MEscope Application Note 48

Setting Up a 3D Model for Frequency-Based ODS Animation

The steps in this Application Note can be carried out using any MEscope package. These steps might also require MEscope software with *a more recent release date*.

APP NOTE 48 PROJECT FILE

- To retrieve the Project for this App Note, **click here** to download **AppNote48.zip**
- Open **AppNote48** project file

This Project contains *numbered Hotkeys & Scripts* for carrying out the steps of this App Note.

- When a **Hotkey is** *pressed*, a Script referenced by the **Hotkey** is executed
- To display a Script, *hold down* **the Ctrl key** and *click* **on a Hotkey** to open its Script window

INTRODUCTION

In this App Note, a 3D model of a flat plate is built and frequency-based **ODS's** are displayed in animation on the model from the Line cursor position in a set of **FRFs**. The following steps are carried out;

1. **Create** a 3D model of the test article
2. **Number** the test Points on the model
3. **Orient the Local Axes** at each test Point to coincide with the measurement directions
4. **Import** the **FRFs** calculated from data acquired from the test article
5. **Create M# Links** to link each **FRF** measurement (**M#**) to a point & direction (**DOF**) on the model from which data was acquired
6. **Display ODS's** in animation on the 3D model **from the cursor position** in the **FRFs**
7. **Position** the cursor at a **resonance peak** in the **FRFs** to display **an approximation of the mode shape** for that resonance
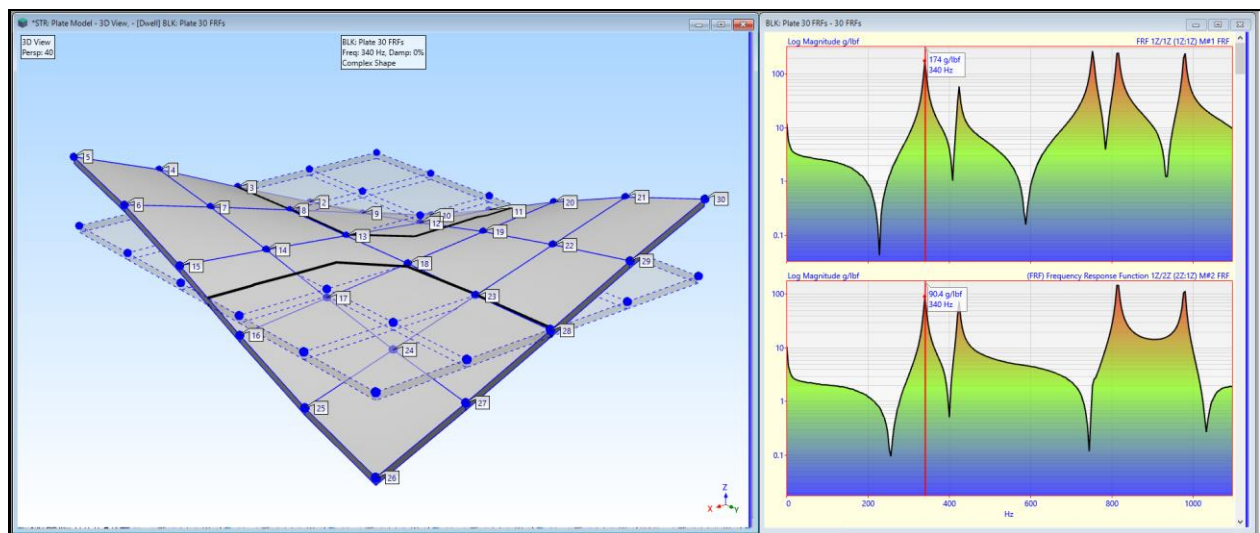
Animating an ODS at a Resonance Peak.

STEP 1 - CREATING THE 3D MODEL

All work is done in MEscope using data files that belong to a **single Project file**.

Only one Project file can be open at a time in MEscope, but a Project can contain multiple data files.

- *Press* **Hotkey 1 Create a 3D Model**

When **Hotkey 1 is** *pressed*, a Structure (**STR**) window will open in MEscope with the completed 3D model in it.

- To skip over re-drawing**,** *press* **No** in the dialog box that opens
- To re-draw the 3D model**,** *press* **Yes** in the dialog box
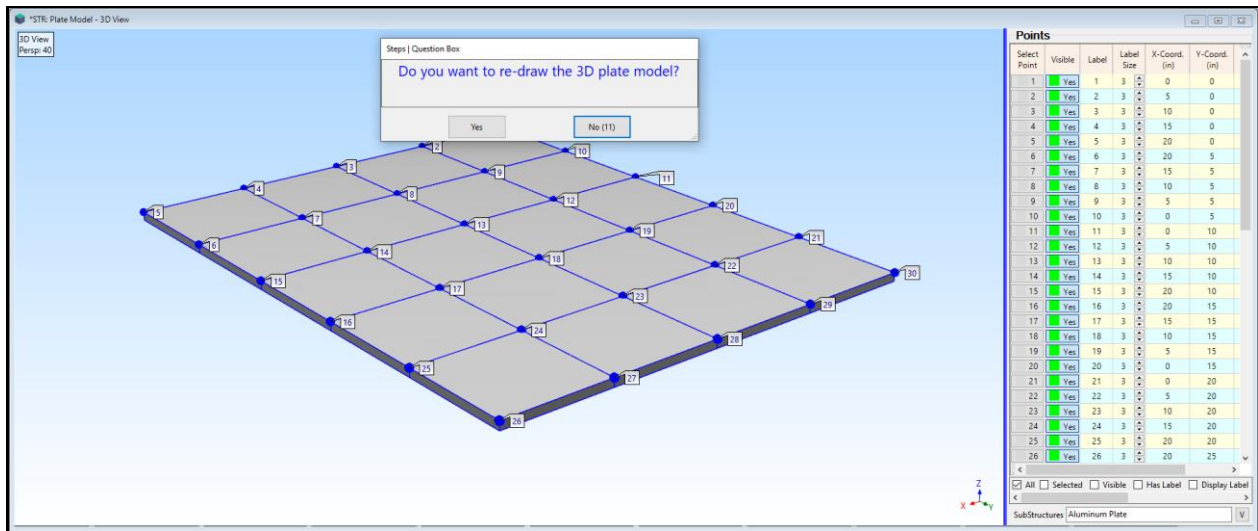
Structure Window Showing a Completed 3D Plate Model.

