if this file exists then the code automatically calls the routines in the ‘Export ASET UFF’ form to create the ‘anim.aset’ file.
- If the file, ‘anim.test’ is found in the selected ASET’s directory, the file is read in.
- The ‘.test.mode_pairs’ file is read in if ‘anim.test’ was found.
- The animation widgets are populated as follows:
    - If ‘anim.aset’ was found, then the ASET mode listbox for the ‘ASET Only’ viewing method is populated.
    - If ‘anim.test’ was also found, then the Test mode listbox for the ‘Test Only’ viewing method is populated, and the ASET and Test mode optionmenus and mode pair listboxes for the ‘ASET/Test Adjacent’, ‘ASET/Test Overlay’ and ‘ASET/Test Difference’ viewing methods are populated.
- The animation widgets are enabled. If only ‘anim.aset’ was found, then the only viewing method that is enabled is ‘ASET Only’. If ‘anim.test’ was also found, then all viewing methods are enabled.
- The display in the viewport is changed to animation mode. The undeformed stick model for the selected ASET is displayed in yellow, and the deformed shape for the first ASET mode is shown in purple. Titles are posted to the viewport.

Once the data has been imported, the user is ready to begin animating modal results. The animations are shown in the viewport, and the mouse may be used to rotate/zoom the model during animations. The viewing methods, animation widgets, and viewport displays for the various selections are discussed in the next sections.

4.3.1•Action: ‘ASET Only’

The ‘ASET Only’ viewing method animates the reduced FEM modal results on the stick model for the selected ASET. The form and animation widgets are shown below.



List box showing existing ASETs. Selecting an ASET purges animation data and disables all animation widgets until ‘Import Animation Files’ has been selected.

Action set to ‘ASET Only’. Selection of this action causes the ‘ASET Modes’ listbox to be posted to the form and animation of the current ASET mode continues.

Listbox containing the full list of ASET modes. All modes found in the NASTRAN analysis are shown. Selection of a mode changes which mode is displayed in the viewport.

Toggle (on by default) controlling whether the undeformed geometry is posted to the viewport.

Test mode phase shift toggle is disabled for ‘ASET Only’ viewing.

Toggle (on by default) controlling whether results titles are posted to the viewport.

Controls # of frames used to display a sinusoidal animation.

Current frame slide. This slide is continuously updated during an animation. When animation is stopped, user can move the current frame slide to step through the frames.

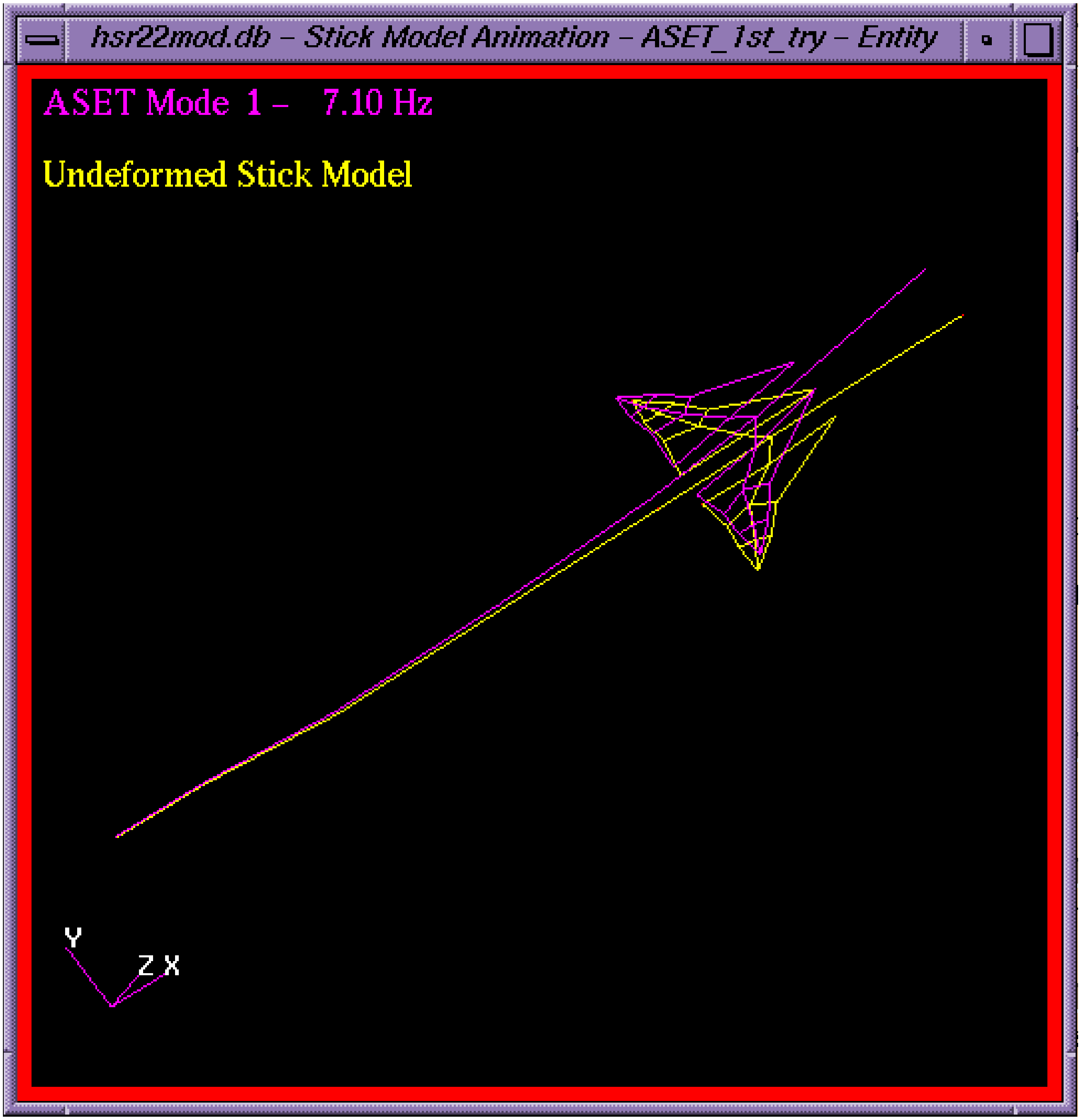
Amplitude slide. By default the mode shape is scaled to have a max value of 10% of the stick model size.

