

WORKSHOP 2

ANTI-SYMMETRIC WORKSHOP

Aircraft Description

- **Wingspan: 12 m**
- **Chord: 2 m**
- **Leading Edge: 0.3 m aft of datum**
- **Nodes: 2 m forward of datum**
- **Length: 7 m**

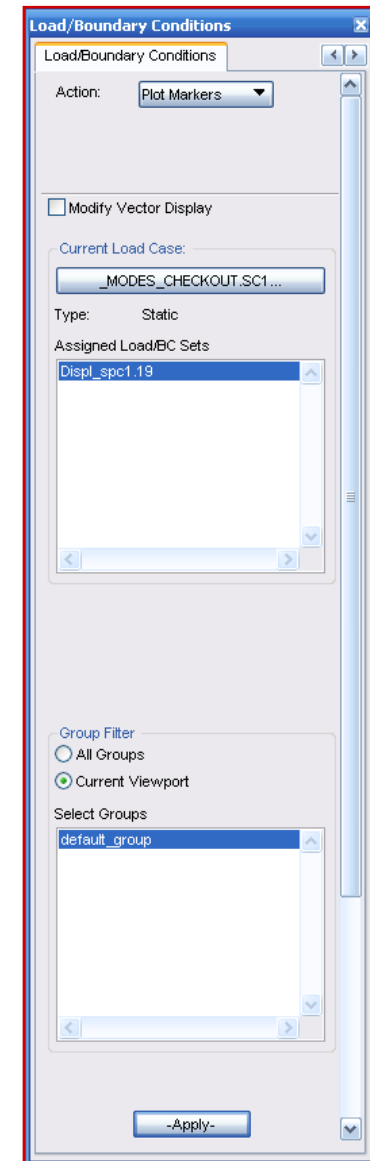
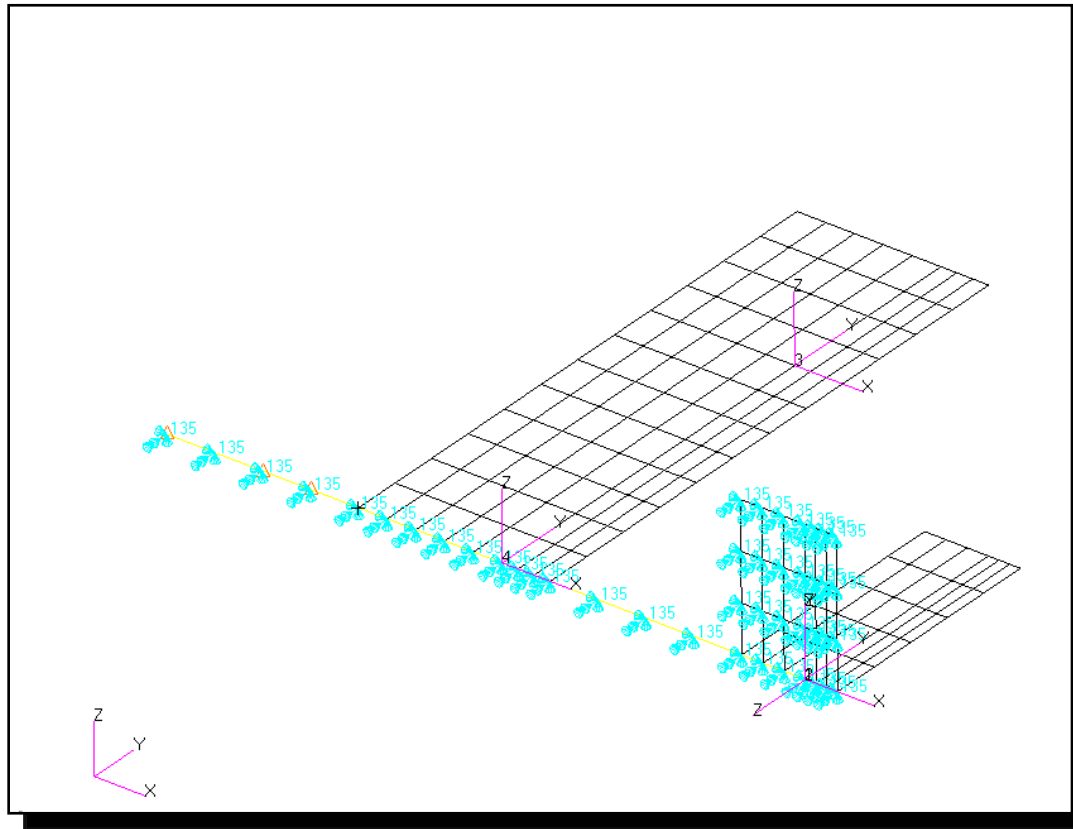
- **Workshop Objectives**
 - View elastic and rigid deformations and loads
 - Verify splines
- **Software Version**
 - Flightloads 2014
- **Files Required**
 - Sol_example_2a_modes.bdf
- **Problem Description**
 - Half model
 - Vertical surfaces
 - Control surfaces 'Welded' – apart from the aileron
 - Anti-symmetric about XZ plane
 - Flexible aileron hinge

- **Suggested Exercise Steps**

1. Launch Flightloads
2. Create a New Database
3. Import Structural Mesh file i.e. sol_example2a_modes.bdf
4. Run Normal Modes file
5. Attach XDB file to Patran
6. View Results
7. Switch Preference to Aero-elasticity
8. Create Flat Panel Modeling
9. Create Splines
10. Verify Splines
11. Animate Splines
12. Setup 7 Trim Case to study roll rate at varying speeds
13. View Results

Step 1. Boundary Conditions

- Import sol_example2a_modes.bdf into Patran
- Display boundary conditions



Step 2. Run File and Attach XDB to Patran

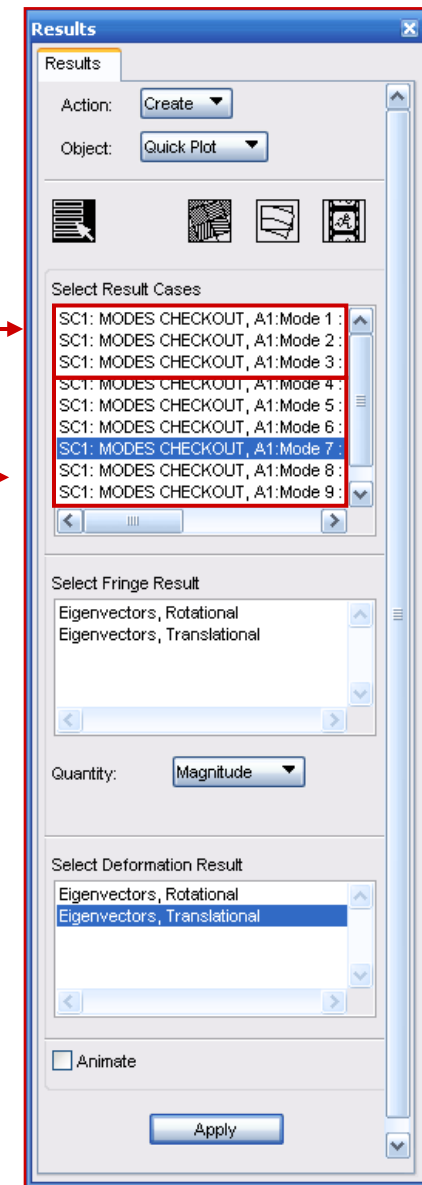
- Run modal analysis (sol_example2a_modes.bdf)
- Check .f06 file
 - Identify:
 - 3 rigid body modes
 - Elastic modes
- Attach .xdb in Patran
 - Identify :
 - 3 rigid body modes
 - Significant elastic modes

Step 3. Results

- **Results expected**

- 3 rigid body modes

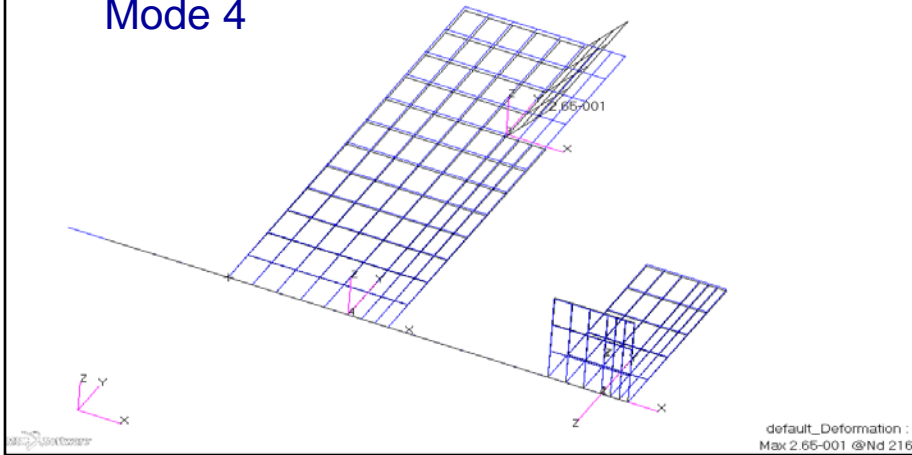
- Significant elastic modes



Significant Elastic Modes

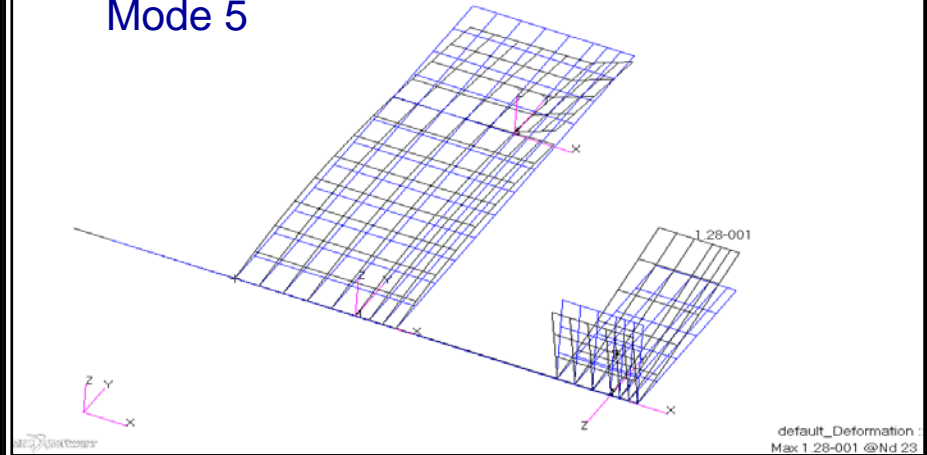
Deform: SC1: MODES CHECKOUT, A1 Mode 4 : Freq. = 1.2754, Eigenvectors, Translational.

Mode 4



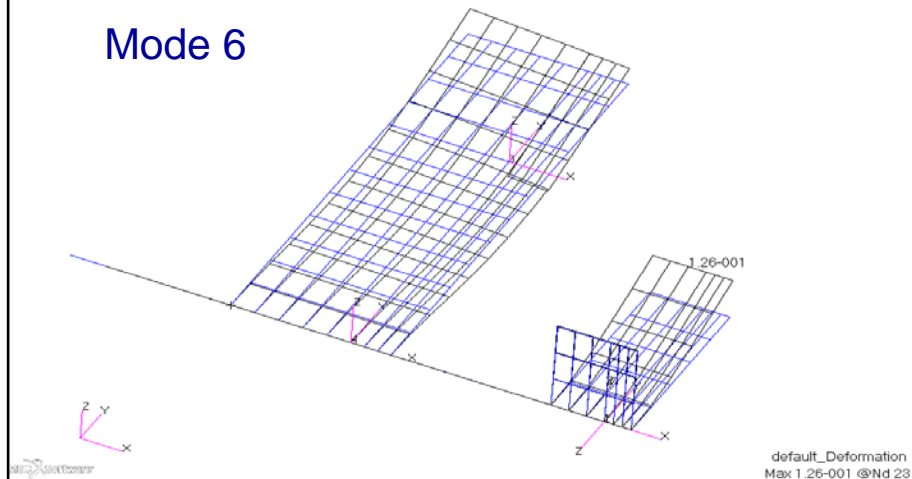
Deform: SC1: MODES CHECKOUT, A1 Mode 5 : Freq. = 8.2599, Eigenvectors, Translational.

Mode 5



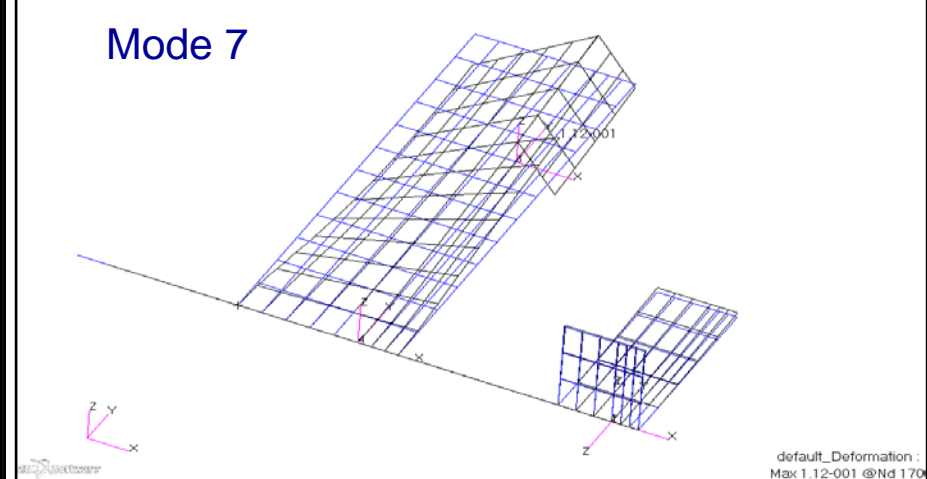
Deform: SC1: MODES CHECKOUT, A1 Mode 6 : Freq. = 14.81, Eigenvectors, Translational.

Mode 6



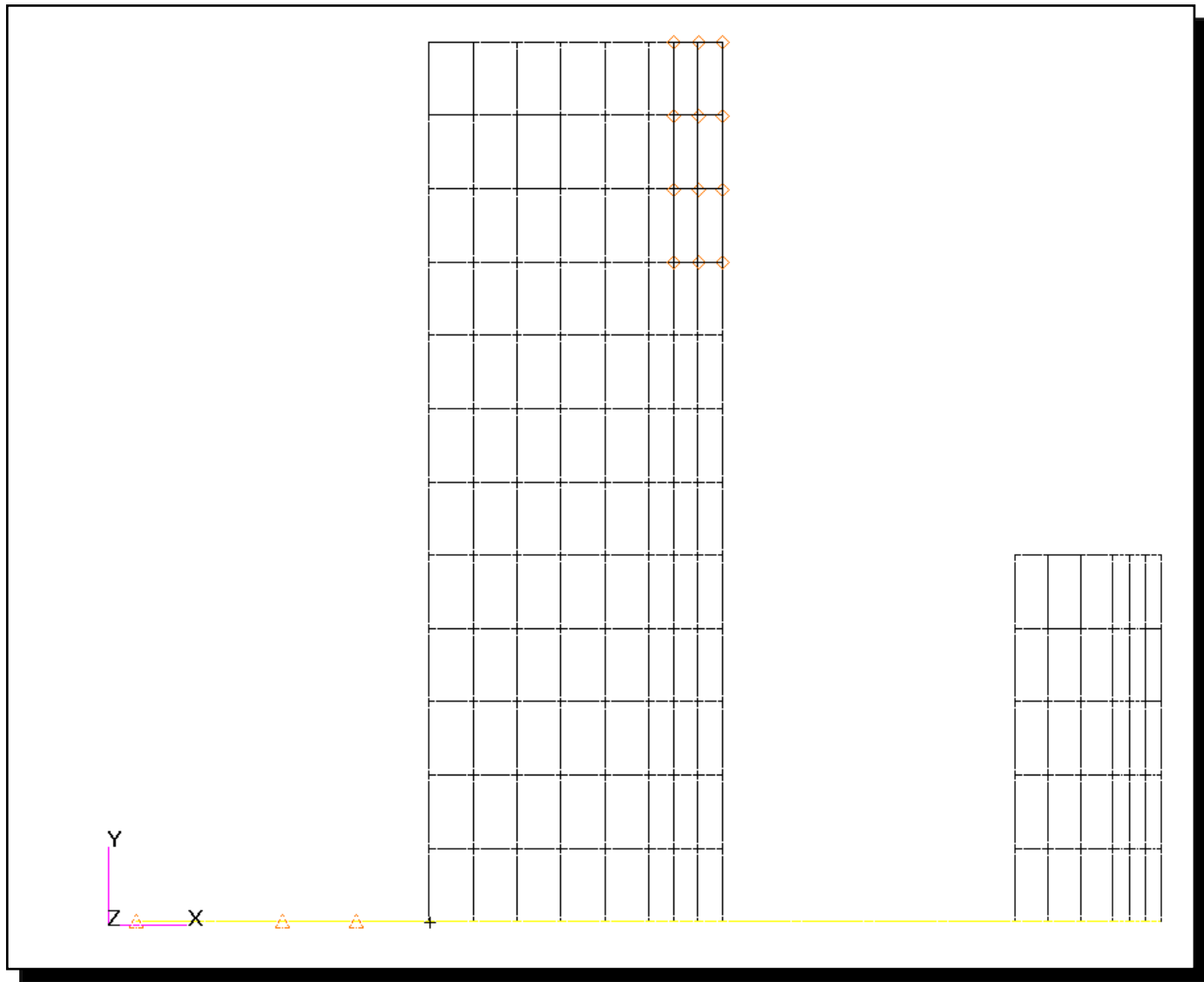
Deform: SC1: MODES CHECKOUT, A1 Mode 7 : Freq. = 17.856, Eigenvectors, Translational.