DRAWING A 3D MODEL WITH THE DRAWING ASSISTANT

Most structure models are more easily built in MEscope by using the **Drawing Assistant.** When the Drawing Assistant is enabled, special tabs are displayed on the ***upper right side*** of the Structure window, and the **Substructure** Objects spreadsheet is displayed below the **Substructure** tab.
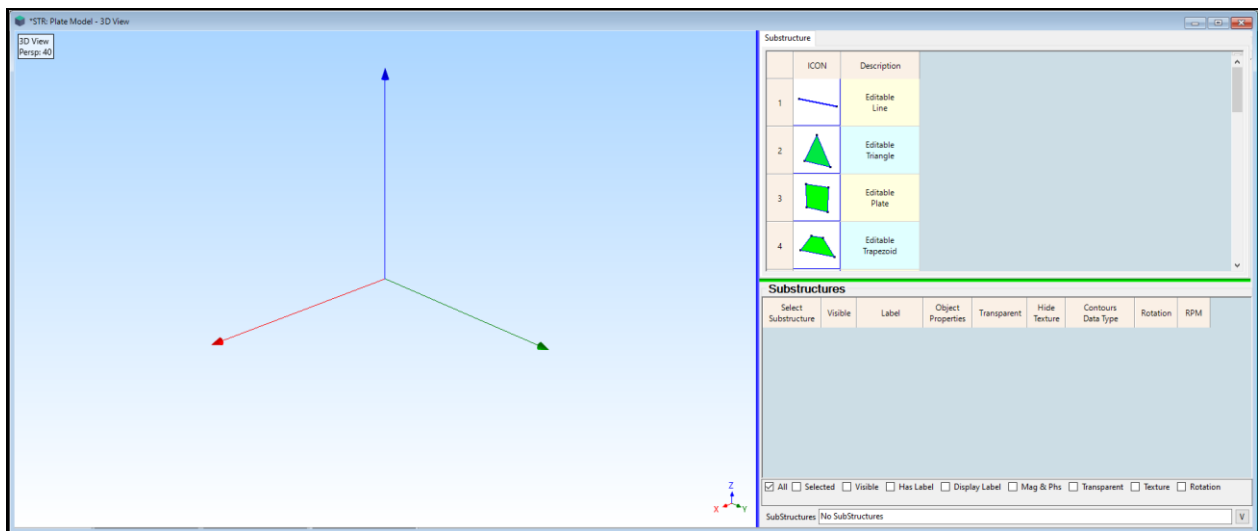
Structure Window Ready to Draw the Model Using the Drawing Assistant.

LENGTH UNITS

To display data on a 3D model of the test article, it is only necessary to create a structure model that **looks like the test article**.

A model with **correct length units** is only required when using the **SDM and FEA** commands.

Length units for the structure model are chosen in the **File | MEscope Options** box,

- Execute **File | MEscope Options** in the MEscope window to open the **MEscope Options** dialog box.
- On the **Units** tab, choose the desired **Length** units, and *click* on **OK**

USING THE DRAWING ASSISTANT

The **Drawing Assistant** tabs are displayed by executing **Draw | Drawing Assistant** in any Structure (**STR**) window as shown above.

A 3D plate model will be built by modifying one of the **editable Substructures** selected from the **Substructure** pallet.

- On the **Substructure** tab, scroll the browser to display the **Editable Plate** Substructure, and *double click* on it

A vertical plate Substructure will be displayed in the graphics area of the Structure window, and the **Editable Plate** will be added to the **Substructures** spreadsheet below the tabs. This Substructure **will be edited** so that it becomes a **horizontal rectangular grid of 30 Points** spaced **10 length units** apart, with **5 points** in the **Global X** direction and **6 points** in the **Global Y** direction.