Speed slide, defaults to fast. Moving the slide toward ‘Slow’ adds a delay to each frame. Decreasing the #frames also increases animation speed.

Start/Stop animation switch. When stop is selected, user may step through the frames using the current frame slide.

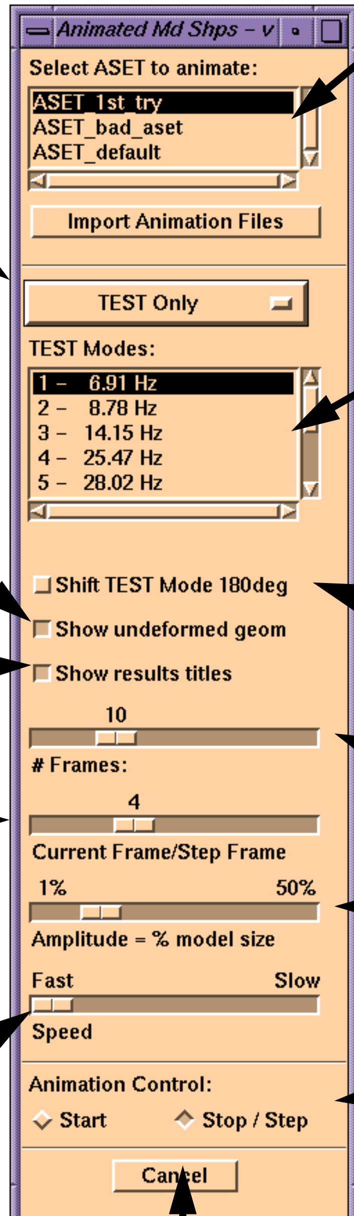
Closes the form. This button is disabled during an animation and enabled when animation is stopped.

A typical viewport display for the ‘ASET Only’ viewing method is shown below.



4.3.2•Action: 'Test Only'

The 'Test Only' viewing method animates the test modal results corresponding to the selected ASET. The form and animation widgets are shown below.



List box showing existing ASETs. Selecting an ASET purges animation data and disables all animation widgets until 'Import Animation Files' has been selected.

Action set to 'Test Only'. Selection of this action causes the 'Test Modes' listbox to be posted to the form and animation of the current test mode continues.

Listbox containing the full list of Test modes. All modes imported from the test are shown. Selection of a mode changes which mode is displayed in the viewport.

Toggle (on by default) controlling whether the undeformed geometry is posted to the viewport.

Toggle (off by default) to apply a 180 degree phase shift to the selected test mode.

Toggle (on by default) controlling whether results titles are posted to the viewport.

Controls # of frames used to display a sinusoidal animation.

Current frame slide. This slide is continuously updated during an animation. When animation is stopped, user can move the current frame slide to step through the frames.

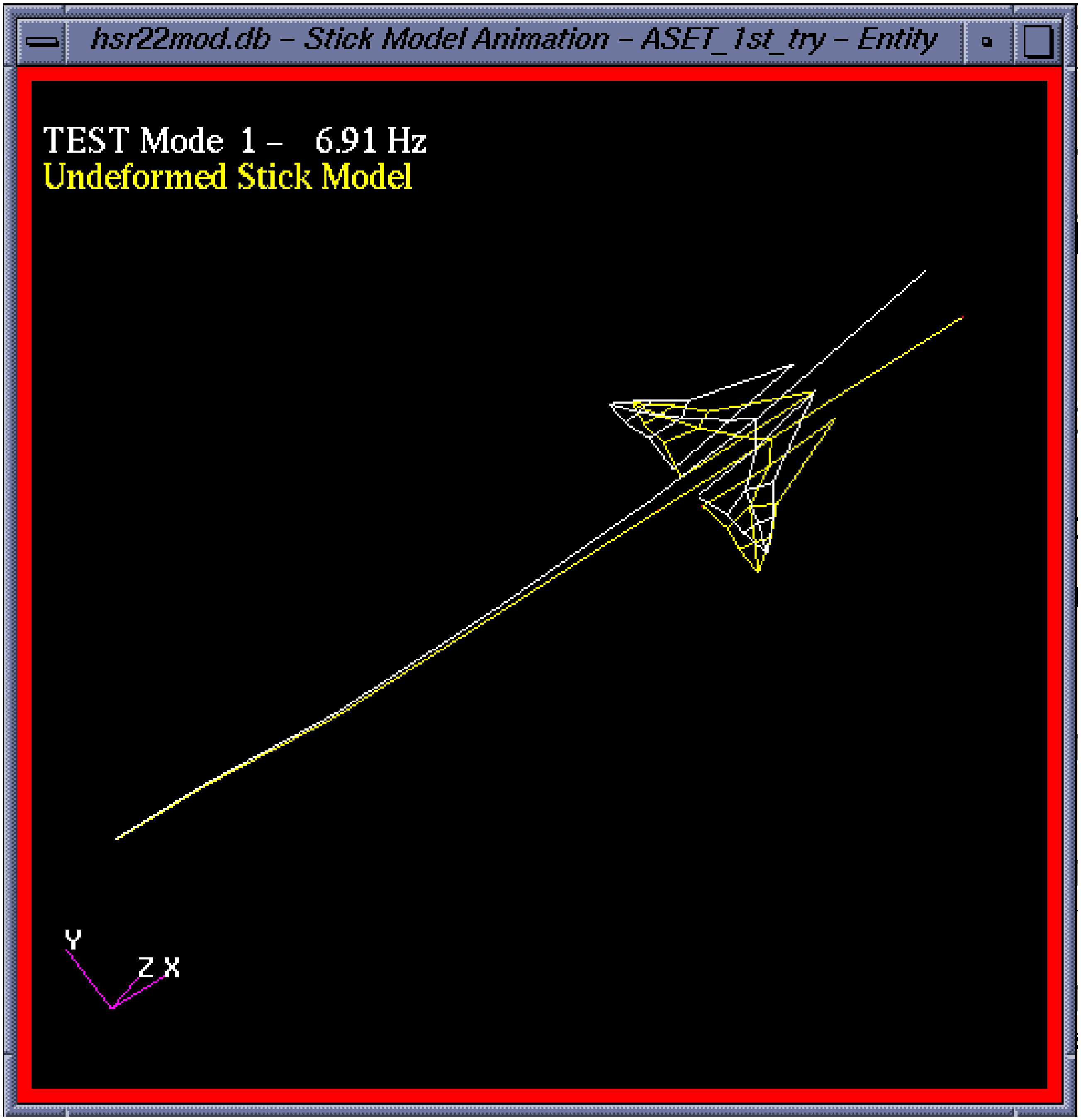
Amplitude slide. By default the mode shape is scaled to have a max value of 10% of the stick model size.