Mode 7

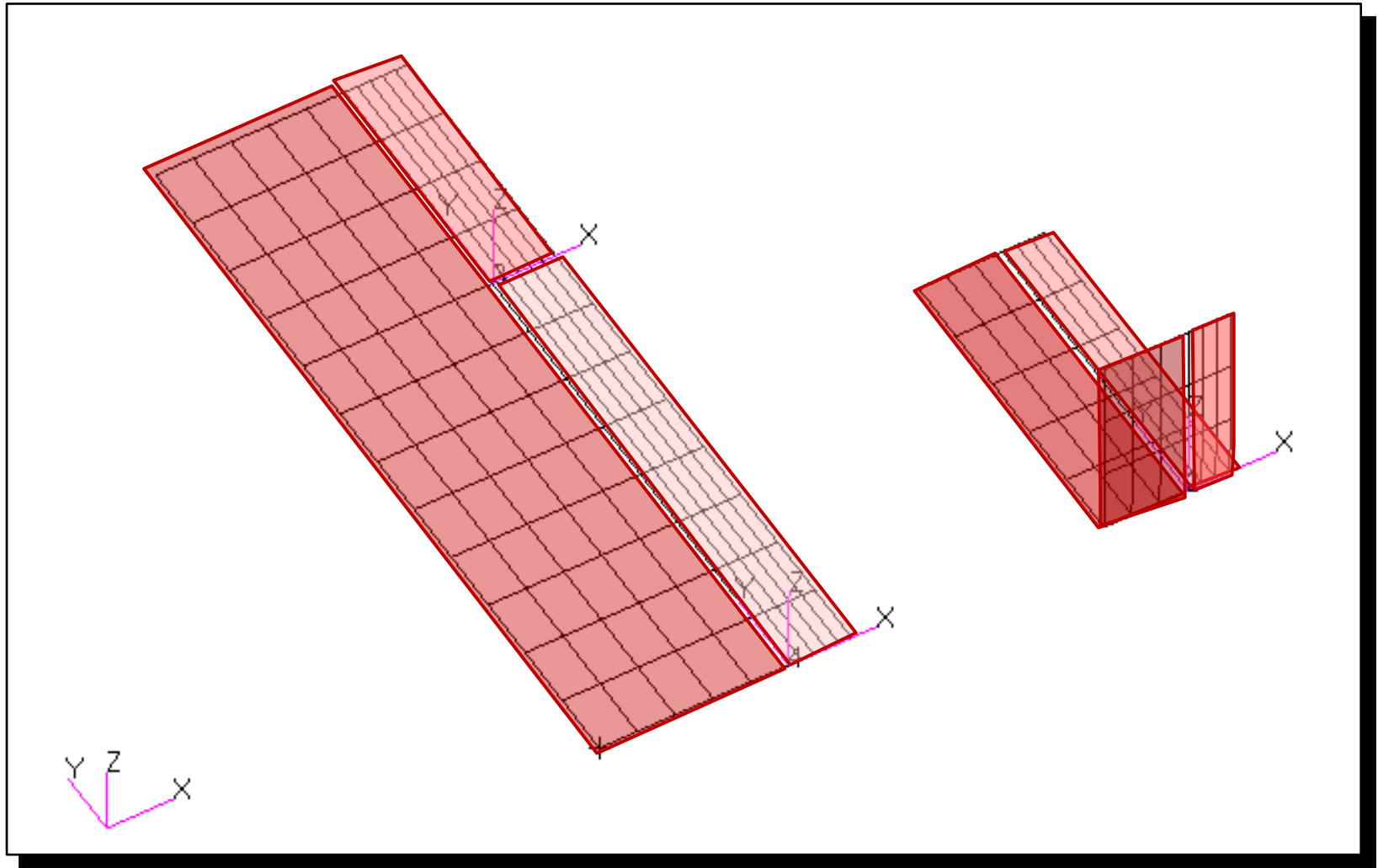


AERODYNAMIC MESH

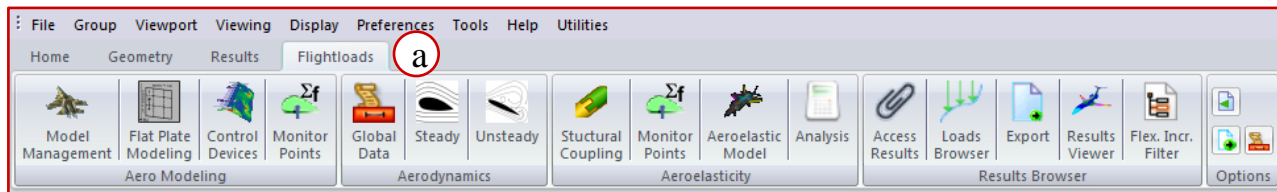
Structural Mesh



Suggested Aero Mesh

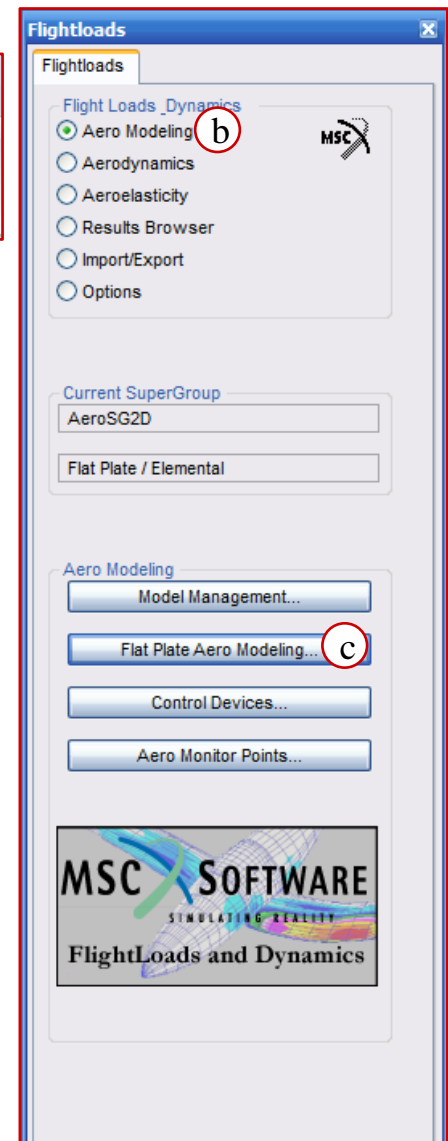


Create Flat Panel Modeling



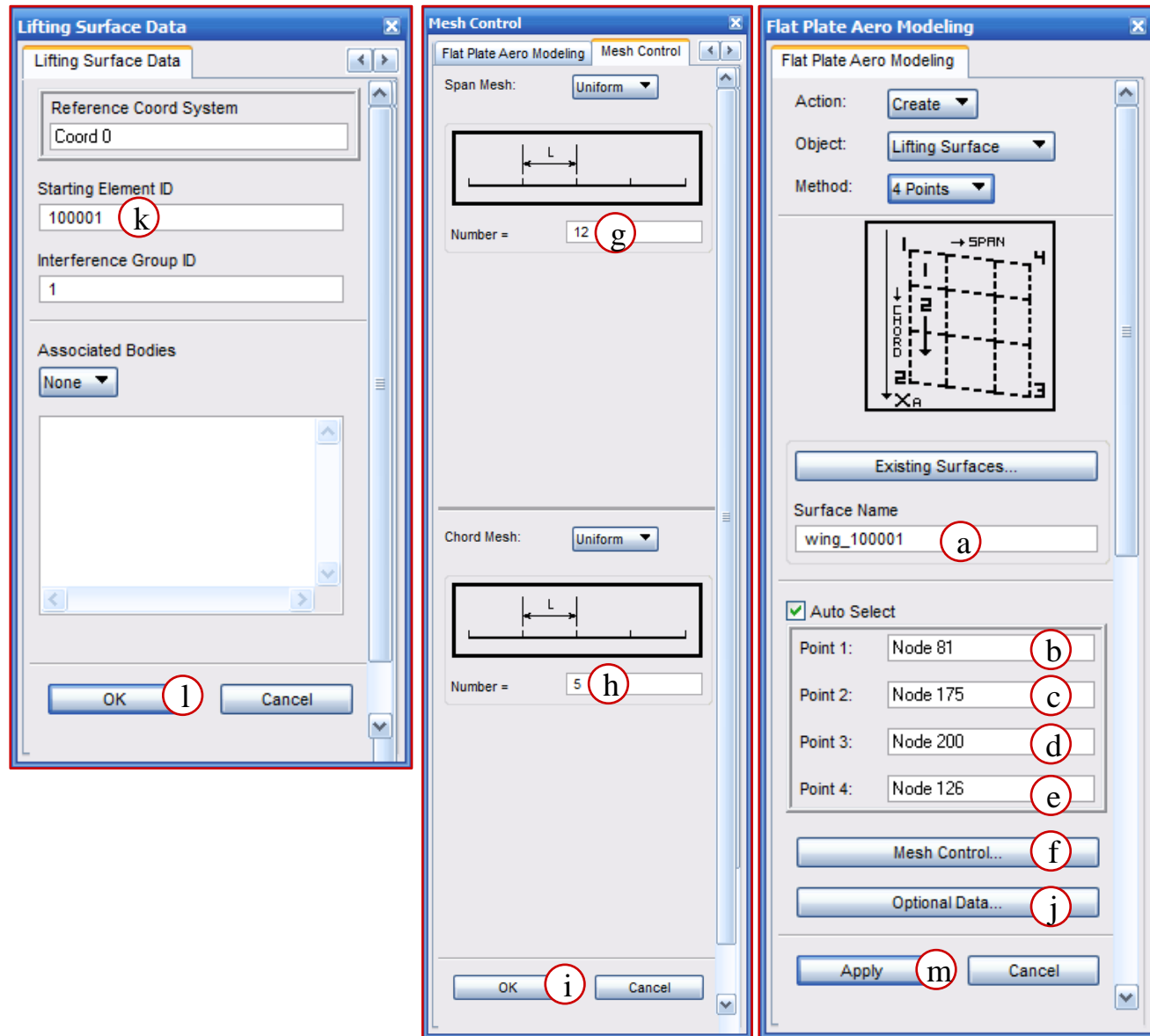
- **7 Aero-meshes need to be created.**

- Main wing
- Wing tail
- Aileron
- Tail
- Elevator
- Fin
- Rudder



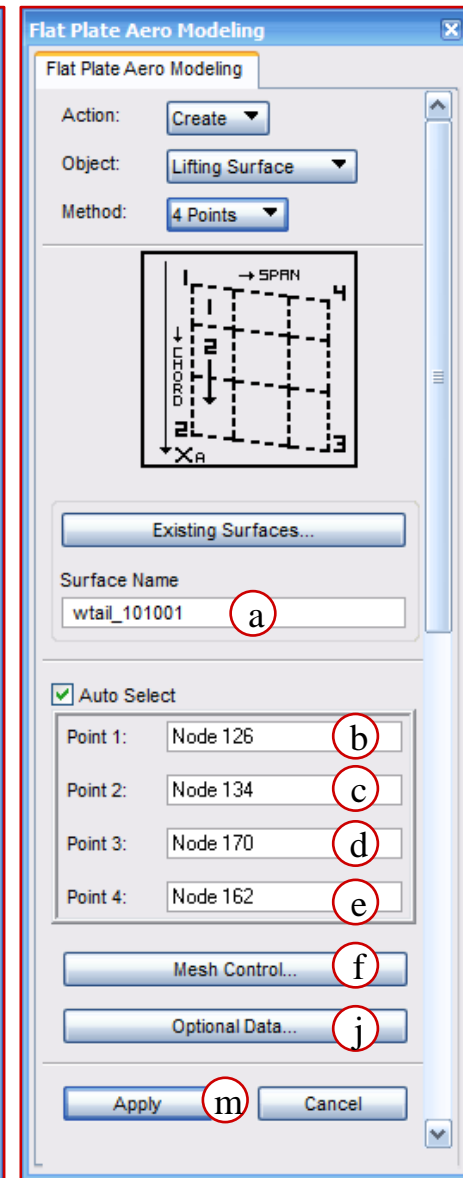
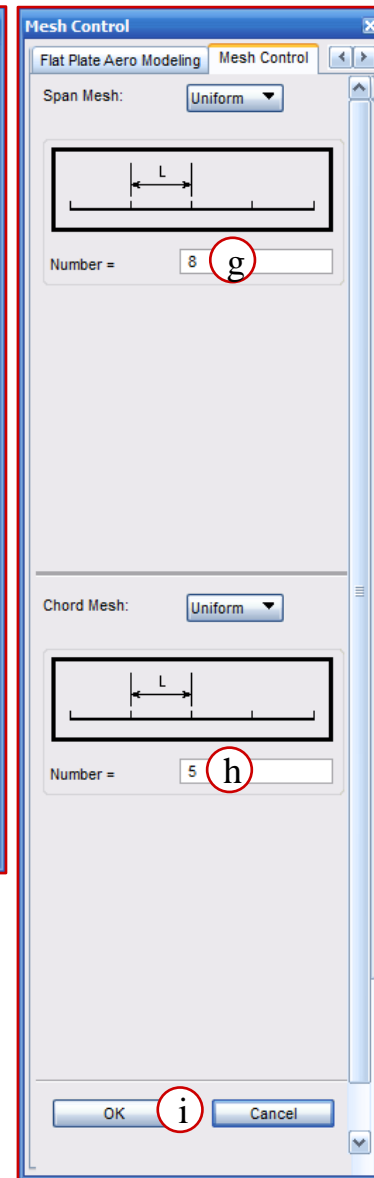
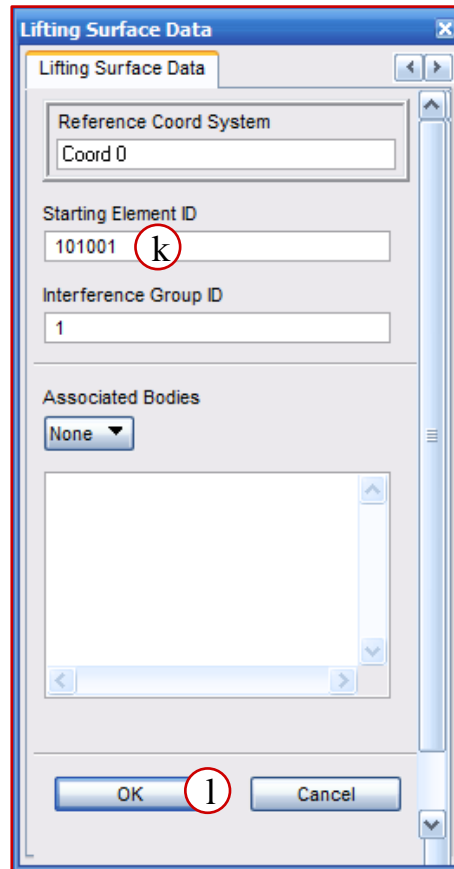
Create Flat Panel ID- 100001

- This is Flat Aero Surface for Main Wing



Create Flat Panel ID- 101001

- This is Flat Aero Surface for Wing Tail



Create Flat Panel ID- 102001

- This is Flat Aero Surface for Aileron

Lifting Surface Data

Lifting Surface Data

Reference Coord System
Coord 0

Starting Element ID
102001 **k**

Interference Group ID
1

Associated Bodies
None

OK **l** Cancel

Mesh Control

Flat Plate Aero Modeling Mesh Control

Span Mesh: Uniform

Number = 4 **g**

Chord Mesh: Uniform

Number = 5 **h**

OK **i** Cancel

Flat Plate Aero Modeling

Flat Plate Aero Modeling

Action: Create

Object: Lifting Surface

Method: 4 Points

Existing Surfaces...