- On the **Dimensions** tab, enter
- **Width ➔ 25 ,** and **Points ➔ 6**
- **Height ➔ 20,** and **Points ➔ 5**
- **Length ➔ 0.5, and Points ➔ 2**, as shown below
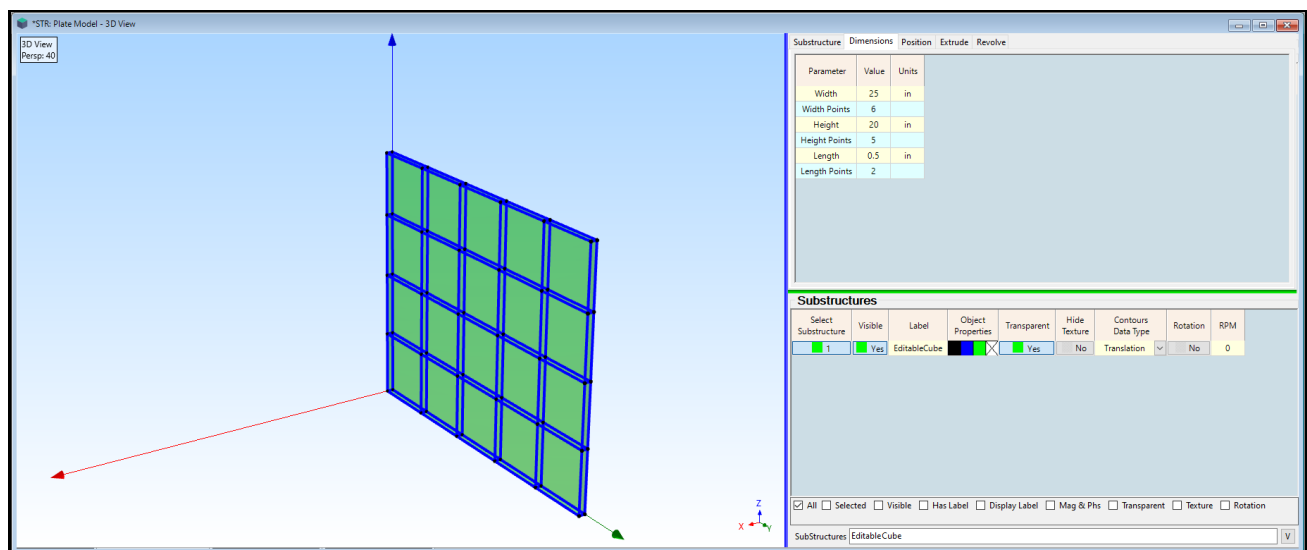
Vertical Plate as a 6 by 5 Grid of Points.

Next, the plate **will be rotated** from its vertical position to a horizontal position in two increments of **45 degrees** each.

- On the **Position** tab, enter **Degrees ➔ 45** into the box
- In the **Rotate** area, choose **Global** coordinates and *press* **the Y up arrow** *twice*
- On the **Substructures** spreadsheet, change the Substructure Label to **3D Plate**
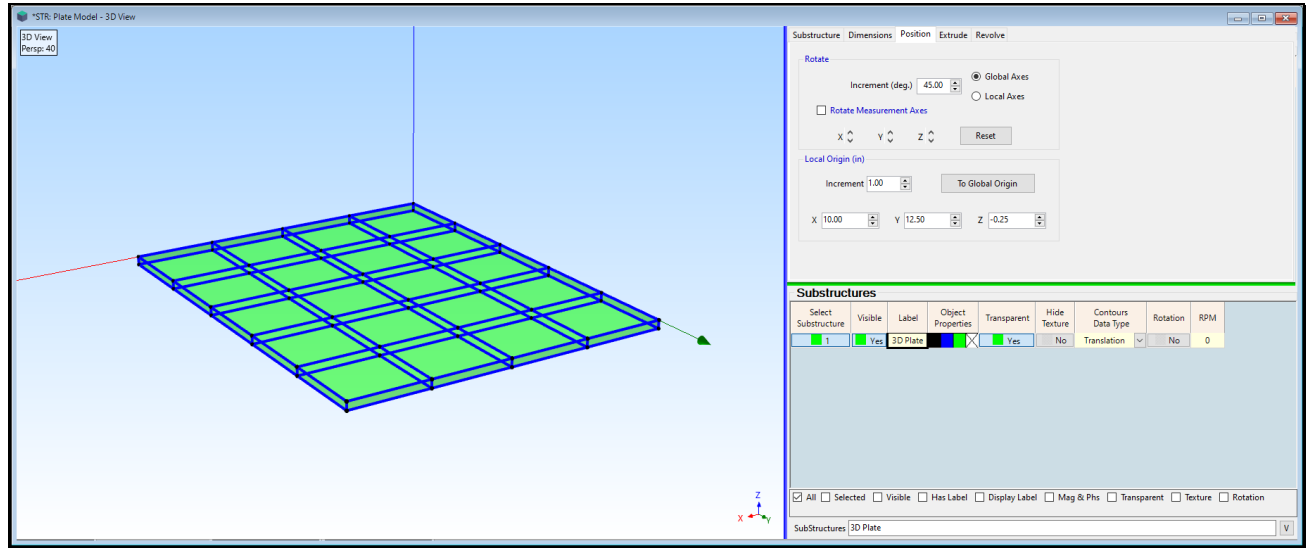
Completed 3D Plate Model.

STEP 2 - NUMBERING THE TEST POINTS

Numbering the test points on a 3D model of the test article **is the most important step** in all ODS or modal testing.

Numbering the points creates a record of where data was acquired so that each measurement function (like an FRF) that is calculated from the acquired data can be linked to the correct Point & direction on the model.

- *Press* **Hotkey 2 Number the Points**

When **Hotkey 2 is** *pressed*, the Structure (**STR**) window will open with the Points already numbered.

- To skip over Point numbering**,** *press* **No** in the dialog box that opens
- To re-number the test Points**,** *press* **Yes** in the dialog box

POINT LABELS

When **Yes is** *pressed*, the **Draw | Points | Number Points** dialog box will open, as shown below. Point numbering is done interactively with the floating Number the Points dialog box open, a shown below.

- *Press* the **Clear All** button to clear the current Point Labels

The Point number for each Point is saved in the **Point Label** for that Point.