Speed slide, defaults to fast. Moving the slide toward 'Slow' adds a delay to each frame. Decreasing the #frames also increases animation speed.

Start/Stop animation switch. When stop is selected, user may step through the frames using the current frame slide.

Closes the form. This button is disabled during an animation and enabled when animation is stopped.

A typical viewport display for the ‘Test Only’ viewing method is shown below.



4.3.3•Action: ‘ASET/Test Adjacent’

The ‘ASET/Test Adjacent’ viewing method animates the ASET and test modal results as two separate models which are next to each other in the viewport. Animations are synchronized. The form and animation widgets are shown below.

Action set to ‘ASET/Test Adjacent’. Selection of this action causes the mode pair switch to be posted to the form and animation of the current ASET and test modes continue.

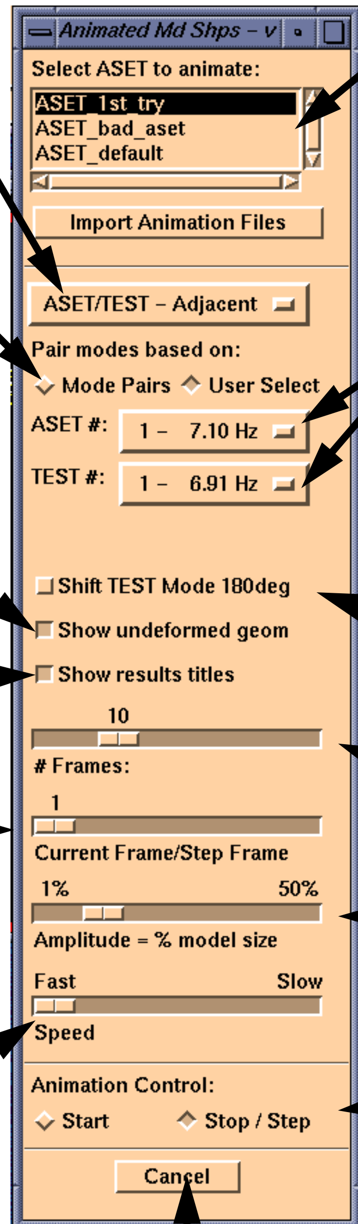
Mode Pair switch. User can either display ASET and test mode combinations to the viewport based on mode pairs or by selecting modes individually. Form changes based on selection.

Toggle (on by default) controlling whether the undeformed geometry is posted to the viewport.

Toggle (on by default) controlling whether results titles are posted to the viewport.

Current frame slide. This slide is continuously updated during an animation. When animation is stopped, user can move the current frame slide to step through the frames.

Speed slide, defaults to fast. Moving the slide toward ‘Slow’ adds a delay to each frame. Decreasing the #frames also increases animation speed.



List box showing existing ASETs. Selecting an ASET purges animation data and disables all animation widgets until ‘Import Animation Files’ has been selected.

ASET and test option-menus which appear when the Mode Pair switch is set to ‘User Select’. Any combination of ASET and test modes can be displayed in the viewport using these controls.

Toggle (off by default) to apply a 180 degree phase shift to the selected test mode.