Surface Name
aileron_102001 **a**

☒ Auto Select

Point 1: Node 134 **b**

Point 2: Node 200 **c**

Point 3: Node 220 **d**

Point 4: Node 170 **e**

Mesh Control... **f**

Optional Data... **j**

Apply **m** Cancel

Create Flat Panel ID- 103001

- This is Flat Aero Surface for Tail

The image displays three software dialog boxes used for creating a flat aero surface, with specific elements marked by letters a through m.

Lifting Surface Data

- Reference Coord System: Coord 0
- Starting Element ID: 103001 (k)
- Interference Group ID: 1
- Associated Bodies: None
- Buttons: OK (l), Cancel

Mesh Control

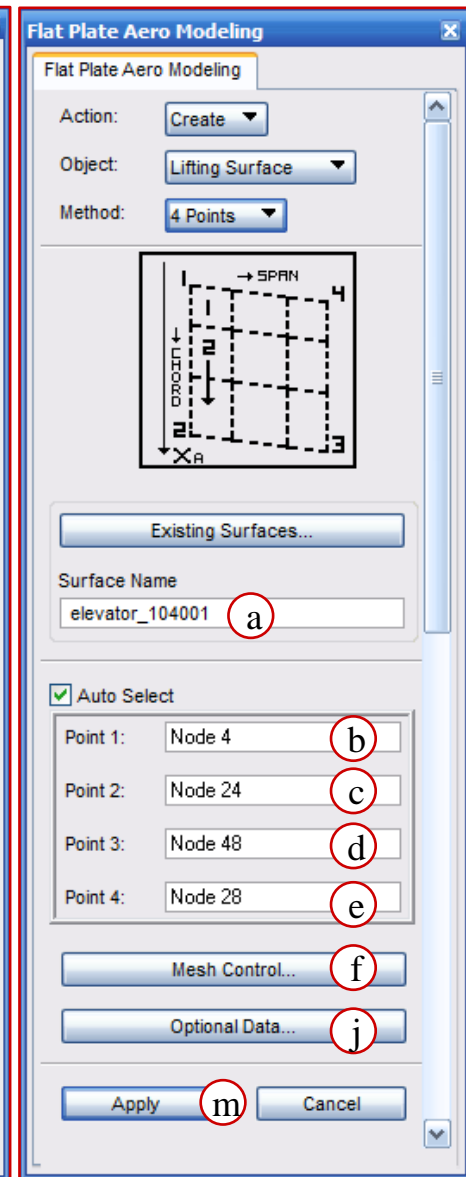
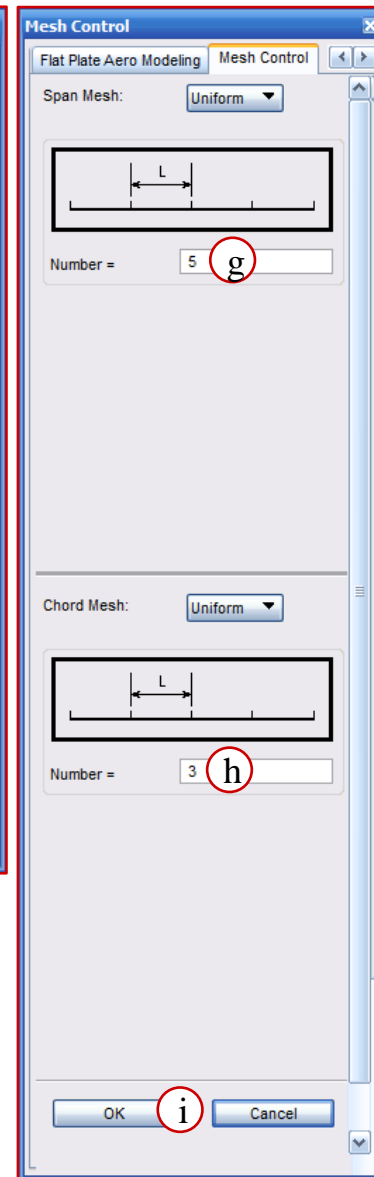
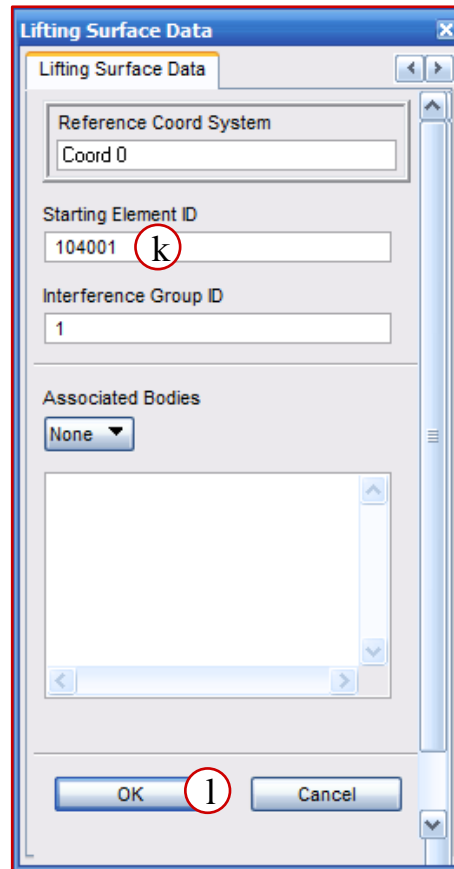
- Span Mesh: Uniform
- Diagram: A line with a segment labeled 'L'.
- Number = 5 (g)
- Chord Mesh: Uniform
- Diagram: A line with a segment labeled 'L'.
- Number = 3 (h)
- Buttons: OK (i), Cancel

Flat Plate Aero Modeling

- Action: Create
- Object: Lifting Surface
- Method: 4 Points
- Diagram: A grid with points 1, 2, 3, 4 and labels SPAN, CHORD, X_R.
- Existing Surfaces... button
- Surface Name: tail_103001 (a)
- Auto Select: ☒
- Point 1: Node 1 (b)
- Point 2: Node 21 (c)
- Point 3: Node 24 (d)
- Point 4: Node 4 (e)
- Buttons: Mesh Control... (f), Optional Data... (j), Apply (m), Cancel

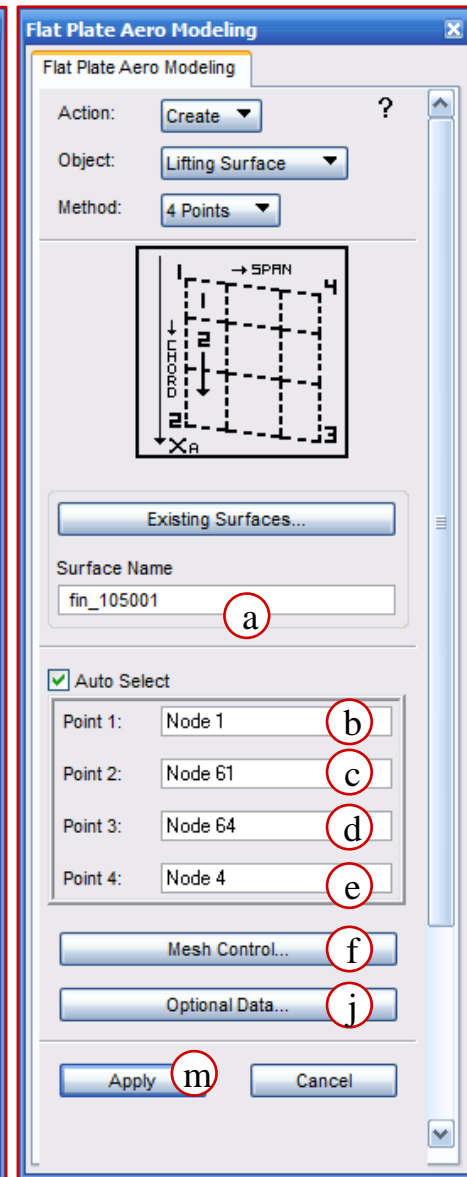
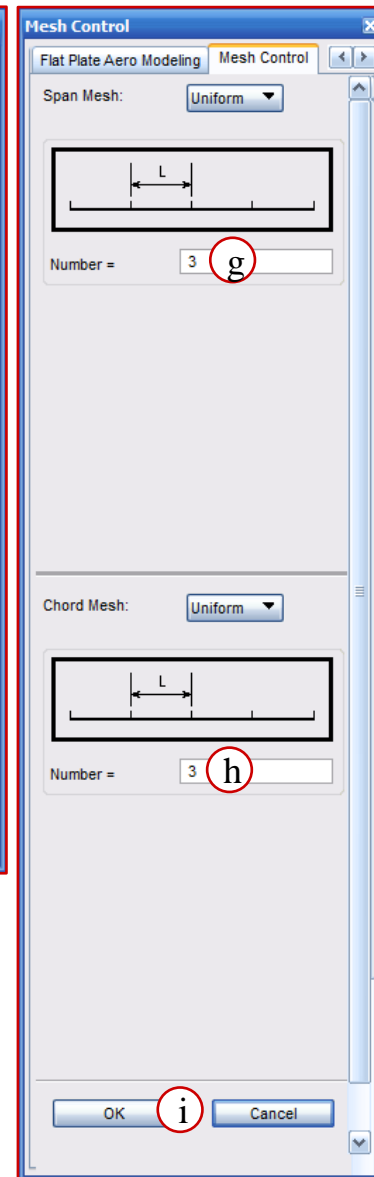
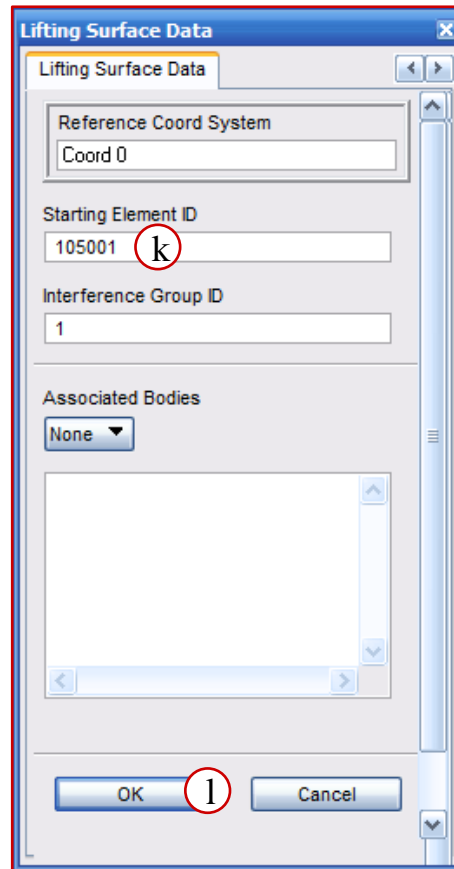
Create Flat Panel ID- 104001

- This is Flat Aero Surface for Elevator



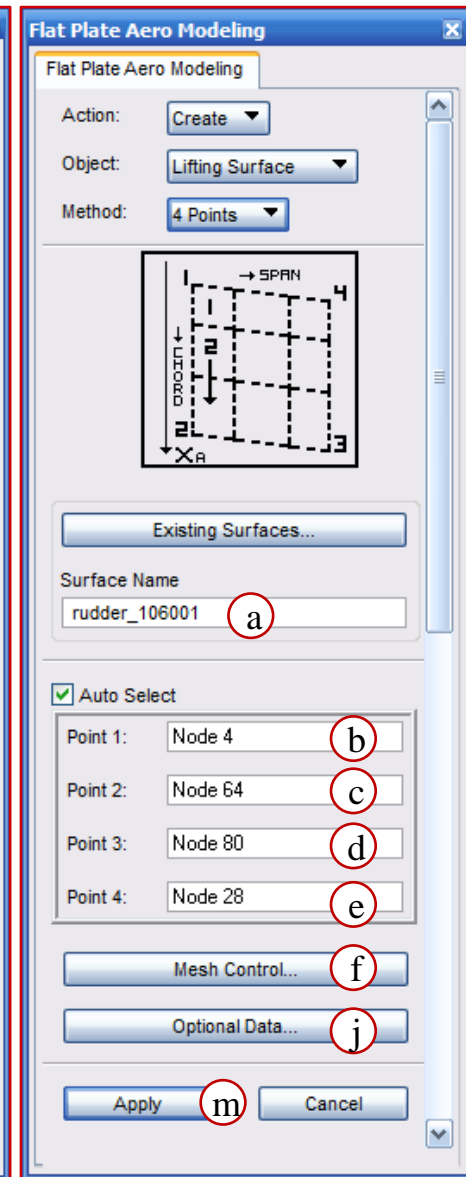
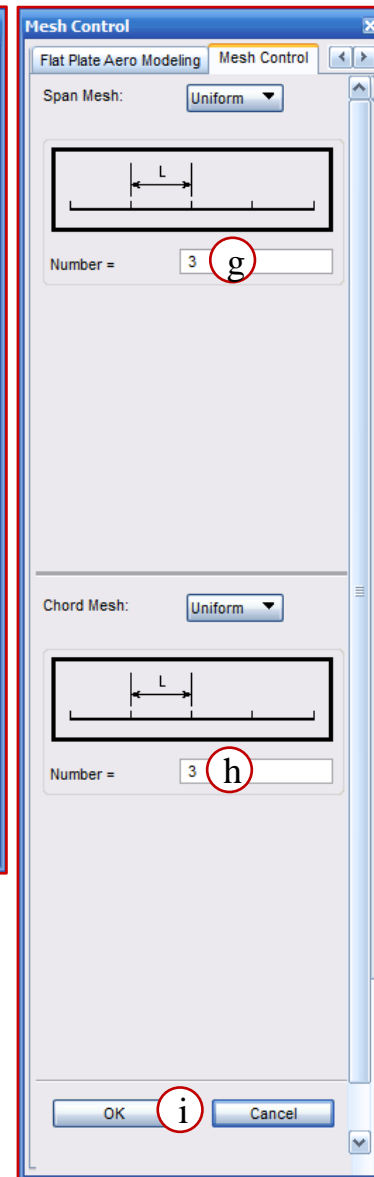
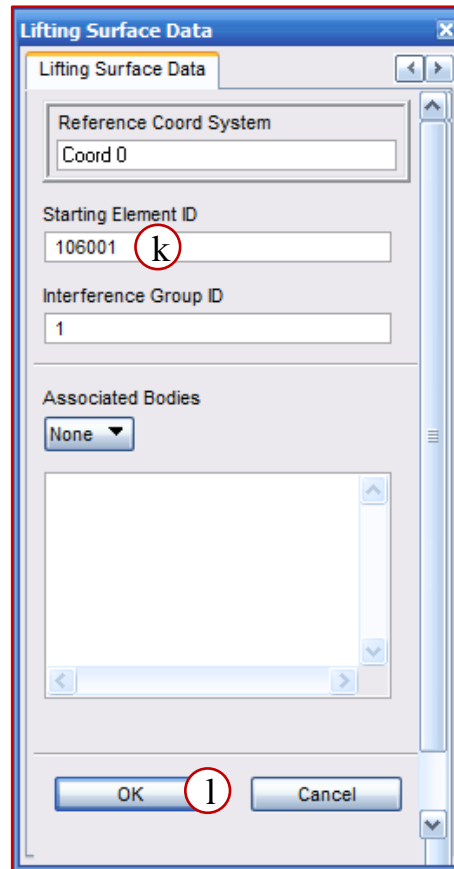
Create Flat Panel ID- 105001