The **Point Label** can contain any text to describe a Point, but **if the Point Label contains a number**, that number is used to create **M# Links** that link measurements (**M#s)** in a Data Block or Shape Table to Points & direction on the 3D model.
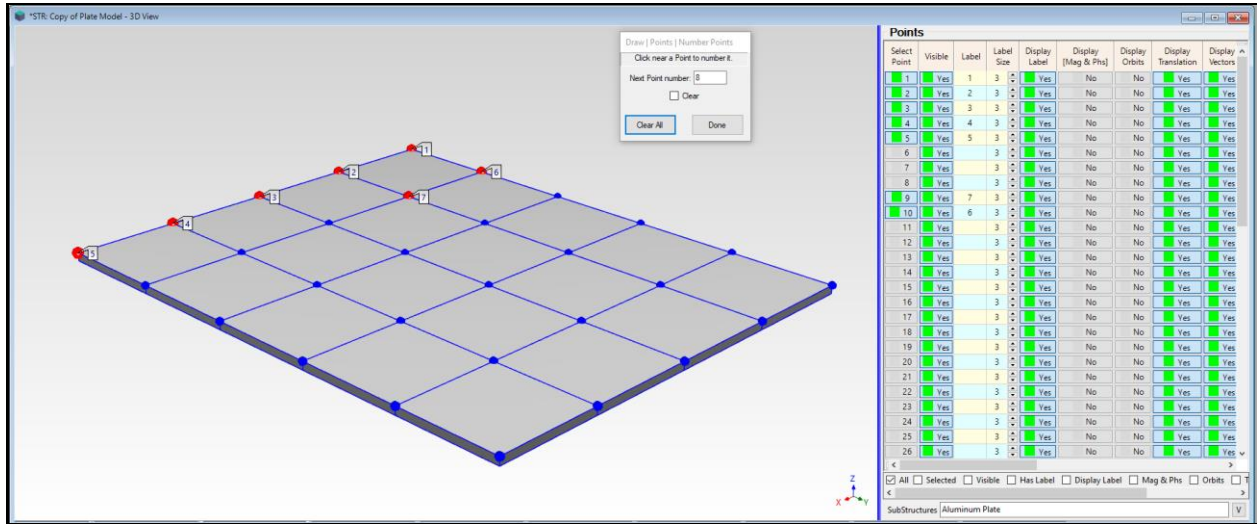
Numbering the Test Points.

Only Test Points should be numbered to create **M# Links** between measurements (**M#s**) and each Test Point & direction on the 3D model.

The Test Points should be numbered in the sequence shown in the figure above.

- When all 30 Points have been numbered, *press* the **Done** button

STEP 3 - IMPORTING THE FRFS

Test data can either be imported from a third party disk file, or acquired directly from supported front-end acquisition hardware using an (optional) Acquisition window.

- **Press Hotkey 3 Import FRFs**

When **Hotkey 3 is** *pressed*, a Data Block (**BLK**) window will open with 30 FRFs in it.
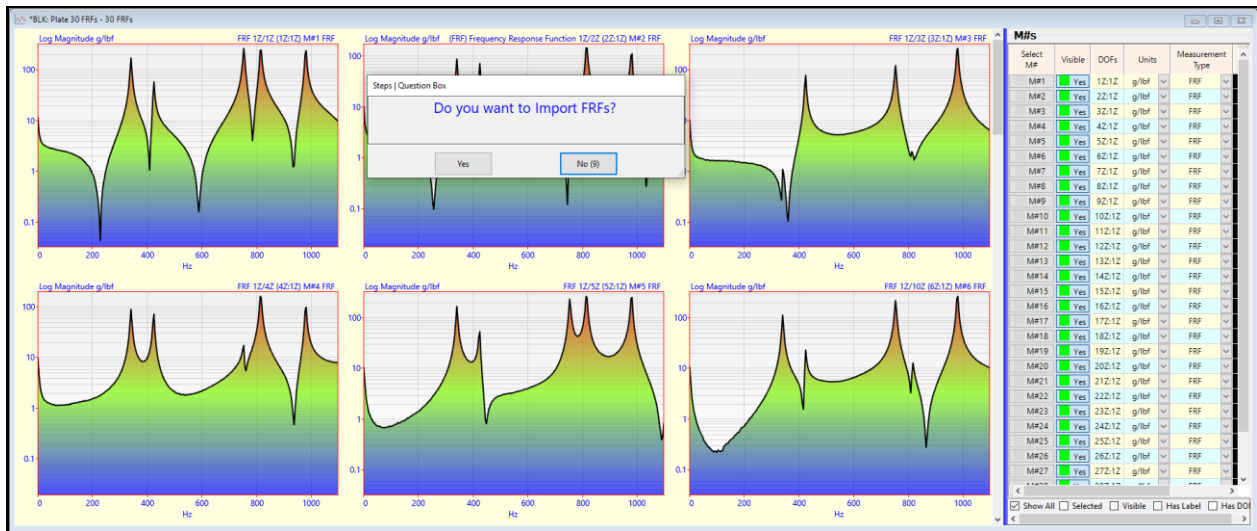

Data Block with 30 FRFs Calculated from Impact Test of an Aluminum Plate.

Save Plate 30 FRFs.UFF on your desktop so it can be imported from there.

To display the ODS's of the flat plate in animation, a set of **FRFs** for a **real aluminum plate** will be imported into a Data Block from a **Universal File format (UFF)** file called **Plate 30 FRFs.UFF**. These **FRFs** were calculated from **force & acceleration** data acquired during a **roving impact test** on the aluminum plate.