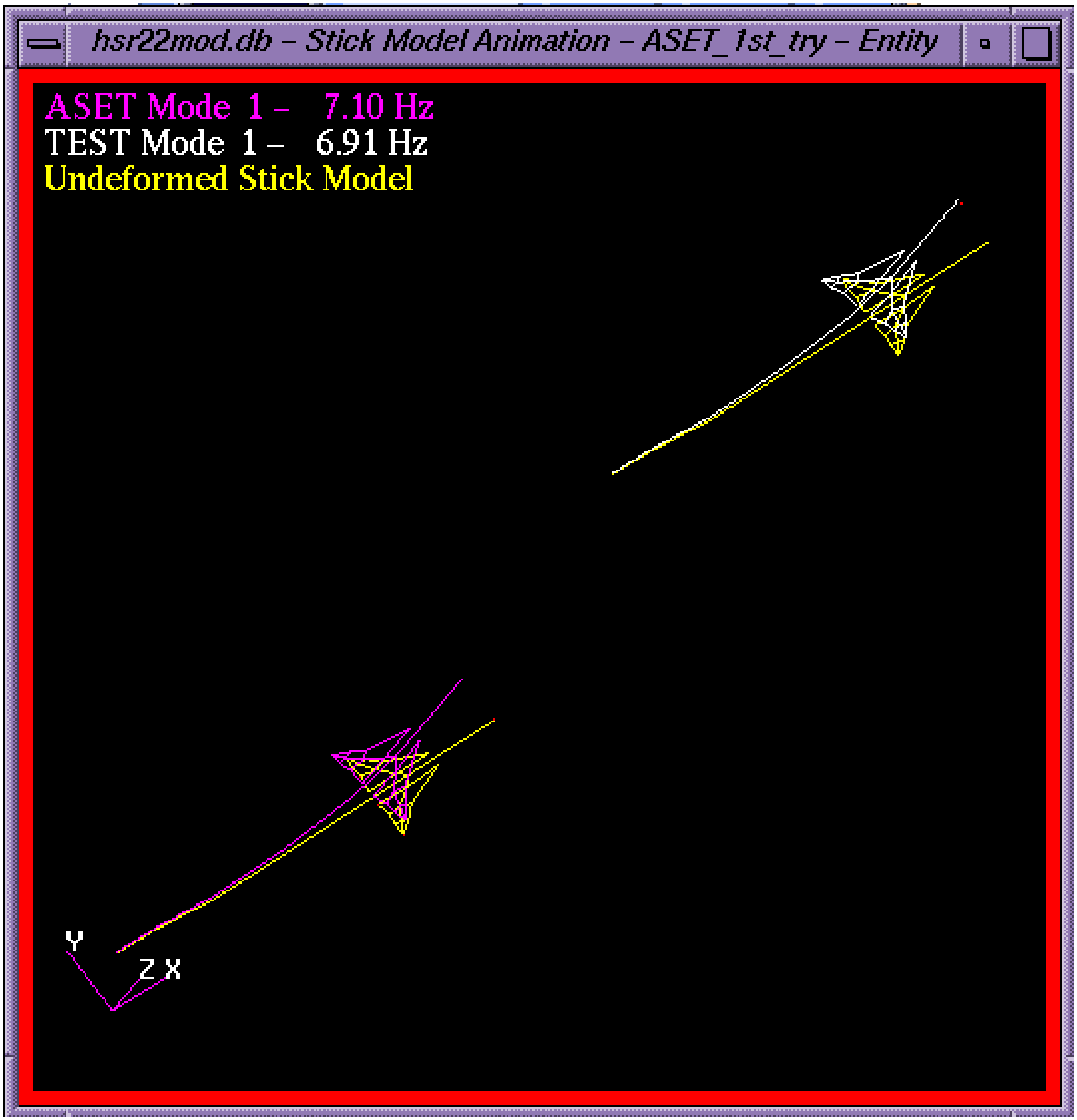
Controls # of frames used to display a sinusoidal animation.

Amplitude slide. By default the mode shape is scaled to have a max value of 10% of the stick model size.

Start/Stop animation switch. When stop is selected, user may step through the frames using the current frame slide.

Closes the form. This button is disabled during an animation and enabled when animation is stopped.

A typical viewport display for the ‘ASET/Test Adjacent’ viewing method is shown below. For this viewing method, TACT creates/deletes Node 100,000,000 as a way of controlling the viewport focus.



4.3.4•Action: ‘ASET/Test Overlay’

The ‘ASET/Test Overlay’ viewing method animates the ASET and test modal results as two separate models which are physically overlaid in the viewport. Animations are synchronized. The form and animation widgets are shown below.

Action set to ‘ASET/Test Overlay’. Selection of this action causes the mode pair switch to be posted to the form and animation of the current ASET and test modes continue.

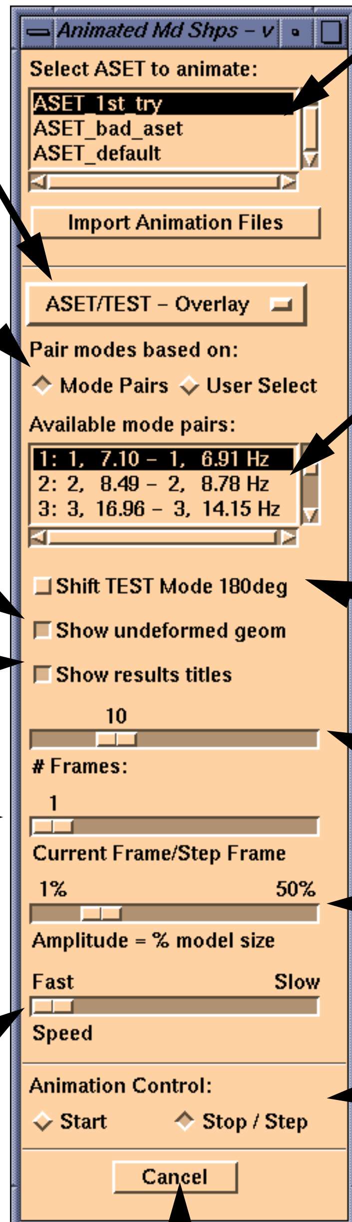
Mode Pair switch. User can either display ASET and test mode combinations to the viewport based on mode pairs or by selecting modes individually. Form changes based on selection.

Toggle (on by default) controlling whether the undeformed geometry is posted to the viewport.

Toggle (on by default) controlling whether results titles are posted to the viewport.

Current frame slide. This slide is continuously updated during an animation. When animation is stopped, user can move the current frame slide to step through the frames.

Speed slide, defaults to fast. Moving the slide toward ‘Slow’ adds a delay to each frame. Decreasing the #frames also increases animation speed.