- This is Flat Aero Surface for Fin



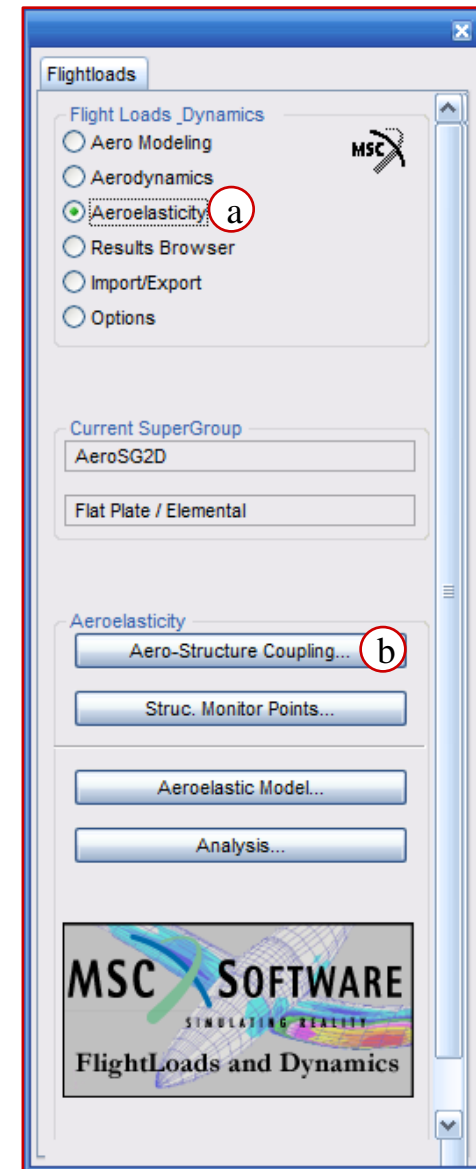
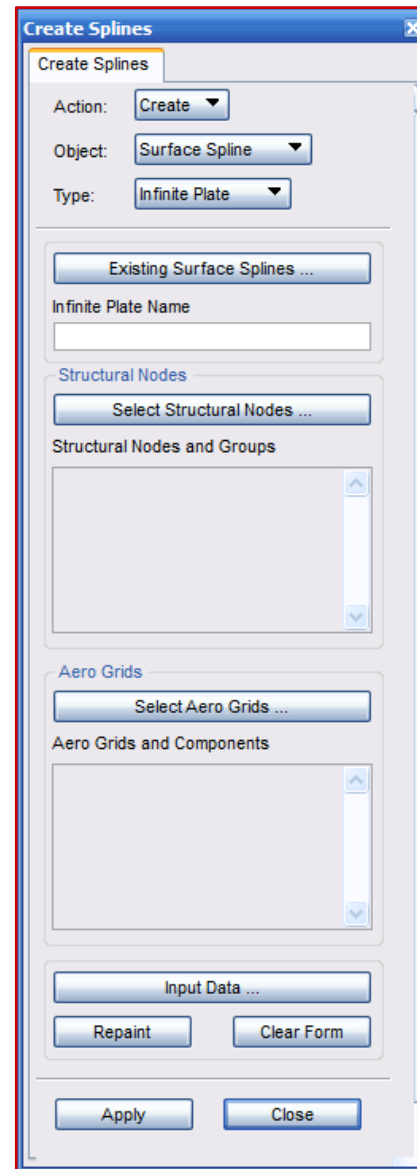
Create Flat Panel ID- 106001

- This is Flat Aero Surface for Rudder



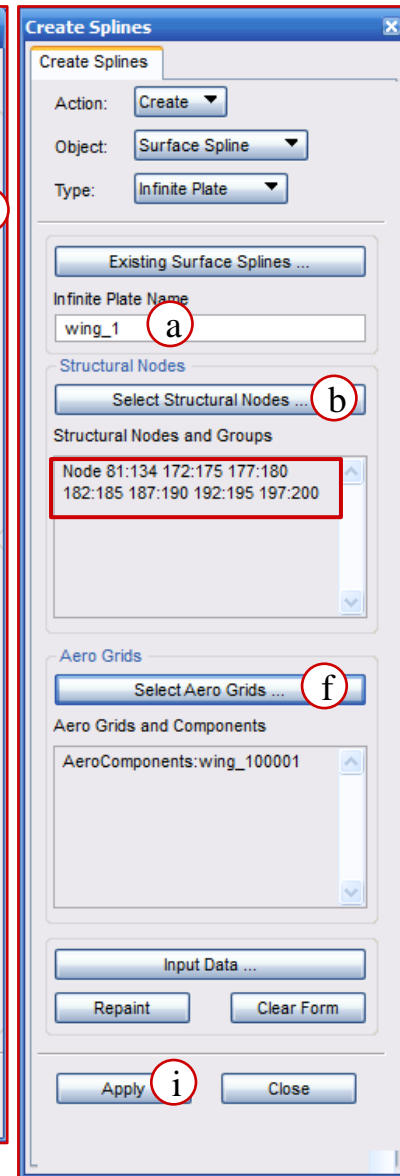
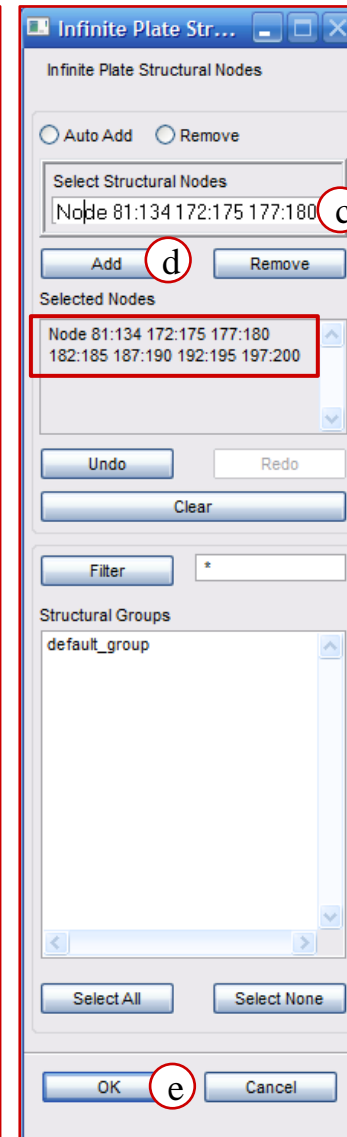
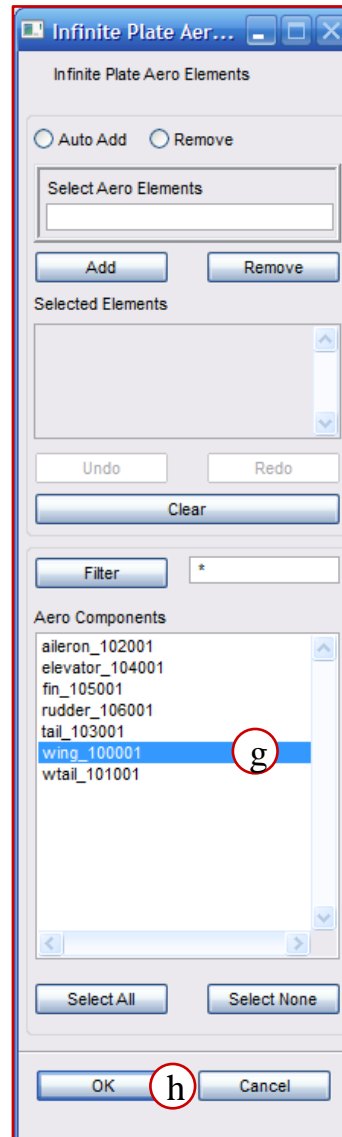
Creating Splines

- This is the step which needs to be executed in order the connect the structural nodes to the Aero Panel Elements.



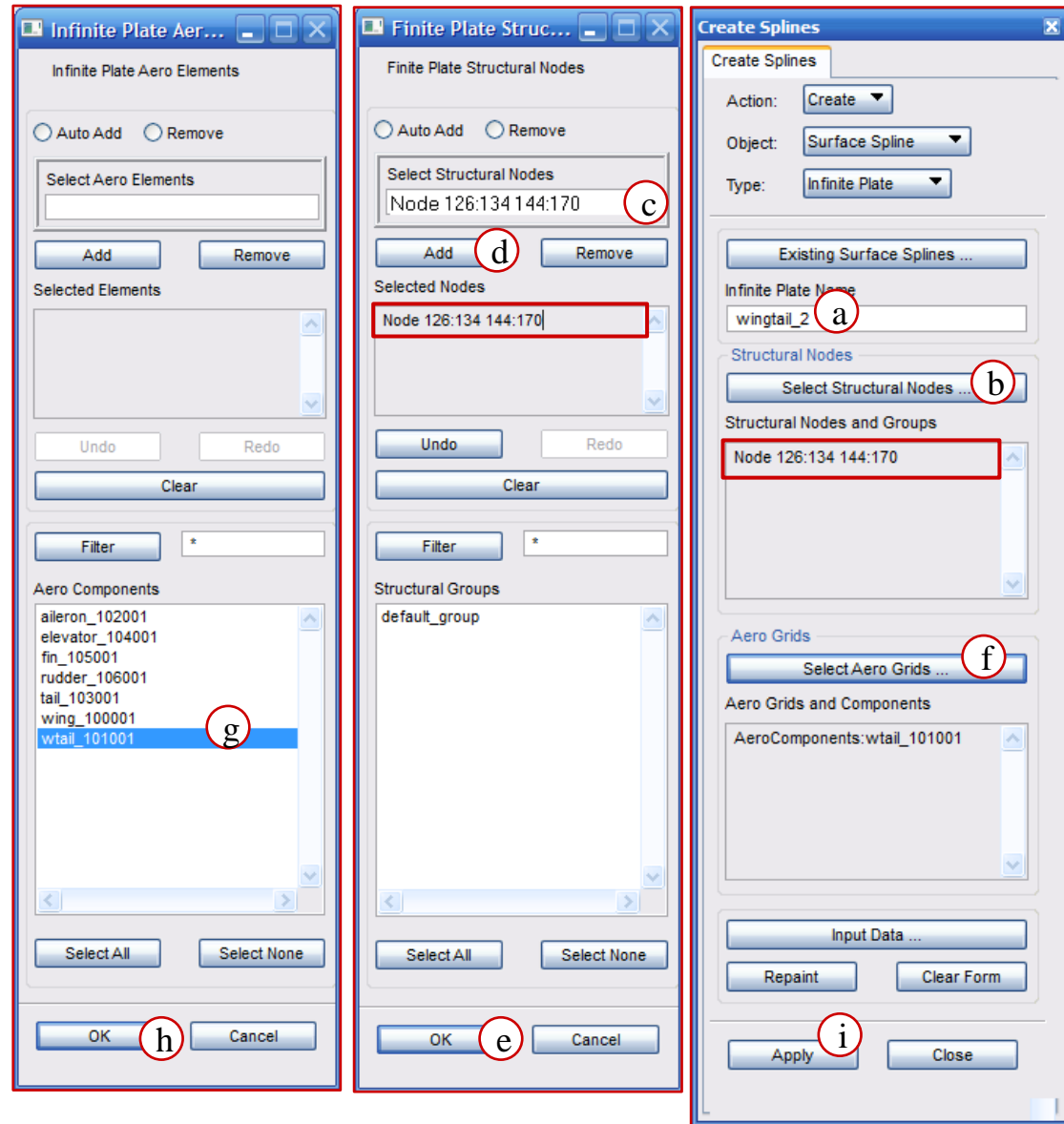
Create Spline for Wing ID - 1

- Insert the nodes shown below in step c as a first trial. The set of nodes will be refined as the workshop proceeds.
- In step d the structural nodes participating the splining with Aero elements are selected. The structural nodes to be used will be finalized using the verify spline operation discussed further.
- In step e the Aero- panel elements to be used in splining are selected. The flat panel have been created, so the specific group needs to be selected.
- **Node 81:134 172:175 177:180 182:185 187:190 192:195 197:200**



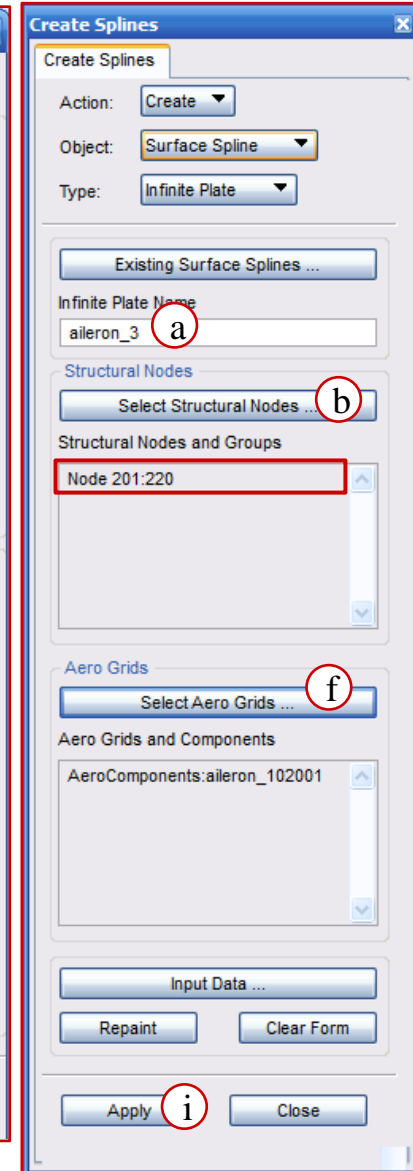
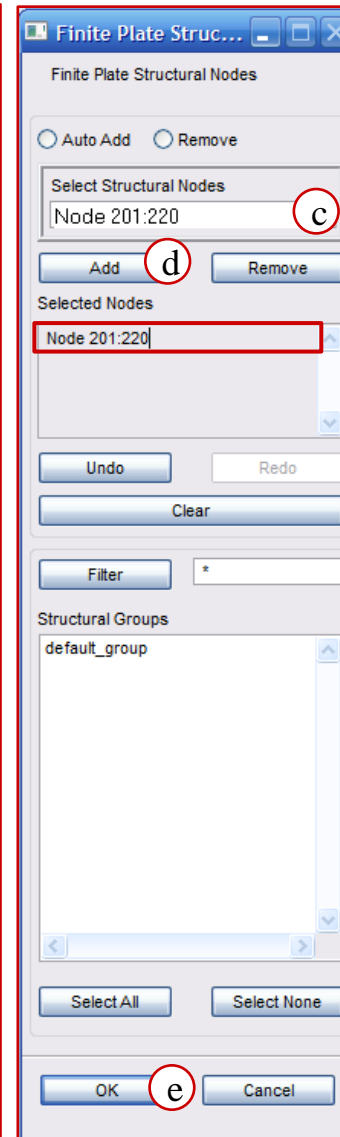
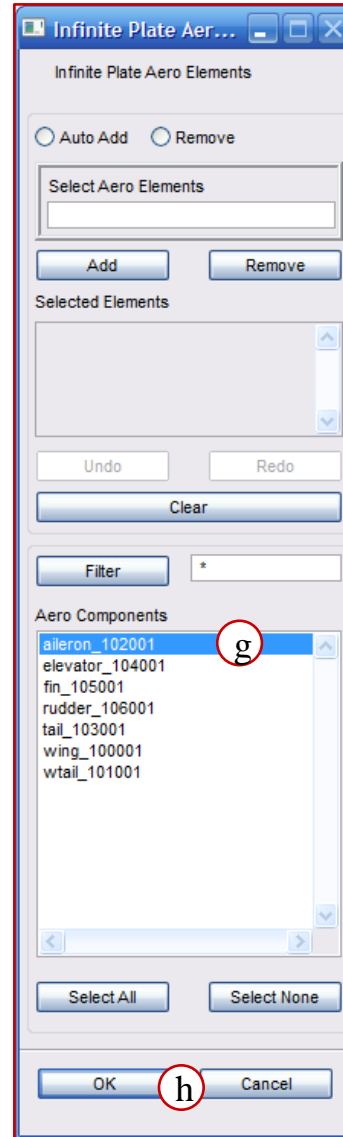
Create Spline for WingTail ID - 2

- Insert the nodes shown below in step c as a first trial. The set of nodes will be refined as the workshop proceeds.
- In step d the structural nodes participating the splining with Aero elements are selected. The structural nodes to be used will be finalized using the verify spline operation discussed further.
- In step e the Aero- panel elements to be used in splining are selected. The flat panel have been created, so the specific group needs to be selected.
- **Node 126:134 144:170**