- To skip over Importing the FRFs again, *press* **No** in the dialog box that opens
- To import the FRFs, *press* **Yes** in the dialog box

The **BLK: Copy of Plate 30 FRFs** window will open showing the imported **FRFs**.
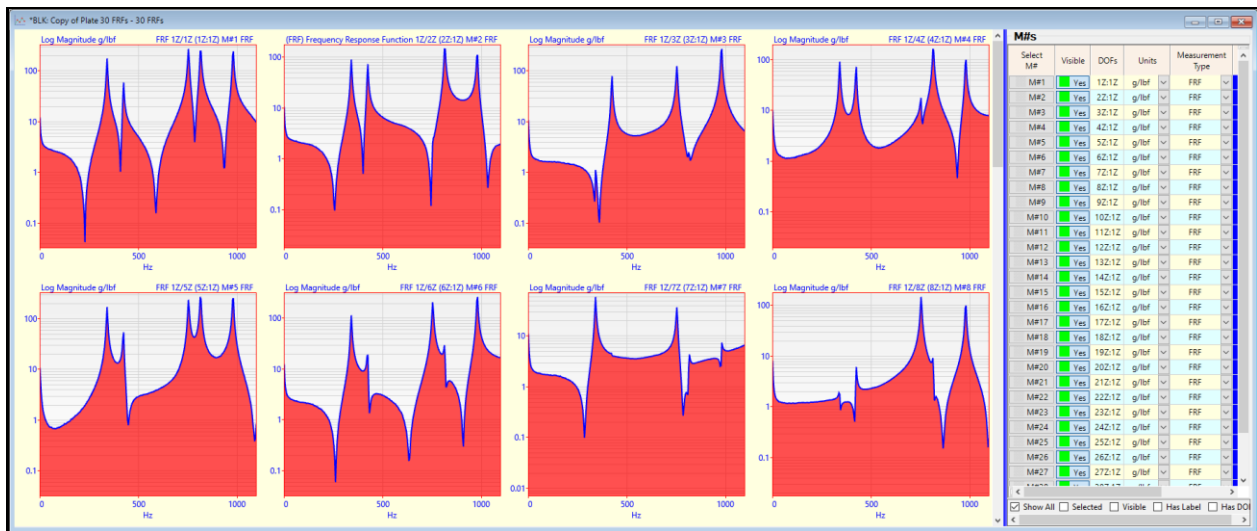
*Data Block Showing Log Magnitudes of 30 FRFs Imported from **Plate 30 FRFs.UFF** on the Desktop..*

- Use the **vertical scroll bar** to the *right of the graphics* area to *scroll* through the FRF measurements

DOFS FROM A ROVING IMPACT TEST

Each **FRF** in the **BLK: Plate 30 FRFs** window is a **cross-channel measurement** between a pair of **DOFs** on the real plate structure. Each FRF was measured by impacting the plate with a hammer at a different point in the Z (vertical) direction. The vibration response was measured with an accelerometer **fixed at point 1 in the Z direction**.

FRF DOFS

- The accelerometer was fixed at **Point 1** throughout the test and measured in the **Z-direction**, so **DOF 1Z** is the **Reference DOF** which **follows the colon (:) in the DOFs of each FRF**

- The plate was impacted at a different Point in the Z-direction, so each FRF has a **Roving DOF in front of the colon (:) in the DOFs of each FRF**

All **cross-channel** measurements (like **FRFs**) use the following DOF format,

Cross Channel DOFs ➜ Roving DOF : Reference DOF

In the DOFs of a cross channel measurement function, the **Roving DOF** *always precedes* the colon **(:)** and the **Reference DOF** *always follows* the colon **(:)**.

Only *cross-channel* measurement functions have both a Roving and a Reference DOF.

All other types of measurement functions have only a Roving DOF.

SINGLE REFERENCE TEST

Since there is **only one reference DOF** in the DOFs of all of the FRFs from this test, it is called a **Single Reference test**.

ENGINEERING UNITS

In the **M#s** spreadsheet, all of the **FRFs** have the same engineering units (**g/lbf**). These units indicate that the **response (or output in the numerator)** was measured with an accelerometer, in (**g**) units, and the **excitation force (or input in the denominator)** was measured with a force gauge or load cell, in (**lbf**)units.

CHANGING UNITS

Engineering units can be changed from English to Metric units and the data will be re-scaled to reflect the change of units. Also, the response units can be changed from acceleration to velocity or displacement, As an example, to change the FRF units from **g/lbf** to **(mm/s)/N**,

- *Double click* on the **Units column heading** in the **M#s** spreadsheet
- Type **"(mm/s)/N"** into the dialog box that opens, as shown below, and click on **OK**

Because the response units where changed **from acceleration to velocity units**, the FRFs were also **integrated once from acceleration to velocity units**.