List box showing existing ASETs. Selecting an ASET purges animation data and disables all animation widgets until ‘Import Animation Files’ has been selected.

Mode pair list box which appears when the Mode Pair switch is set to ‘Mode Pairs’. Any mode pair combination of ASET and test modes can be animated in the viewport using these controls.

Toggle (off by default) to apply a 180 degree phase shift to the selected test mode.

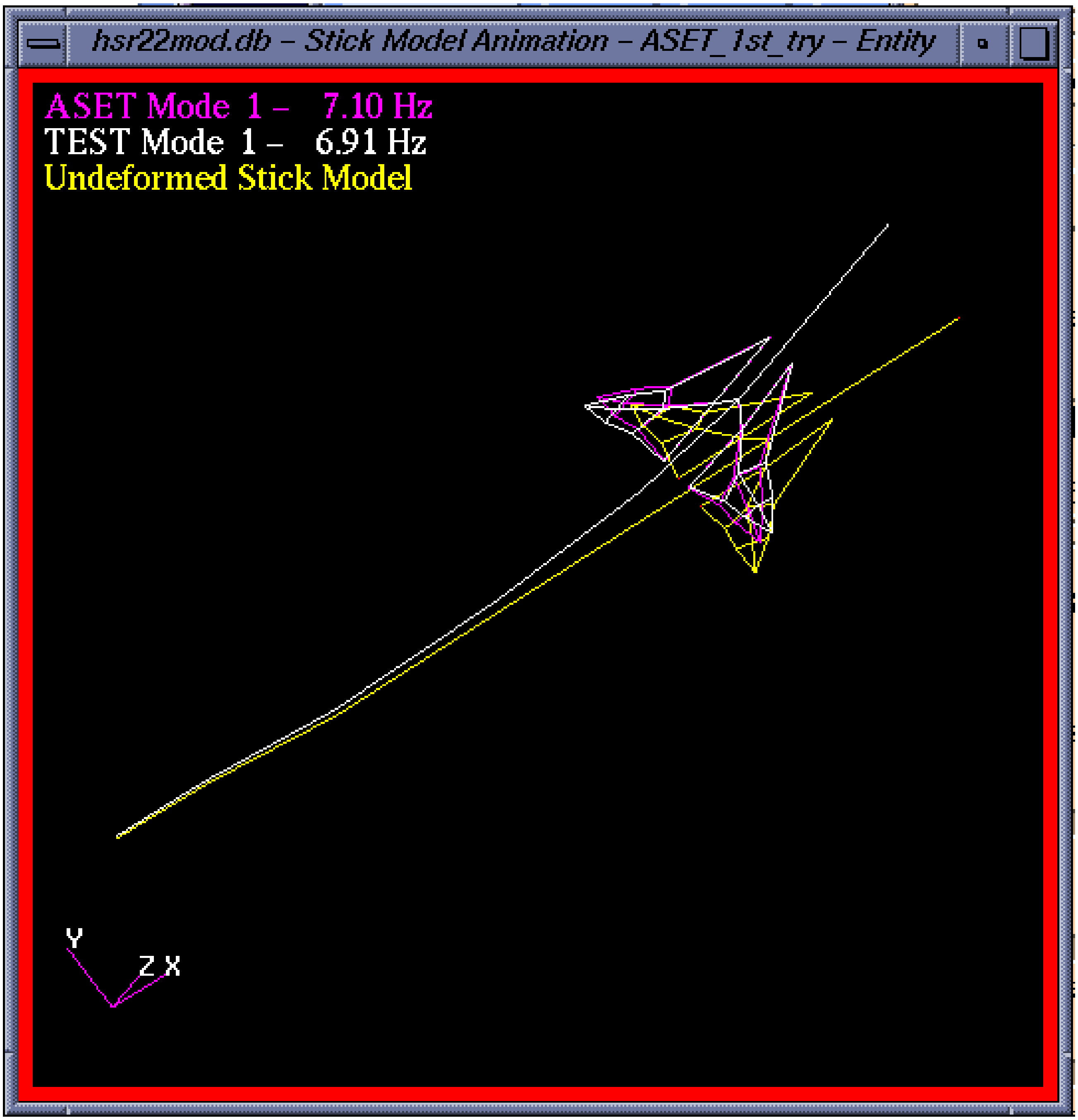
Controls # of frames used to display a sinusoidal animation.

Amplitude slide. By default the mode shape is scaled to have a max value of 10% of the stick model size.

Start/Stop animation switch. When stop is selected, user may step through the frames using the current frame slide.

Closes the form. This button is disabled during an animation and enabled when animation is stopped.

A typical viewport display for the ‘ASET/Test Overlay’ viewing method is shown below.



4.3.5•Action: ‘ASET/Test Difference’

The ‘ASET/Test Difference’ viewing method animates the difference between a selected ASET and test mode. The form and animation widgets are shown below.

Action set to ‘ASET/Test Difference’. Selection of this action causes the mode pair switch to be posted to the form and animation of the difference between the current ASET and test modes continue.

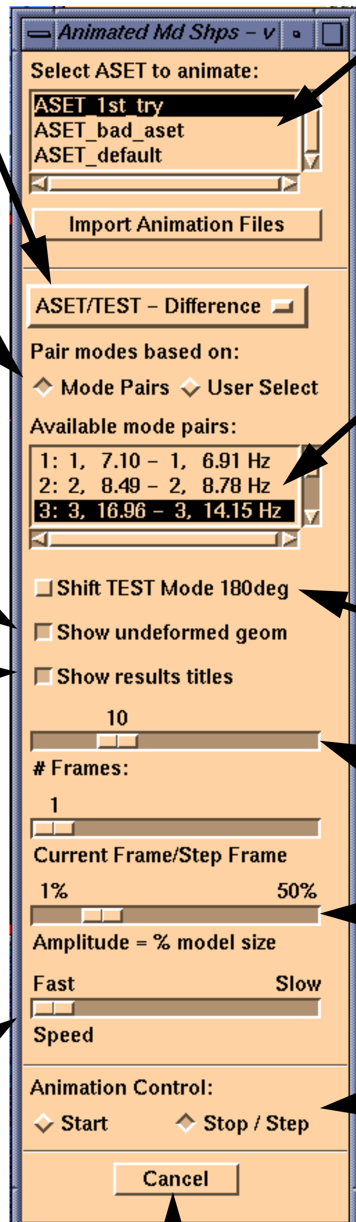
Mode Pair switch. User can either display ASET and test mode combinations to the viewport based on mode pairs or by selecting modes individually. Form changes based on selection.