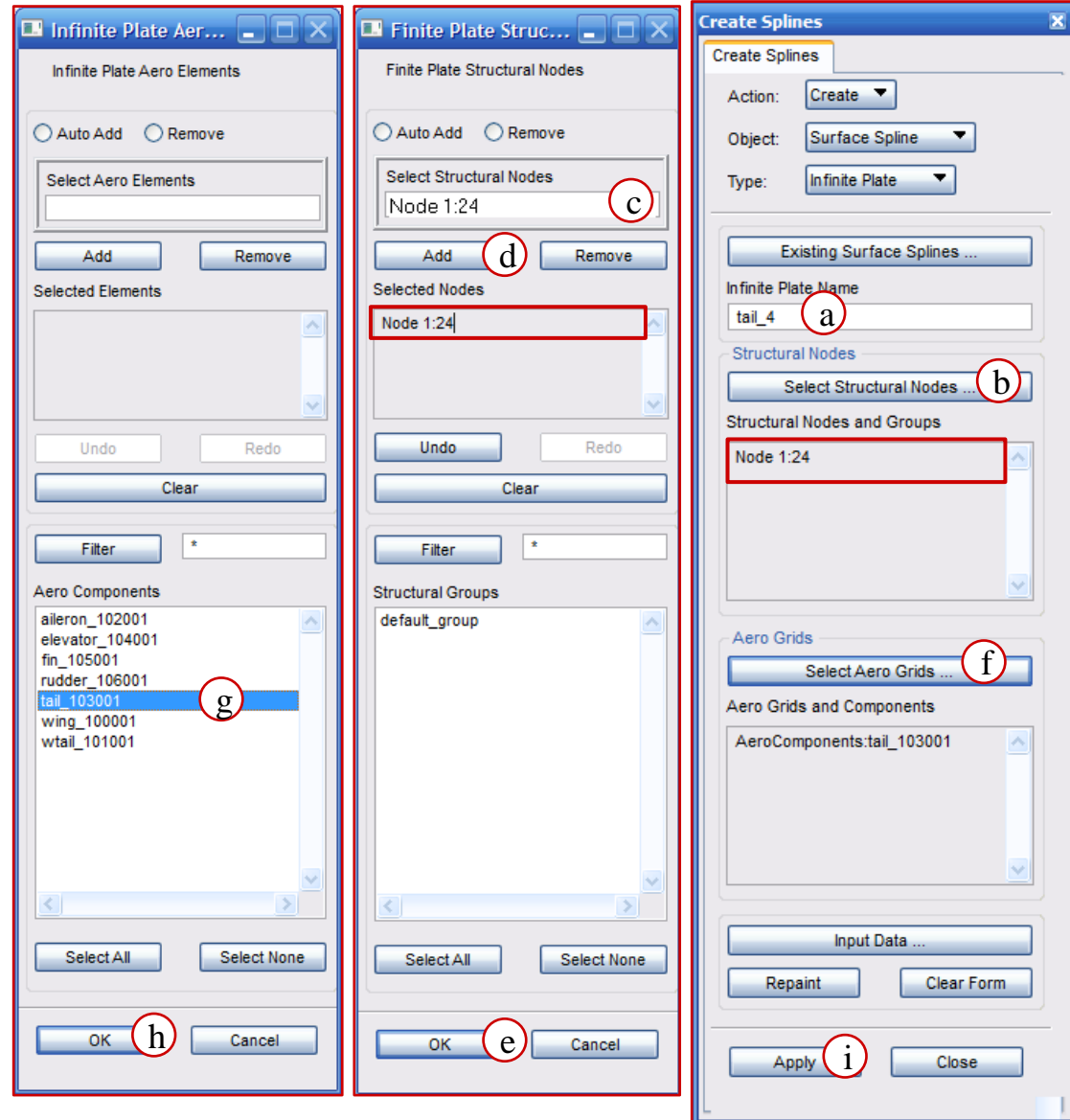
Create Spline for Aileron ID - 3

- Insert the nodes shown below in step c as a first trial. The set of nodes will be refined as the workshop proceeds.
- In step d the structural nodes participating the splining with Aero elements are selected. The structural nodes to be used will be finalized using the verify spline operation discussed further.
- In step e the Aero- panel elements to be used in splining are selected. The flat panel have been created, so the specific group needs to be selected.
- **Node 201:220**



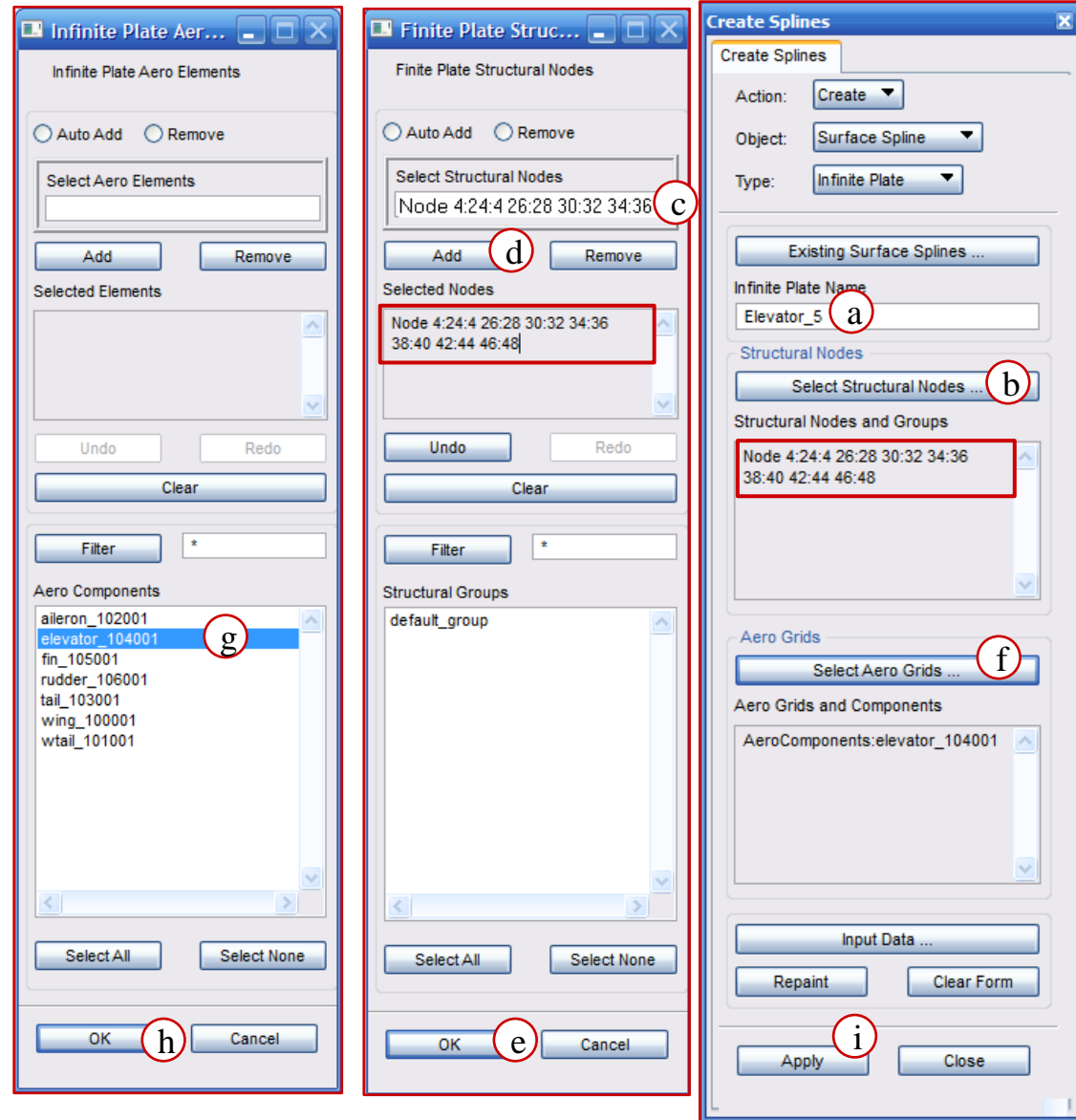
Create Spline for Tail ID - 4

- Insert the nodes shown below in step c as a first trial. The set of nodes will be refined as the workshop proceeds.
- In step d the structural nodes participating the splining with Aero elements are selected. The structural nodes to be used will be finalized using the verify spline operation discussed further.
- In step e the Aero- panel elements to be used in splining are selected. The flat panel have been created, so the specific group needs to be selected.
- **Node 1:24**



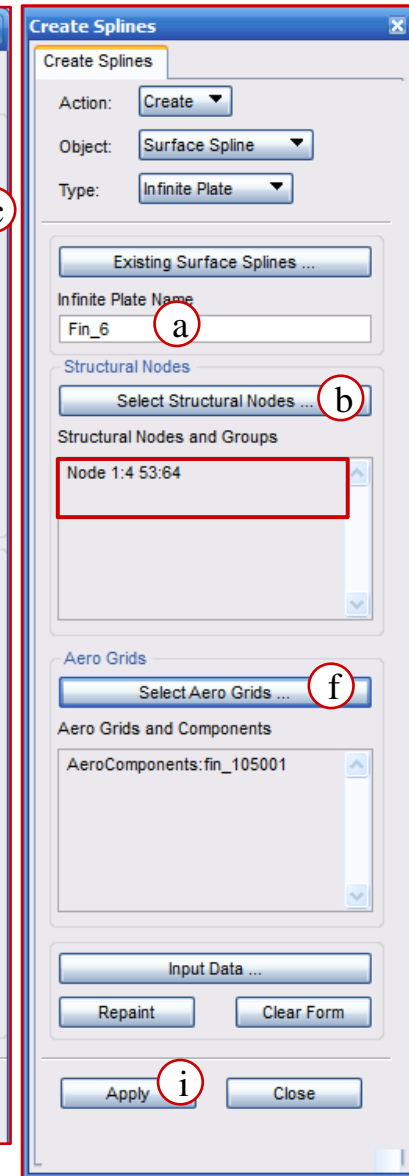
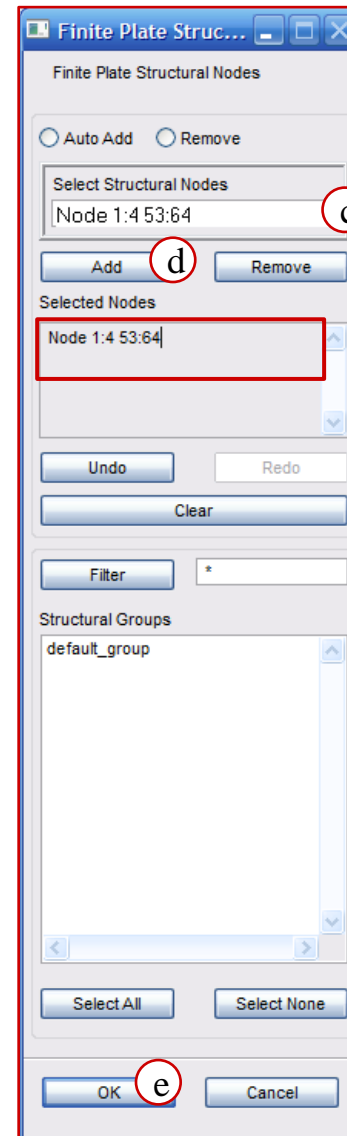
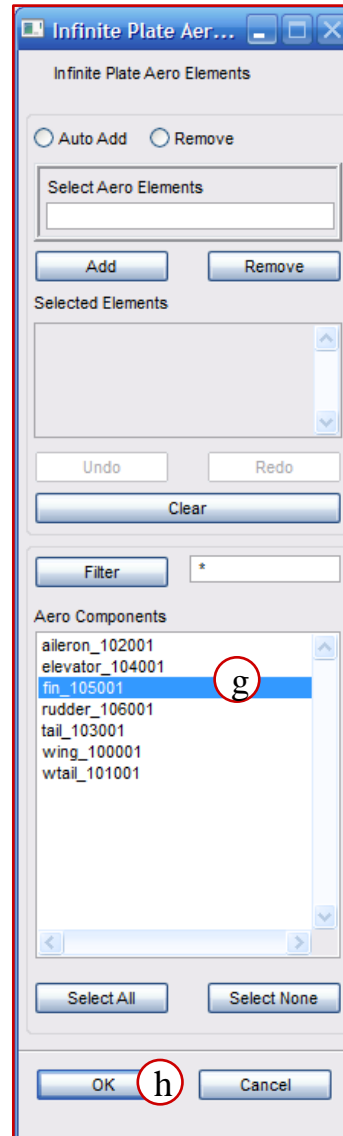
Create Spline for Elevator ID - 5

- Insert the nodes shown below in step c as a first trial. The set of nodes will be refined as the workshop proceeds.
- In step d the structural nodes participating the splining with Aero elements are selected. The structural nodes to be used will be finalized using the verify spline operation discussed further.
- In step e the Aero- panel elements to be used in splining are selected. The flat panel have been created, so the specific group needs to be selected.
- **Node 4:24:4 26:28 30:32 34:36 38:40 42:44 46:48**



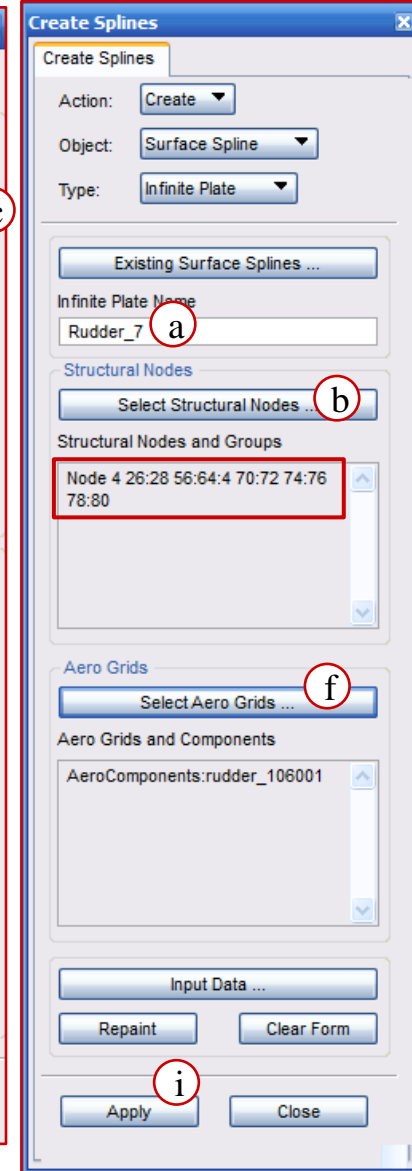
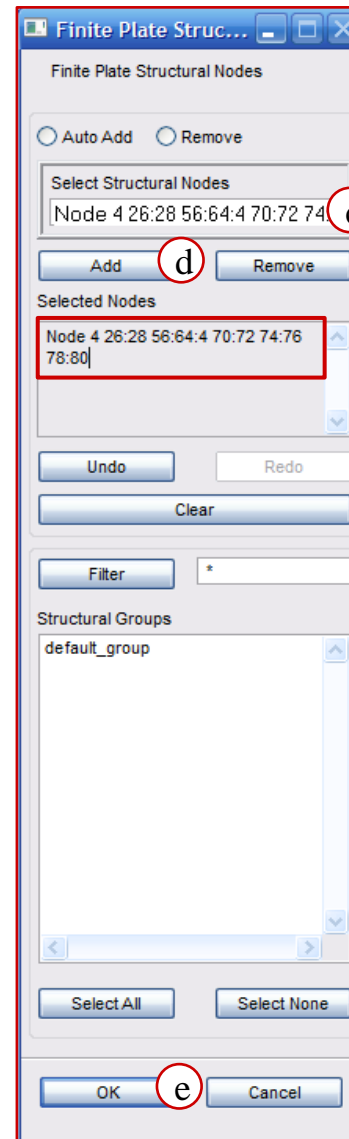
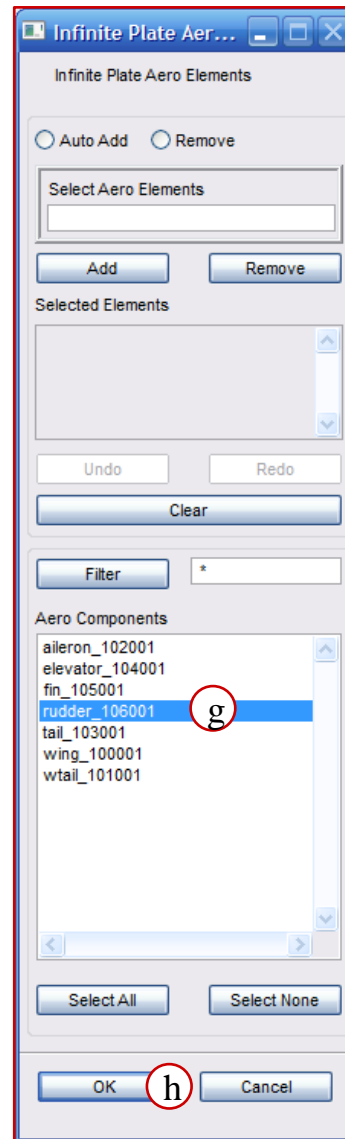
Create Spline for Fin ID - 6