Notice that integration caused the **higher frequency resonance peaks** in the FRFs to become **less than the lower frequency peaks**.
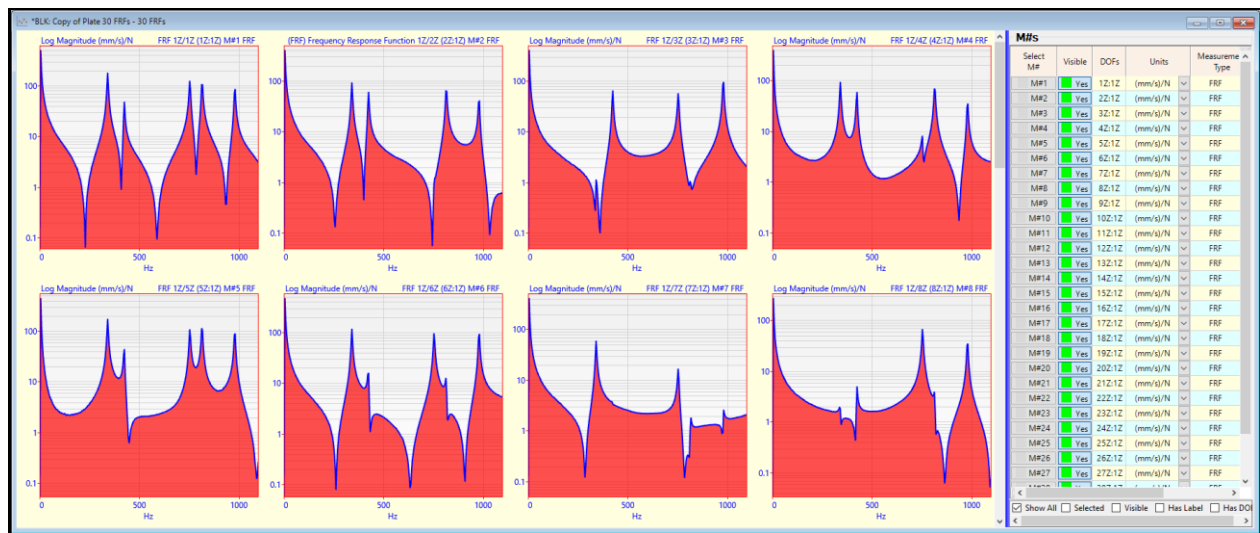
FRFs in (mm/s)/N Units

- Execute **Edit | Edit Undo** to recover the **FRFs** in **g/lbf** units.

STEP 4 - ORIENTING THE TEST POINT AXES

Each Point on a 3D model has three orthogonal measurement axes.

The three measurement axes associated with each Test Point should be oriented to coincide with the axes of measurement at that Point.

During a test, sensors can be mounted in the most convenient directions at each Test Point.

During animated display of ODS or mode shape data each Point will be deflected in the correct direction of measurement.

- *Press* **Hotkey 4 Orient the Test Point Axes**

When **Hotkey 4 is** *pressed*, a Structure (**STR**) window will open with the measurement axes display at each Test Point.

The **Measurement Axes** tab and **Links Editor** tab are also displayed on the right side of the window. The Measurement Axes tab contains controls for rotating and labeling the axes at each Point.

The Points on the **bottom side** of the 3D plate model **are hidden** , so their Measurement Axes are not displayed.
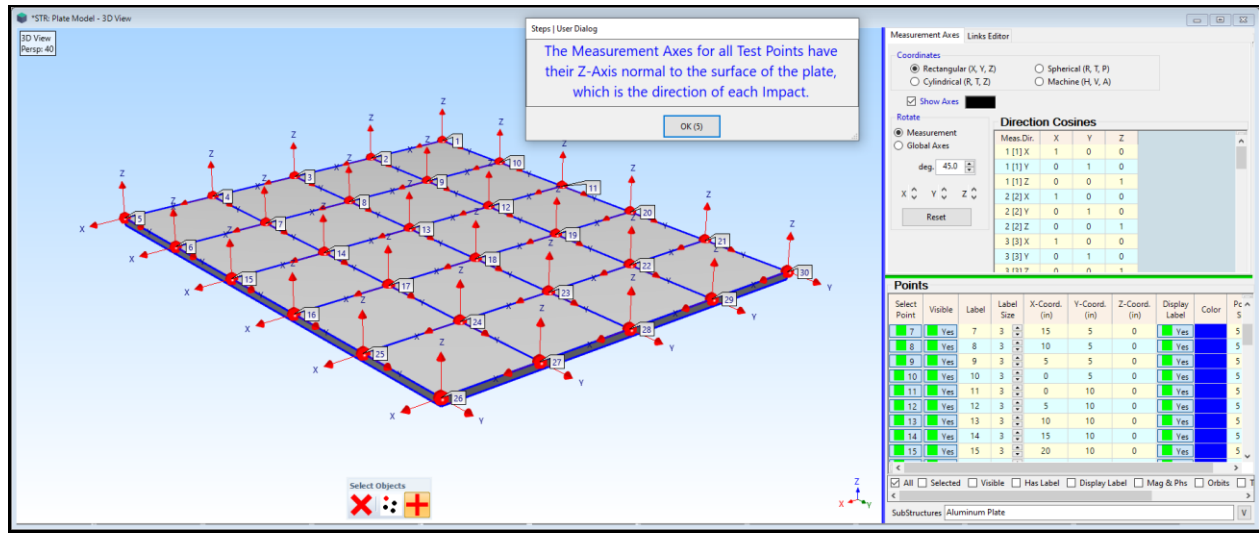
3D Model Showing Measurement Axes Oriented Properly

Measurement Axes are displayed for selected Points.

- *Double click* on the **Select Point column** heading in the **Points** spreadsheet to un-select all Points
- *Click* **near a Point** to display its Measurement Axes

All the Measurement Axes are properly oriented with the Z-direction perpendicular to the surface, which is how the surface was impacted with the impact hammer.

> In a Roving Impact Test, the direction of impact at each Point is the direction of deflection of an ODS or mode shape at t-

STEP 5 - CREATING M# LINKS

- *Press* **Hotkey 5 Create M# Links**

When **Hotkey 5 is** *pressed*, a Structure (**STR**) window will open with the measurement axes display at each Test Point, and the **Links Editor** tab displayed *on the right*.