Toggle (on by default) controlling whether the undeformed geometry is posted to the viewport.

Toggle (on by default) controlling whether results titles are posted to the viewport.

Current frame slide. This slide is continuously updated during an animation. When animation is stopped, user can move the current frame slide to step through the frames.

Speed slide, defaults to fast. Moving the slide toward ‘Slow’ adds a delay to each frame. Decreasing the #frames also increases animation speed.



List box showing existing ASETs. Selecting an ASET purges animation data and disables all animation widgets until ‘Import Animation Files’ has been selected.

Mode pair list box which appears when the Mode Pair switch is set to ‘Mode Pairs’. Any mode pair combination of ASET and test modes can be animated in the viewport using these controls.

Toggle (off by default) to apply a 180 degree phase shift to the selected test mode.

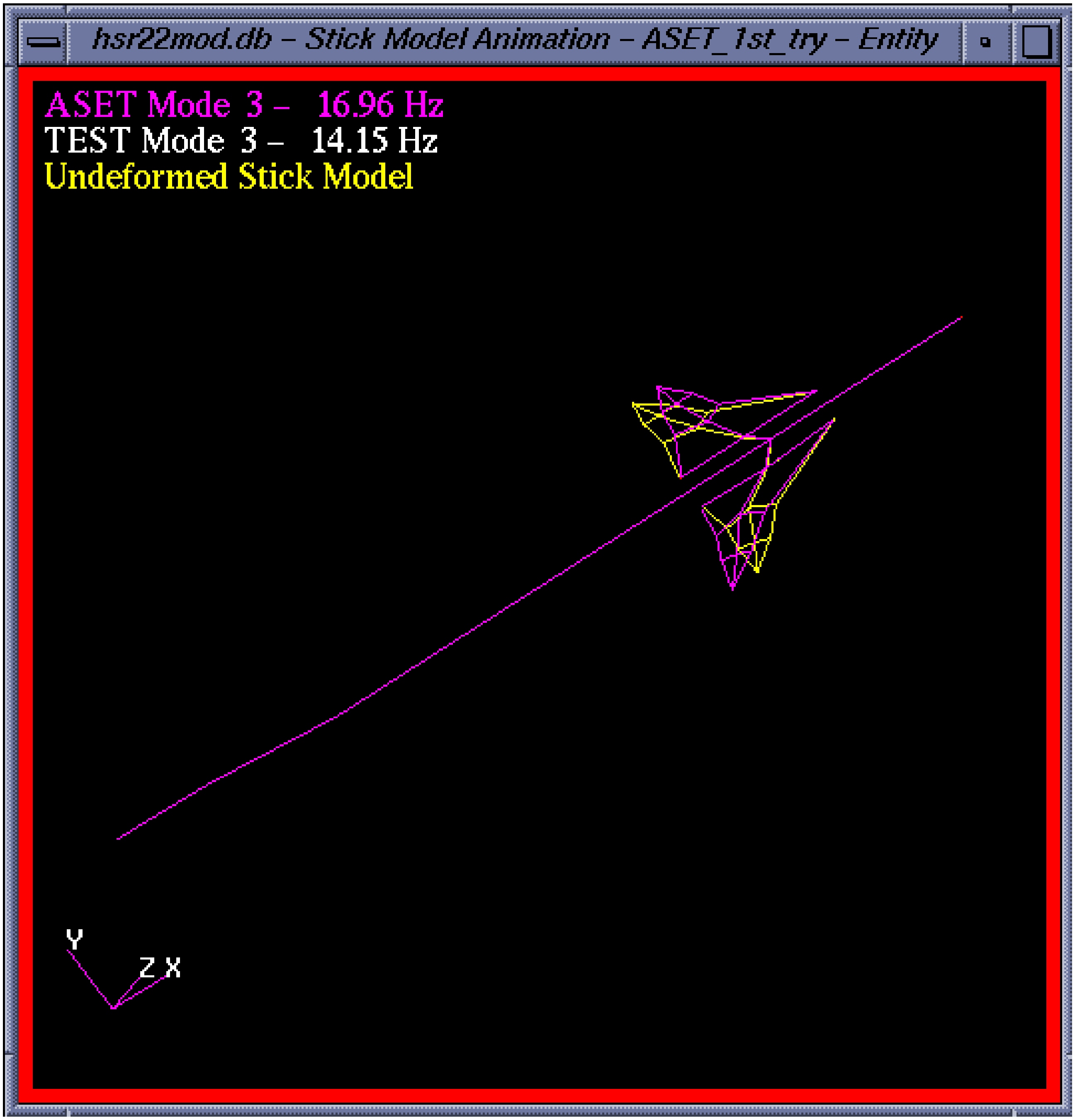
Controls # of frames used to display a sinusoidal animation.

Amplitude slide. By default the mode shape is scaled to have a max value of 10% of the stick model size.

Start/Stop animation switch. When stop is selected, user may step through the frames using the current frame slide.

Closes the form. This button is disabled during an animation and enabled when animation is stopped.