- Insert the nodes shown below in step c as a first trial. The set of nodes will be refined as the workshop proceeds.
- In step d the structural nodes participating the splining with Aero elements are selected. The structural nodes to be used will be finalized using the verify spline operation discussed further.
- In step e the Aero- panel elements to be used in splining are selected. The flat panel have been created, so the specific group needs to be selected.
- **Node 1:4 53:64**



Create Spline for Rudder ID - 7

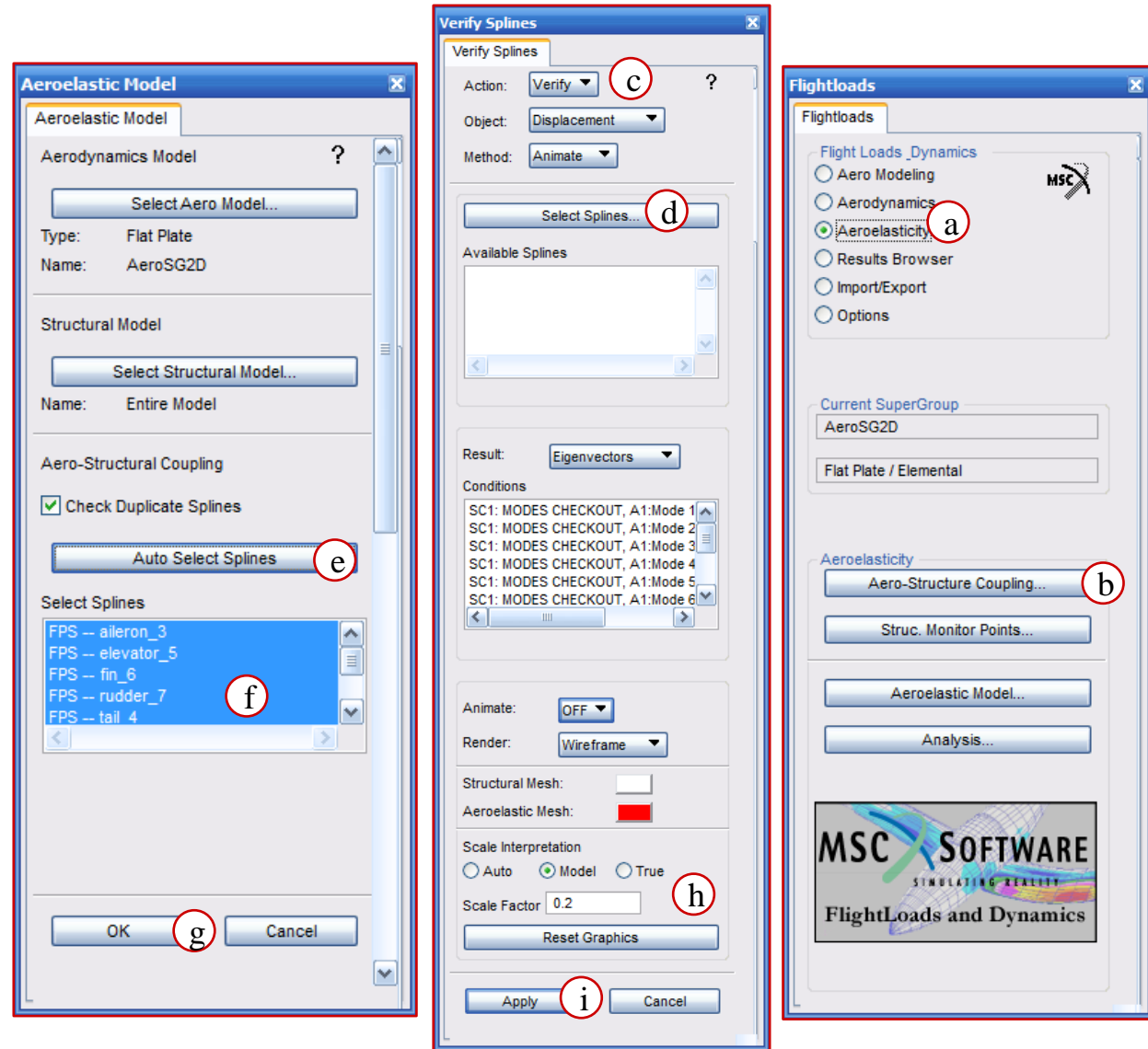
- Insert the nodes shown below in step c as a first trial. The set of nodes will be refined as the workshop proceeds.
- In step d the structural nodes participating the splining with Aero elements are selected. The structural nodes to be used will be finalized using the verify spline operation discussed further.
- In step e the Aero- panel elements to be used in splining are selected. The flat panel have been created, so the specific group needs to be selected.
- **Node 4 26:28 56:64:4 70:72 74:76 78:80**



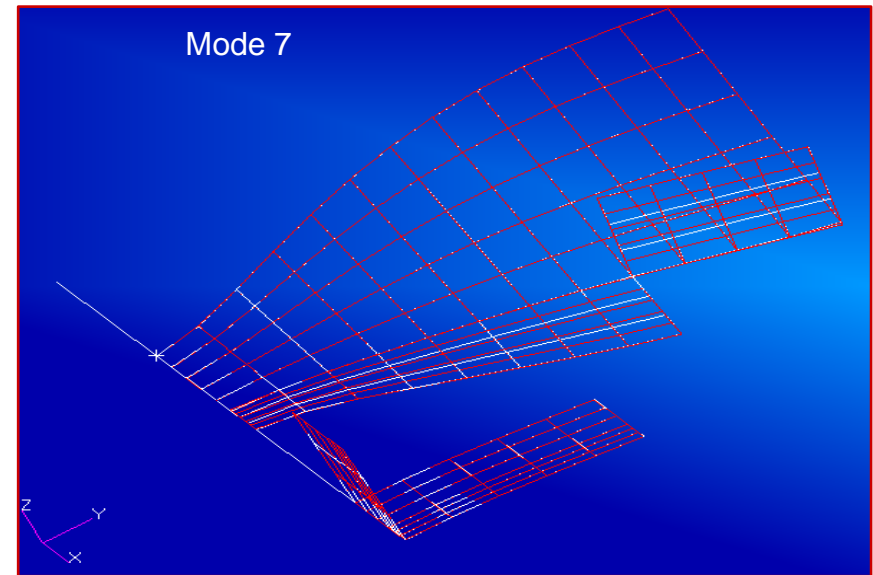
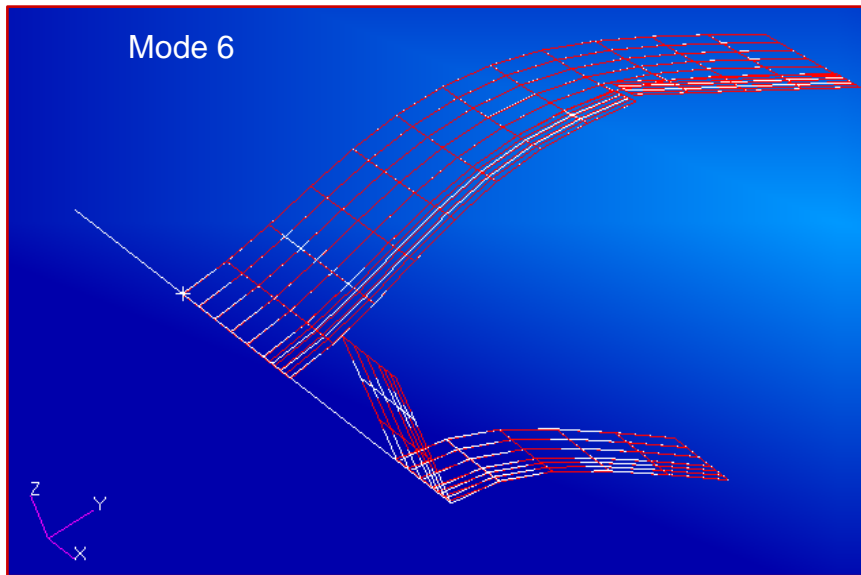
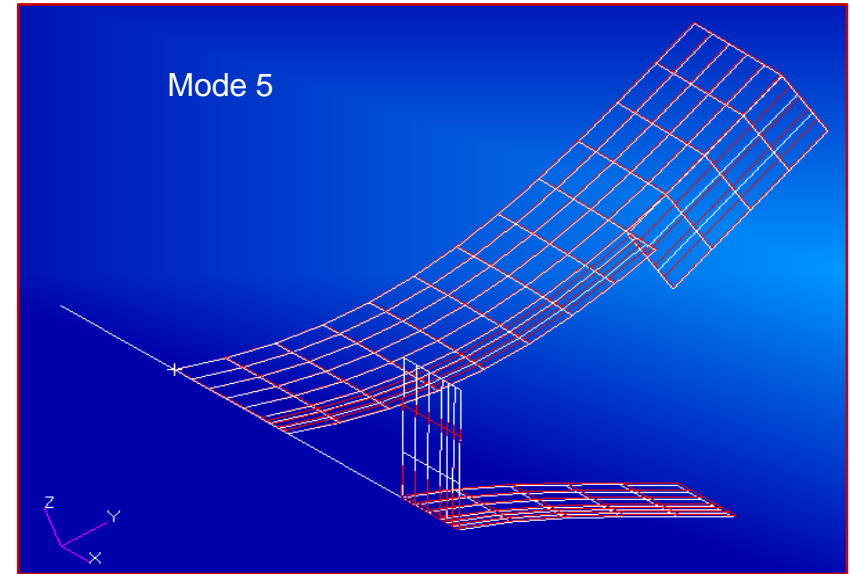
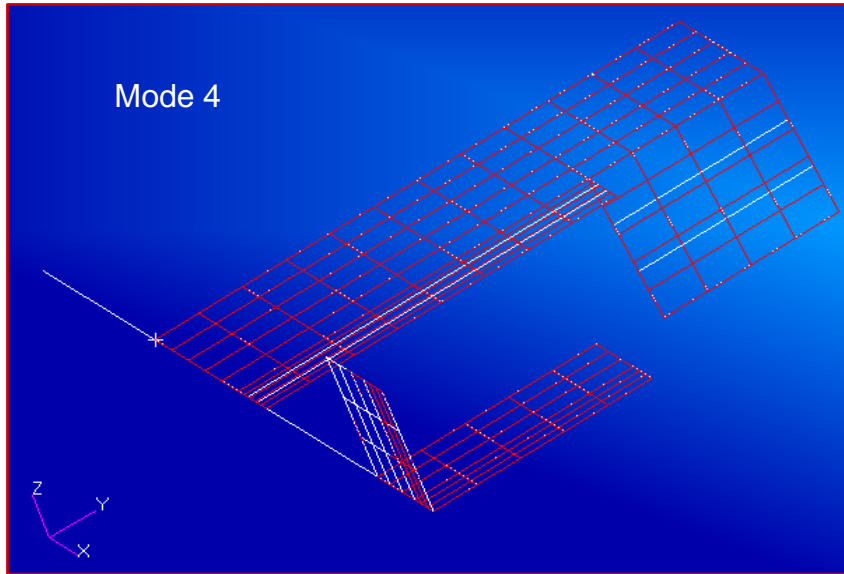
Verify Spline

- **Animate**

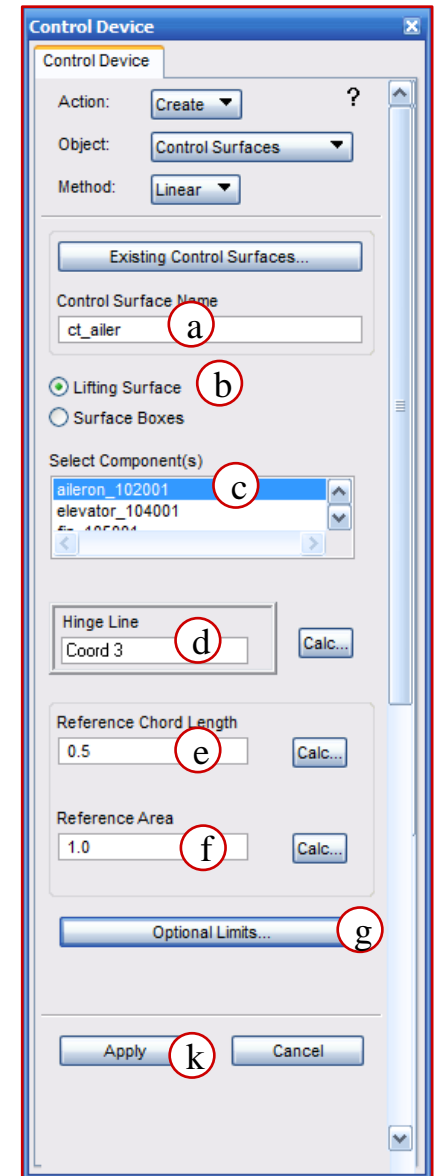
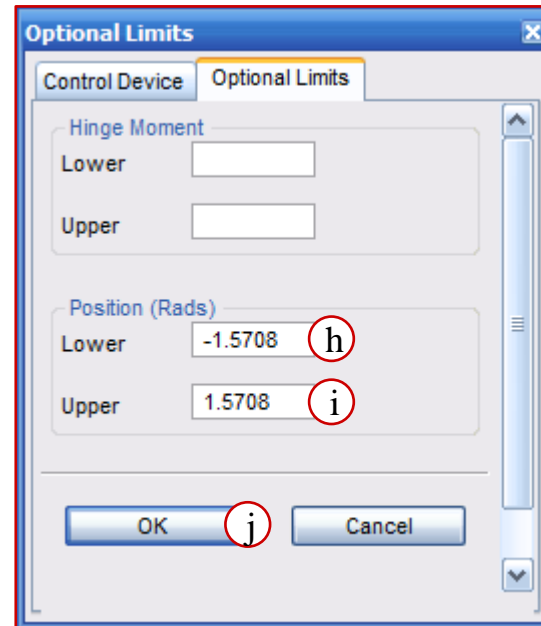
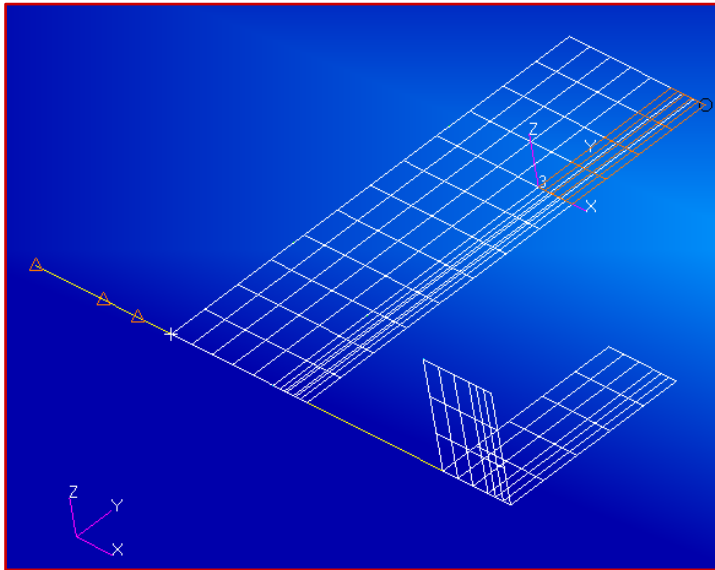
- Aeroelasticity click Aero-Structural Coupling
- Select Splines
- Auto Select Splines
- Select from available splines and pick the first non-rigid mode
- Click Apply to see the animation