Measured M# Links have been created to link the 30 **M#s** in **BLK: Plate 30 FRFs** to the numbered Points on the top of the 3D model. **Interpolated M# Links** were created for the hidden Points on the bottom of the 3D model. Each Interpolated Link uses the **Measured M# Link** of the Point geometrically closest to its Point, which is the Point **directly above each un-labeled Point**.
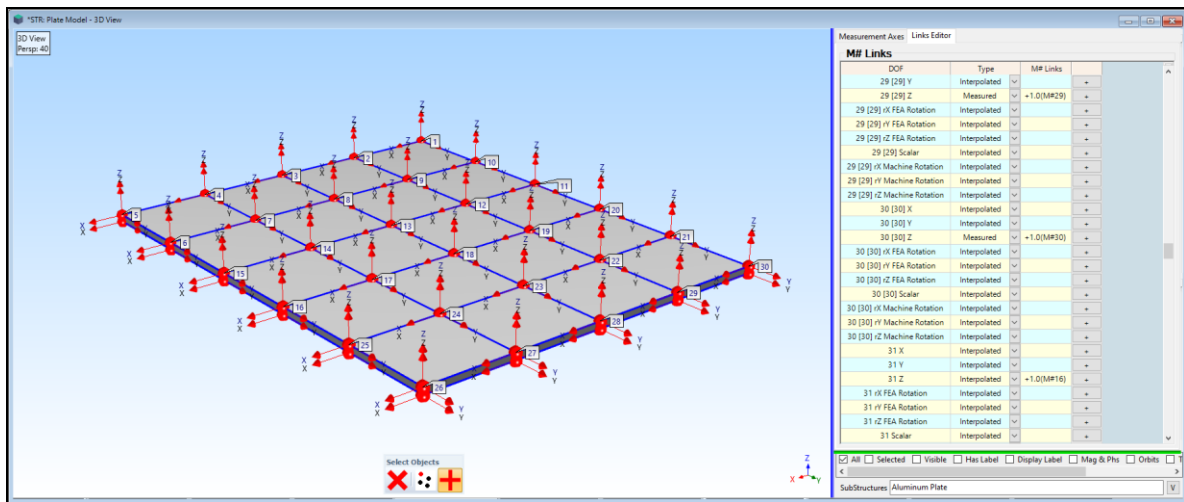
*3D Model Showing Measured & Interpolated M# Links.*

- Scroll through the M# Links *on the right* to display the **Measured & Interpolated M# Links**

All 60 Points on the 3D model have been linked to an M# in **BLK: Plate 30 FRFs**. The 3D Model is now ready to display ODS's in animation.

STEP 6 - DISPLAYING ODS's IN ANIMATION

- *Press* **Hotkey 6 Display ODS's in Animation**

Sinusoidal animation of the ODS from the **Line cursor** position in the Data Block *on the right* will begin. Data from the **current Animation Source** is used to display shapes in animation on a structure model.
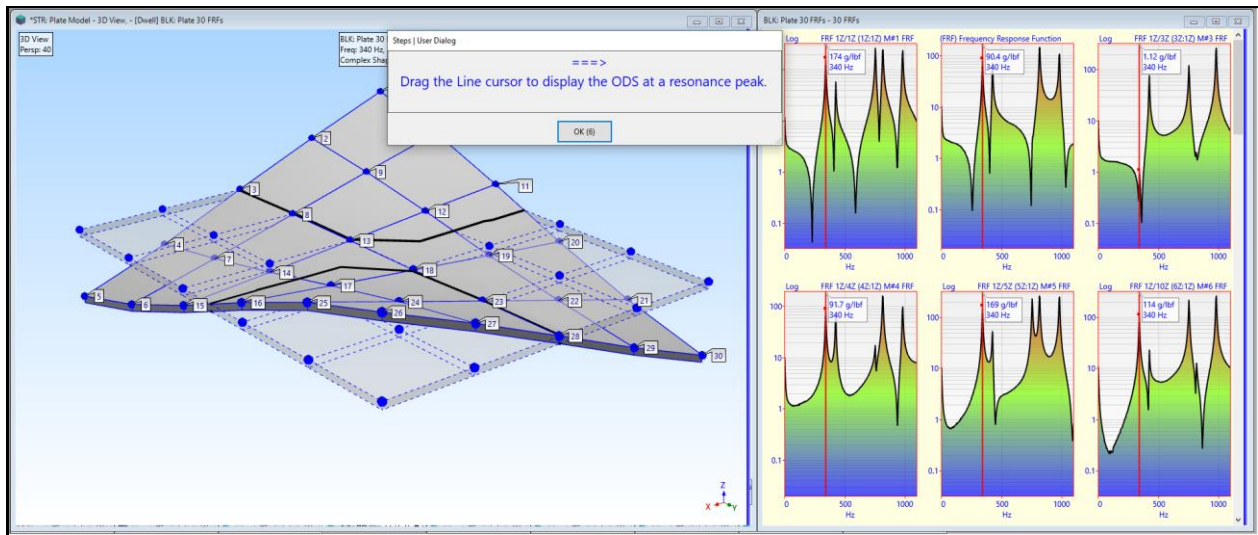
Sinusoidal ODS Animation from a Data Block.