A typical viewport display for the 'ASET/Test Difference' viewing method is shown below.



5•Files

5.1•Directory Structure

There is a tremendous amount of file input/output involved in the normal execution of TACT. To prevent the user from having to input file names and locations continuously throughout execution of TACT, a directory structure and file naming convention are used for organization of TACT files.

TACT assumes that the user has executed PATRAN from within the directory where the PATRAN database that is being used is located. For example, if the PATRAN database ‘test.db’ were located inside the directory ‘test.dir’, TACT requires that the user change directories to ‘test.dir’ before executing PATRAN. PATRAN automatically writes its journal file and any analysis decks created in the ‘Analysis’ form to this directory. TACT then creates subdirectories for each ASET created, and one for the ‘baseline full FEM’ job.

The following example illustrates how these directories are created. Suppose that the user brought up ‘test.db’ from ‘test.dir’, and then went to the PATRAN ‘Analysis’ form and created a NASTRAN deck called ‘test.bdf’. When the user executes the first step in TACT, ‘Run FullFEM Job’, TACT will then create a subdirectory inside ‘test.dir’ called ‘test’. Results from that full FEM analysis will be stored inside that subdirectory. Next, suppose the user created two ASETs, one called ‘ASET_1st_try’ and another called ‘ASET_2nd_try’. When the user first executes any of the steps in TACT that require file output, the directories ‘ASET_1st_try’ and ‘ASET_2nd_try’. All results or TACT files associated with these two ASETs are stored in the corresponding directory.

All of the files that TACT generates and stores in each of these directories will be discussed in the following section in detail.

5.2•Files Generated

The table below identifies the files that are stored in the subdirectory corresponding to the baseline full FEM job.

File Name	Generated by	Description
<*jobname*>.bdf	TACT	Upon execution of 'Run FullFEM Job', the original BDF located at the main directory level is copied into the full FEM directory and modified before NASTRAN execution.
<*jobname*>.f04, .f06, .log, .mon, .tml, .op2	NASTRAN	Output files from NASTRAN which are stored in this directory.
<*jobname*>.f18	NASTRAN	This file contains the DMI cards that contain the full FEM eigenvalues and eigenvectors. If this file is deleted, then the full FEM analysis will have to be rerun before ASETs can be evaluated.

The table below identifies the files that are stored in subdirectories corresponding to ASETs.

File Name	Generated by	Description
<*ASET_name*>.bdf, .bdf_backup	TACT	Upon execution of 'Run FullFEM/ASET Job' or 'Run Test/ASET Job', the original BDF located at the main directory level is copied into the full FEM directory and modified before NASTRAN execution.
<*ASET_name*>.f04, .f06, .log, .mon, .tml, .op2	NASTRAN	Output files from NASTRAN which are stored in this directory.
<*ASET_name*>.f15, .f15_backup	NASTRAN	This file contains the full FEM vs. ASET frequency percent differences and cross-orthogonality matrix in NASTRAN OUTPUT4 format.
<*ASET_name*>.f16, .f16_backup	NASTRAN	This file contains the reduced FEM eigenvalues and eigenvectors in NASTRAN OUTPUT4 format.

File Name	Generated by	Description
<ASET_name>.f17, .f17_backup	NASTRAN	This file contains the Test vs. ASET frequency percent differences and cross-orthogonality matrix in NASTRAN OUTPUT4 format.
<ASET_name> .full.mode_pairs	TACT	This file is created by the 'Mode Pairs & Correlation' form, and contains 4 columns of data which identify mode pairs for the full FEM vs. ASET results.
<ASET_name> .test.mode_pairs	TACT	This file is created by the 'Mode Pairs & Correlation' form, and contains 4 columns of data which identify mode pairs for the Test vs. ASET results.
<ASET_name>.uff	TACT	This file is created by the 'Export ASET UFF' form, and contains reduced FEM model data and modal results in the form of U15, U82, and U55 UFF records.
anim.aset	TACT	This file is created by the 'Export ASET UFF' form (which can also be executed from 'Animated Mode Shapes'), and contains ASET stick model and modal results in a format which is quick for PATRAN to animate.
test.dmi	TACT	This file is created by the 'Import Test UFF' form, and contains the DMI cards that contain the Test eigenvalues and eigenvectors.
anim.test	TACT	This file is created by the 'Import Test UFF' form, and contains Test stick model and modal results in a format which is quick for PATRAN to animate.
TXT_REPORT .aset_map	TACT	Created by the 'Edit Accel #s' subform in 'Create/Modify ASET', this file is a text report of the node#/accelerometer#/DOF for a selected ASET.

File Name	Generated by	Description
TXT_REPORT .full.mpair_list .full.mpair_freq .full.mpair_ochk .full.orig_freq .full.orig_ochk .full.auto_pair	TACT	Created by the ‘Mode Pairs & Correlation Results’ form, these files are text reports of the full FEM vs. ASET results displayed in each of the various actions available on the form.
TXT_REPORT .test.mpair_list .test.mpair_freq .test.mpair_ochk .test.orig_freq .test.orig_ochk .test.auto_pair	TACT	Created by the ‘Mode Pairs & Correlation Results’ form, these files are text reports of the Test vs. ASET results displayed in each of the various actions available on the form.

Additionally, all TACTevents that modify/create/delete geometry, groups or field are recorded to the session file. TACT events that create NASTRAN files, results files or initiate NASTRAN runs are not recorded and will need to be re-executed by the user.

6•Troubleshooting

This chapter documents the list of known errors or unusual messages in PATRAN that are issued due to TACT.

6.1•Anomalies

The table below documents various messages and behaviors in PATRAN which occur as a result of using TACT which may confuse the user. These are not errors or 'bugs'.