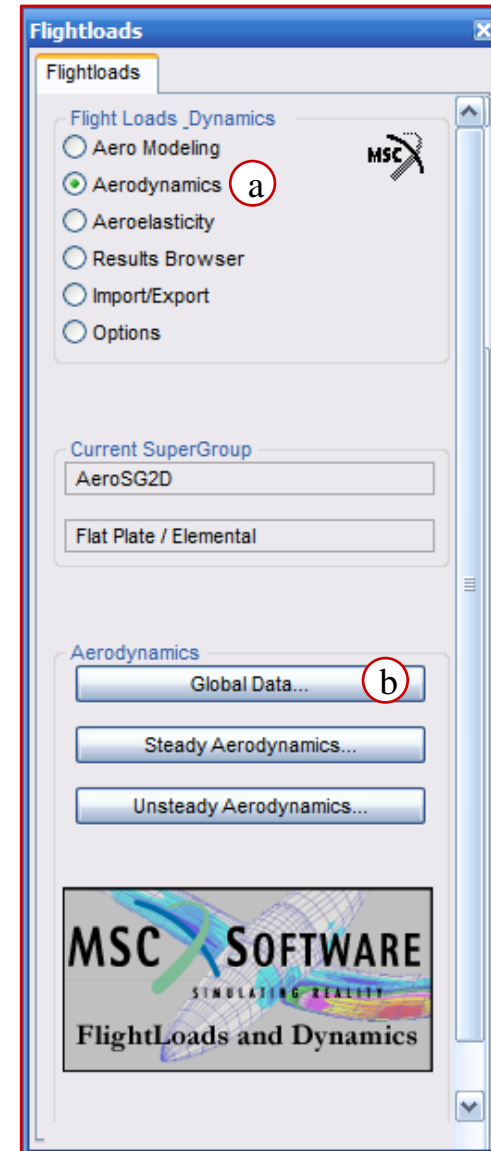
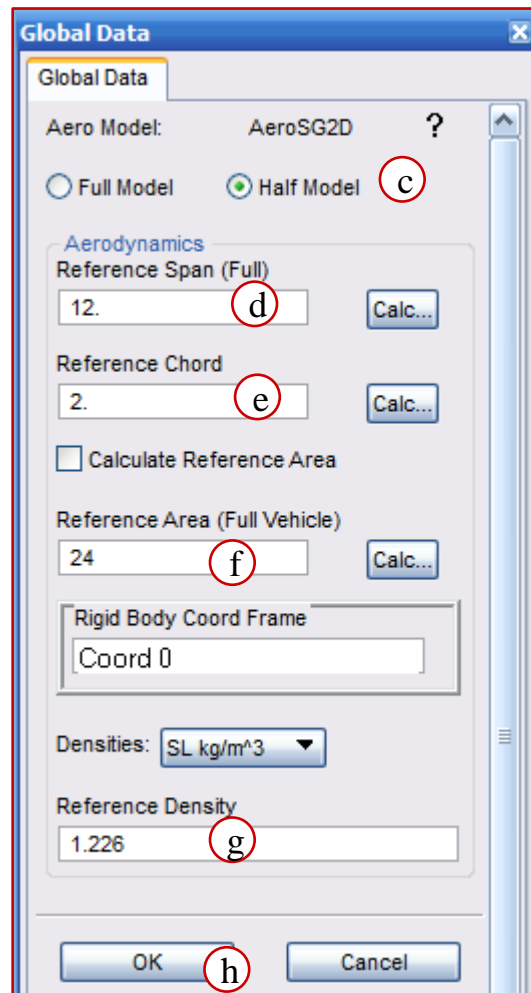
Verify Spline → Results



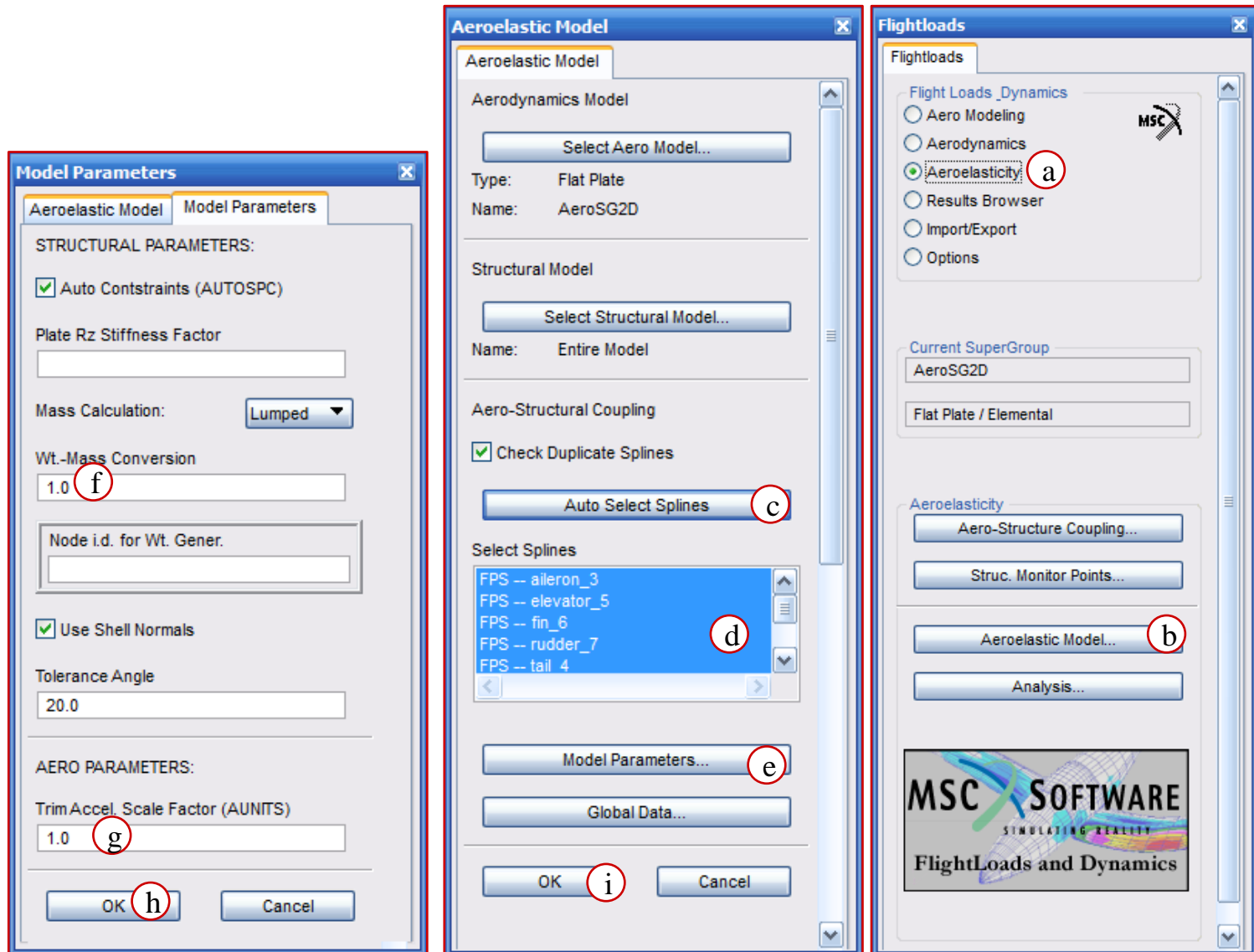
Define Control Surface for Aileron



Define Global Data for Aircraft

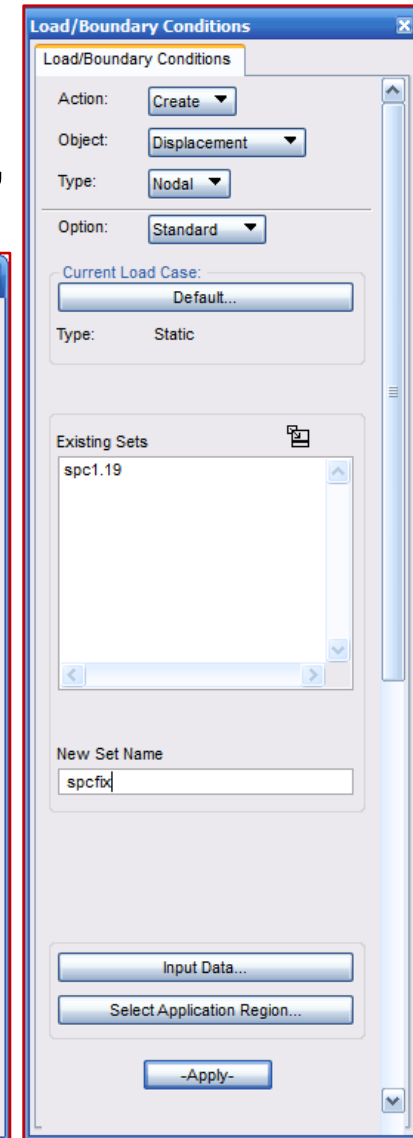
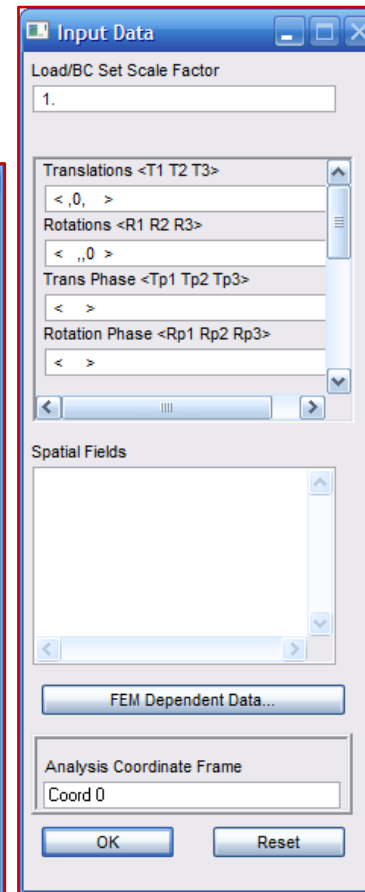
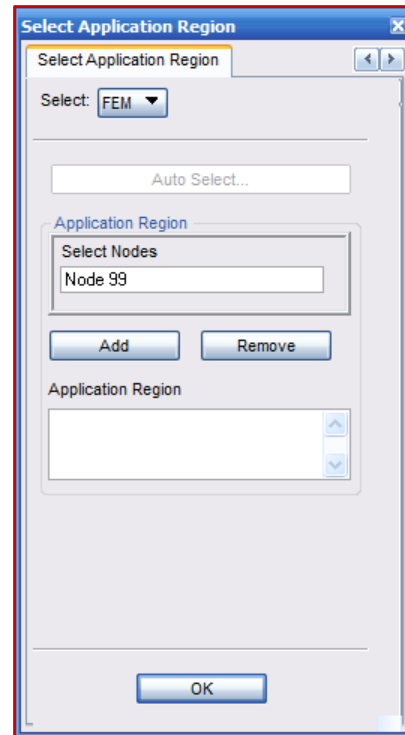


Define Model Parameters



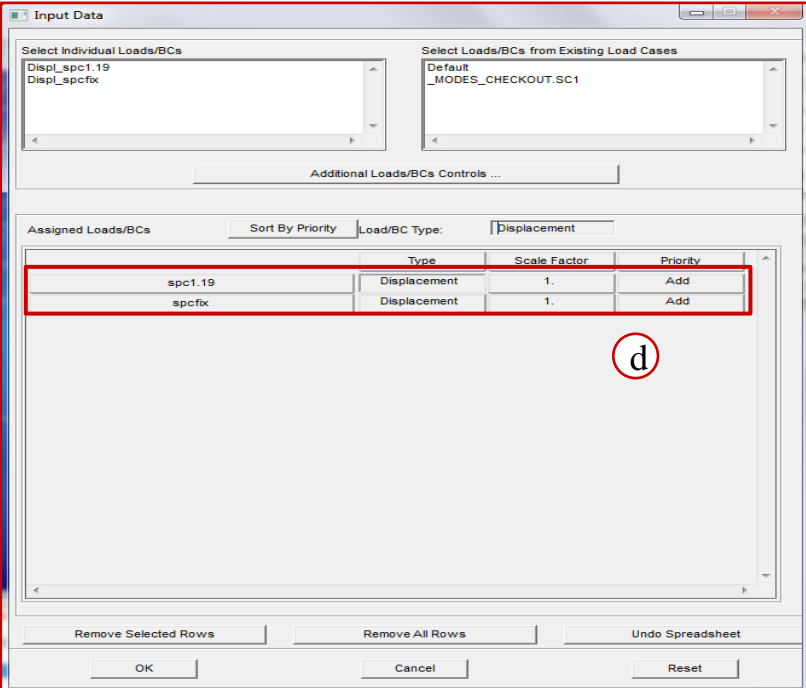
Add Structural BC to study Roll motion

- Switch to Structural Preference.
- Add constraint with 2nd and 6th dof fixed at node 99. Named it as spcfix. Now model is free in other 4 dof, so the rolling motion of model can be studied.



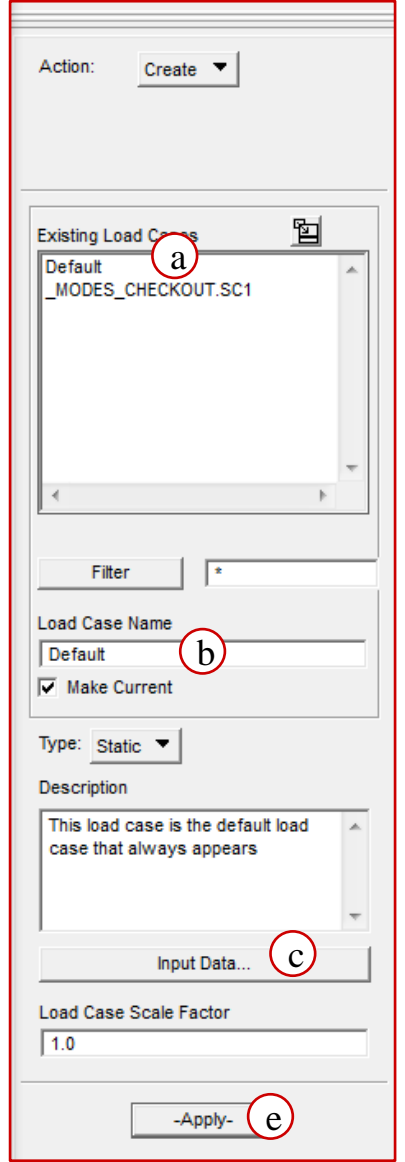
Create Loadcase

- Create Default Load case with Symmetry BC and Constraint in 26 Dof's at Node 99.



The 'Input Data' dialog box is shown. It has two list boxes at the top: 'Select Individual Loads/BCs' containing 'Disp_spc1.19' and 'Disp_spcfx', and 'Select Loads/BCs from Existing Load Cases' containing 'Default' and '_MODES_CHECKOUT.SC1'. Below these is an 'Additional Loads/BCs Controls ...' button. The main section is 'Assigned Loads/BCs' with a table. The table has columns: 'Type', 'Scale Factor', and 'Priority'. Two rows are listed: 'spc1.19' with Type 'Displacement', Scale Factor '1.', and Priority 'Add'; and 'spcfx' with Type 'Displacement', Scale Factor '1.', and Priority 'Add'. Below the table are buttons for 'Remove Selected Rows', 'Remove All Rows', and 'Undo Spreadsheet'. At the bottom are 'OK', 'Cancel', and 'Reset' buttons. A red box highlights the two rows in the table, and a red circle 'd' is next to the table area.