ANIMATION SOURCE

The **Animation Source** is displayed on the Toolbar or Ribbon, as shown below.
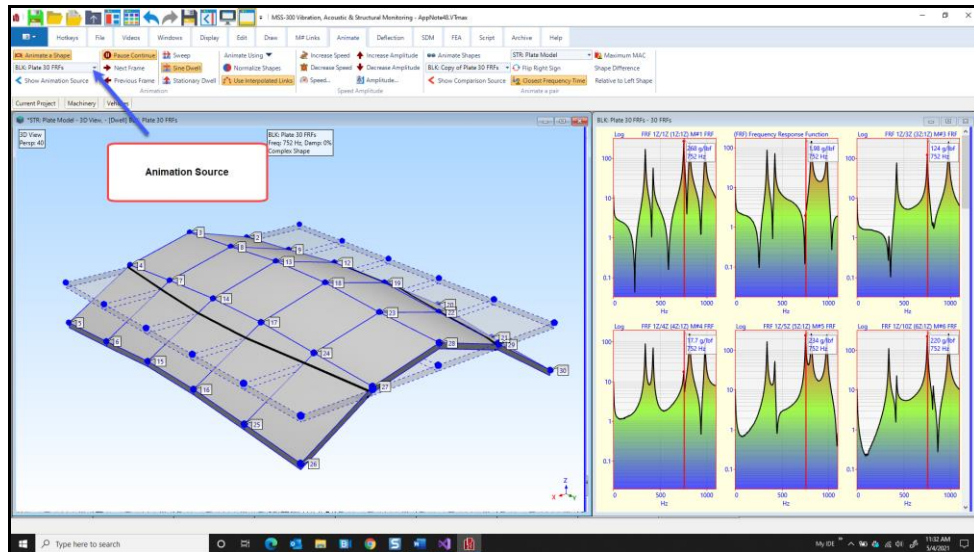
Animation Source From Which Shapes are Displayed in Animation.

Any **Data Block (BLK), Shape Table (SHP), or Acquisition window (ACQ)** can be an **Animation Source**.

The **M# Links** on the 3D model are used to retrieve shape data from the **Animation Source**.

CHANGING SURFACE COLORS

- *Right click* in the graphics area of the **STR:Plate Model** window and execute **Draw | Draw Structure** to stop the ODS animation

- *Drag* the **Blue Splitter Bar** *to the left* to display the Objects spreadsheet

- *Right click* in the graphics area and execute **Edit | Surface Quads**.

- *Right click* in the graphics area and execute **Edit | Select Objects | Interactive**

- *Depress* the **"+"** button on the **Interactive Select Objects** dialog box, as shown below.
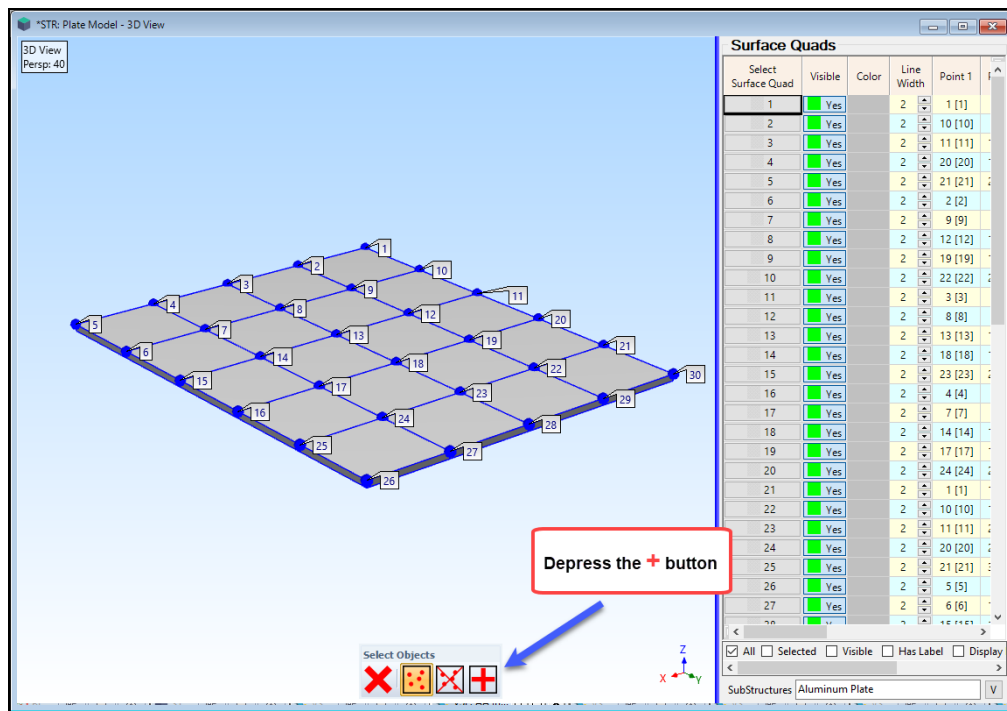
Interactively Selecting Surface Quads.

Each time you *click near the center* of a **Surface Quad**, it will be selected.

- *Select* **two rows** of **Surface Quads** to change their color, as shown below

- ***Click*** on the **Color** column heading in the **Surface Quads** spreadsheet
- Choose a single color for the *selected* **Surface Quads** and click on **OK**
- ***Right clic*k** on the **Surface Quads** spreadsheet and execute **Invert Selection** from the menu
- ***Click*** on the **Color** column heading *again* and choose a different color for the *selected* **Surface Quads**

The surfaces on any 3D model can be colored like this to make parts of the model easier to distinguish from other parts.

3D Plate Model Showing Surface Quads with Different Colors.

STEP 7 - REVIEW THE STEPS

To review the previous steps of this App Note

- ***Press*** **Hotkey 7 Review Steps**