1	**The message below repeatedly appears in the history window:** ***$# 1 FEM entity does not exist or is still associated and cannot be deleted: Node 100000000*** **Solution:** TACT uses Node 100,000,000 to control viewport focus during mode shape animation. The FEM should not contain this node number, since TACT needs to have the ability to create and delete this node.
2	**Automatic submission of NASTRAN jobs inside TACT does not work.** **Solution:** TACT automatically submits NASTRAN jobs using MSC's Analysis Manger by default. If Analysis Manager is not correctly installed and the default is left on, the PCL will have errors. Users not able or not wishing to use Analysis Manager should make sure that the "Submit Job Now" toggle is deselected on the forms that submit NASTRAN jobs. The prepared NASTRAN deck can then be submitted separately by the user and results can be imported with no further adjustments.

3	**When I enter my PATRAN database after using TACT, my FEM is not in the viewport.** **Solution:** If you exited the PATRAN database without closing the 'Animated Mode Shapes' TACT form, then the "Stick Model Animation" viewport was still visible. When you re-enter the PATRAN database, this viewport (with only the undeformed stick model visible) will be posted on top of the default viewport. The user can either delete the "Stick Model Animation" viewport using the Viewport selections in PATRAN, or bring up any TACT form and close it; this will remove that viewport and the posted groups of the FEM should be visible in the default viewport which will then be visible.
4	**Whenever I try to do anything where TACT needs to do file input/output, I get all sorts of error messages from PATRAN and TACT.** **Solution:** If you were not in the same directory as the PATRAN database that you are working in when you entered PATRAN, TACT will give all kinds of errors. You can review Chapter 5 to get a detailed description of the directory structure and files created. For TACT to behave correctly, the user must enter PATRAN from the directory where the database is located.
5	**When I bring up 'Animated Mode Shapes' after importing test results, the test stick model does not seem to be aligned with the ASET stick model.** **Solution:** TACT imports test results that are in different units and/or a different coordinate system than the FEM by performing a transformation on the test results in the 'Import Test UFF' function. TACT performs this transformation by assuming that accelerometer locations and NASTRAN GRID locations are ***exactly*** the same. This assumption is especially important for the first two accelerometer/node pairs in the node#/accelerometer# mapping contianed in the FEM field. If there are large discrepancies between the locations, the program may display misleading results. Since it is good engineering practice to make the locations the same (particularly when the modal survey is conducted for the purpose of correlating the FEA), this will not be a common problem. A work-around is to remove the nodes with descrepancies with accelerometer locations from the ASET, renumber them to be the highest node numbers in the FEM, and add them back to the ASET.

6	**When I submit a NASTRAN jobs, no punch file (.f18) or OP4 (.fXX) files are generated.** **Solution:** Check to make sure that the version of NASTRAN installed on your system is greater than or equal to version 68.2. TACT uses string based alter entries in NASTRAN, and these were introduced in v68.2. To work around, the user must determine the line number corresponding to the first 'CALL SUPER3' entry in the SEMODES DMAP for the version of NASTRAN being used. The user can manually modify the DMAP ALTER statement produced by TACT to use these line numbers instead of the string based Alter statement. After executing NASTRAN, the results files should be produced normally and no further modification to the TACT execution is required.
7	**I get a TACT error message while reading in results in the Correlation Calculator.** **Solution:** The only known anomaly here is that you can not choose all the translational DOF that would remain in the G-set to be in your accelerometer set. This would cause a perfect correlation, which produces 0% frequency difference. Null values are not written in NASTRAN OUTPUT4 files. Since the possiblity of exactly null values occurring is extremely low for a real application, this scenario is not addressed by TACT. The user should eliminate at least one node from the accelerometer set and rerun. This should produce values just slightly above zero.
8	**When I do an 'undo' in PATRAN, all TACT actions are reversed.** **Solution:** In many cases, PATRAN treats all events occurring within a PCL routine as a single event. Don't use PATRAN's undo button to reverse a single TACT action. An undo button within TACT is provided on many of the forms where the action is most often required.

9	**When I replay a session file, my NASTRAN decks and results are not recreated.** **Solution:** Only TACT events that create/modify/delete curves, groups or fields are recorded to the session file. This was done because including the commands that write the NASTRAN decks in the session file caused the normal run time of TACT to increase by a factor of 10. Replaying a session file will properly recreate all ASETs if the user first makes sure that the subject ASET groups and fields do not exist in the database prior to the session file replay. Once the session file has finished, the user can then go back into the 'Run XXX Job' modules in TACT to recreate results.

6.2•Error List

In PATRAN version 8.0, it appears that some PCL routines used in TACT are no longer supported by MSC or have been modified. For one user on one database, this has caused spontaneous deletion of ASET information. Unfortunately, the error is not reproducable. If you experience similar problems, please record the sequence of moves that cause the error and contact the developer so the problem can be addressed!

7•Future Enhancements

During beta testing of the initial release of TACT, users have asked for additional features to be included in the next major release of the code. These enhancements include:

- Inclusion of Modal Assurance Criteria (MAC), and Coordinate Modal Assurance Criteria (CoMAC) calculations.
- The equivalent of a 3D bar chart format to visualize cross-orthogonality matrix results.
- The ability to view the original cross-orthogonality matrix and define mode pairs at the same time.
- An ‘Undo’ button on the ‘Delete ASET’ and ‘Modify ASET’ forms.
- User defined color schemes for all viewport markers/displays.
- The ability to alternate accelerometer marker display in the viewport between DOF and accelerometer numbers.
- Incorporating an optimization and/or design sensitivity solution to assist the analyst with model updating during correlation. This analysis would use minimizing frequency deltas or maximizing diagonal terms of the cross-orthogonality matrix as the objective function and user selected parameters in the FEM as design variables.

8•Acknowledgments

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