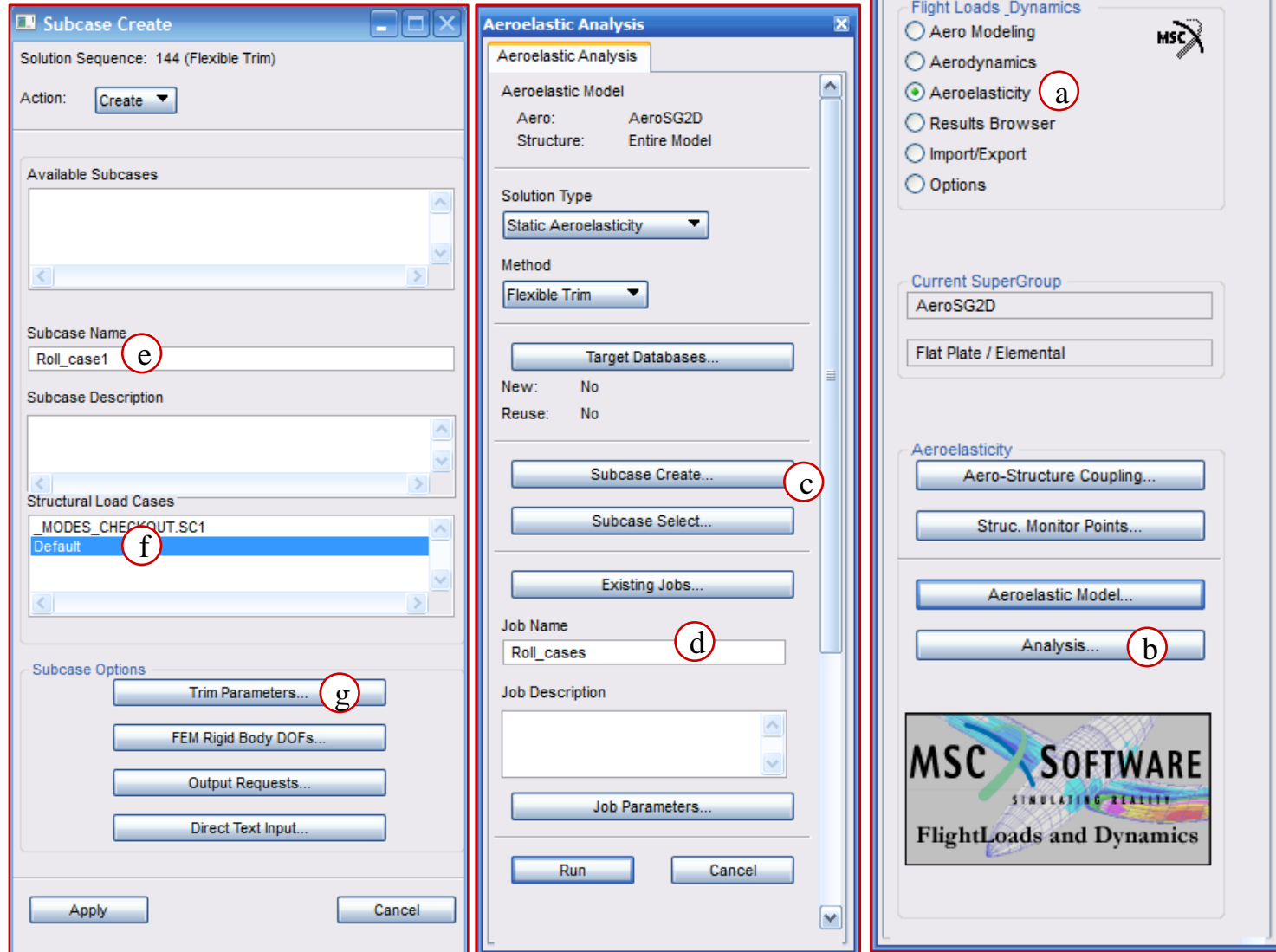
Type	Scale Factor	Priority
Displacement	1.	Add
Displacement	1.	Add



The 'Load Case' dialog box is shown. It has an 'Action:' dropdown set to 'Create'. Below is a list box 'Existing Load Cases' containing 'Default' and '_MODES_CHECKOUT.SC1'. A red circle 'a' is next to the list box. Below the list box is a 'Filter' button and a text field with an asterisk. The 'Load Case Name' section has a text field with 'Default' and a red circle 'b' next to it. Below is a checked 'Make Current' checkbox. The 'Type:' dropdown is set to 'Static'. The 'Description' text area contains the text 'This load case is the default load case that always appears'. Below the description is an 'Input Data...' button with a red circle 'c' next to it. The 'Load Case Scale Factor' text field contains '1.0'. At the bottom is a '-Apply-' button with a red circle 'e' next to it.

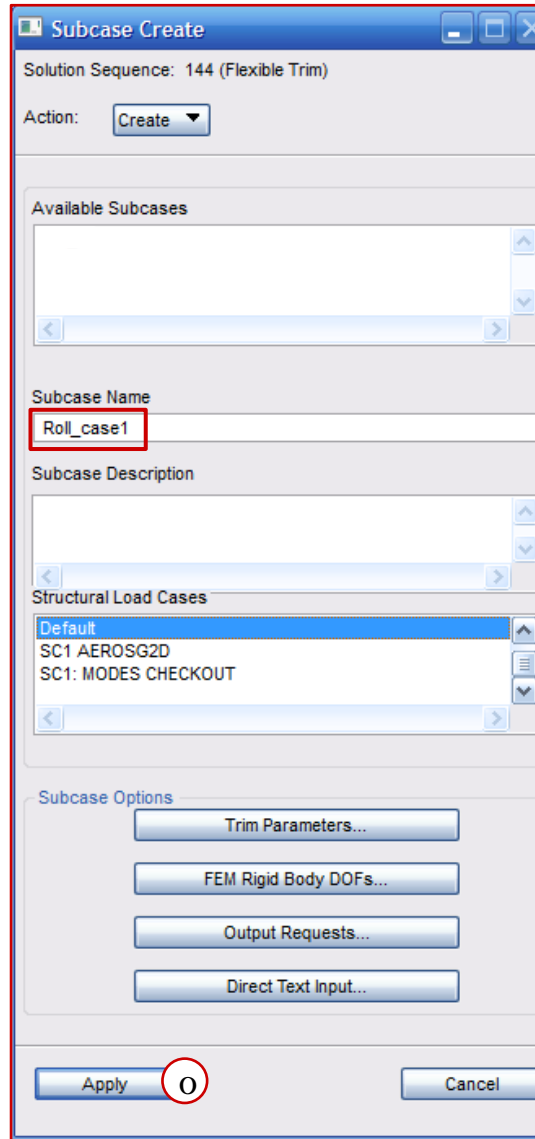
Setup For Trim Case

- Switch back to Aero elasticity Preference



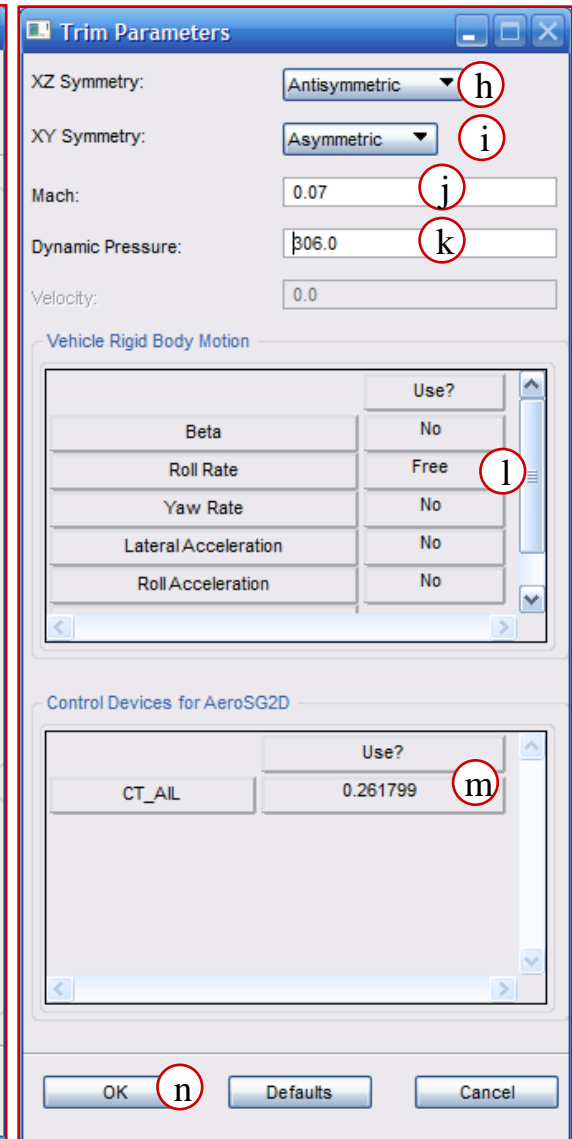
Job Setup for Roll Trim Analysis (Cont.)

- This procedure will write out the TRIM entry into the Nastran input deck
- Steady roll:
 - Aileron deflection: 15°
 - Roll rate to be determined



The Subcase Create dialog box is shown with the following settings:

- Solution Sequence: 144 (Flexible Trim)
- Action: Create
- Available Subcases: (empty list)
- Subcase Name: Roll_case1
- Subcase Description: (empty text area)
- Structural Load Cases: Default, SC1 AEROSG2D, SC1: MODES CHECKOUT
- Subcase Options: Trim Parameters..., FEM Rigid Body DOFs..., Output Requests..., Direct Text Input...
- Buttons: Apply, Cancel



The Trim Parameters dialog box is shown with the following settings:

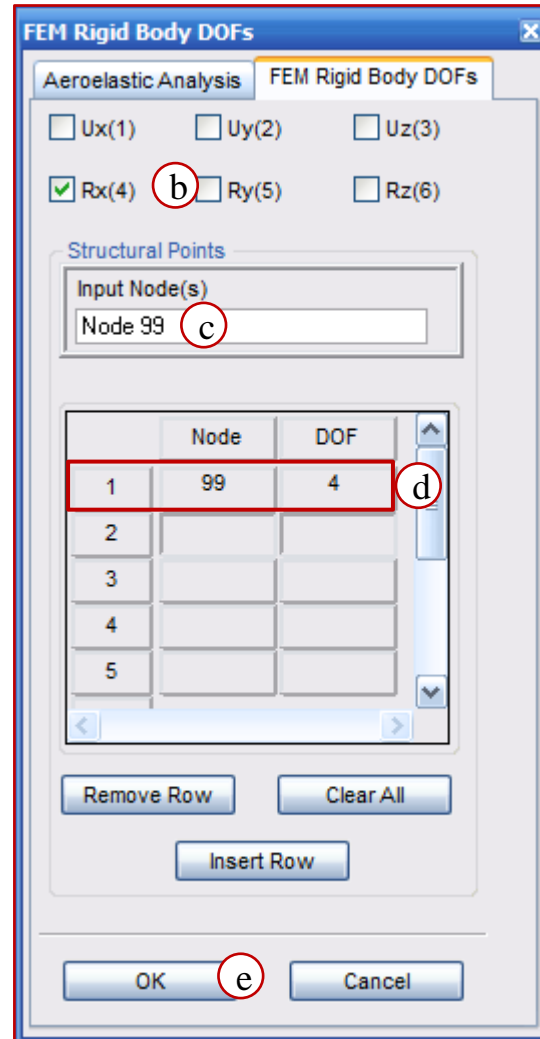
- XZ Symmetry: Antisymmetric
- XY Symmetry: Asymmetric
- Mach: 0.07
- Dynamic Pressure: 306.0
- Velocity: 0.0
- Vehicle Rigid Body Motion:

	Use?
Beta	No
Roll Rate	Free
Yaw Rate	No
Lateral Acceleration	No
Roll Acceleration	No
- Control Devices for AeroSG2D:

	Use?
CT_AIL	0.261799
- Buttons: OK, Defaults, Cancel

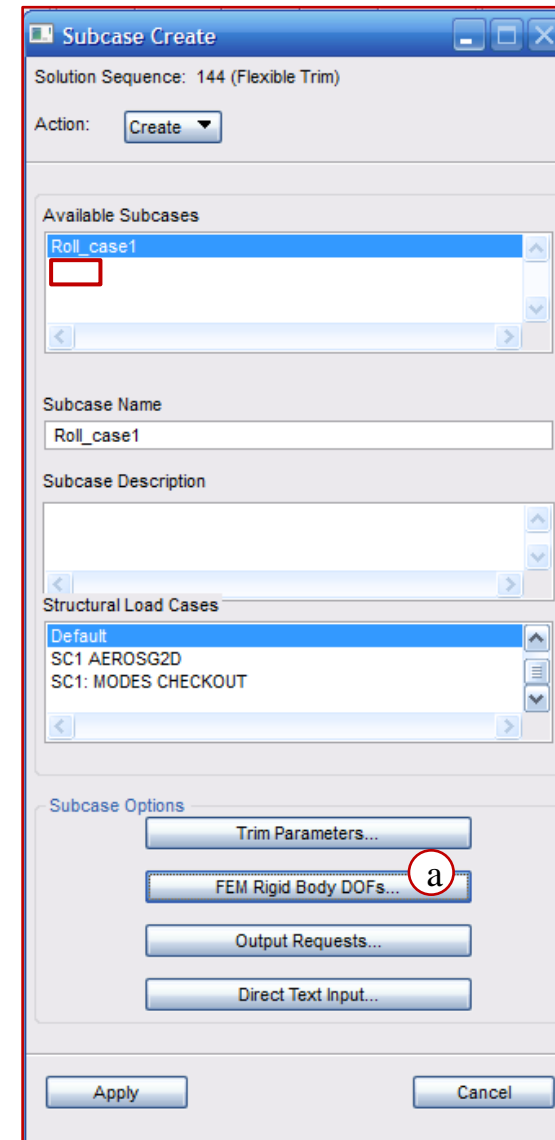
Define FEM Rigid Body DOFs

- This will write the SUPORT1 entry in the Case control and Begin Bulk Section



The dialog box is titled "FEM Rigid Body DOFs" and has two tabs: "Aeroelastic Analysis" and "FEM Rigid Body DOFs". The "FEM Rigid Body DOFs" tab is active. It contains several checkboxes for degrees of freedom: Ux(1), Uy(2), Uz(3), Rx(4), Ry(5), and Rz(6). The Rx(4) checkbox is checked and circled with a red 'b'. Below these is a section titled "Structural Points" with an "Input Node(s)" text box containing "Node 99" and circled with a red 'c'. Below that is a table with columns "Node" and "DOF". The first row is highlighted with a red box and circled with a red 'd', showing "1" in the "Node" column and "4" in the "DOF" column. Below the table are buttons for "Remove Row", "Clear All", and "Insert Row". At the bottom are "OK" and "Cancel" buttons, with the "OK" button circled with a red 'e'.

	Node	DOF
1	99	4
2		
3		
4		
5		



The dialog box is titled "Subcase Create" and shows the "Solution Sequence: 144 (Flexible Trim)". The "Action:" dropdown is set to "Create". It has sections for "Available Subcases" (showing "Roll_case1" selected), "Subcase Name" (set to "Roll_case1"), "Subcase Description", "Structural Load Cases" (showing "Default", "SC1 AEROSG2D", and "SC1: MODES CHECKOUT"), and "Subcase Options". In the "Subcase Options" section, the "FEM Rigid Body DOFs..." button is circled with a red 'a'. At the bottom are "Apply" and "Cancel" buttons.

Table of Remaining 6 → Roll trim cases

- The same procedure as shown for Roll_case1 needs to be repeated for 6 different mach no's and Dynamic pressure as shown in Table below.

- **Steady roll:**

- Aileron deflection: 15°
- Roll rate to be determined

- **Investigate roll rate at varying speeds**

- Roll Rate is derived from Trim Variable
ROLL

$$\text{ROLL} = \frac{\text{roll rate} \cdot \text{semi span}}{\text{Velocity}}$$

Mach No	Q
0.07	306.01
0.13	1224.05
0.20	2754.11
0.26	4896.20
0.33	7650.31
0.39	11016.44
0.46	14994.60

Roll Results from F06 file for Subcase 1

3

SUBCASE 1

AEROSTATIC DATA RECOVERY OUTPUT TABLES
 CONFIGURATION = AEROSG2D XY-SYMMETRY = ASYMMETRIC XZ-SYMMETRY = ANTISYMMETRIC
 MACH = 7.000000E-02 Q = 3.060000E+02
 CHORD = 2.0000E+00 SPAN = 1.2000E+01 AREA = 1.2000E+01

TRIM ALGORITHM USED: LINEAR TRIM SOLUTION WITHOUT REDUNDANT CONTROL SURFACES.

AEROELASTIC TRIM VARIABLES

ID	LABEL	TYPE	TRIM STATUS	VALUE OF UX	
	INTERCEPT	RIGID BODY	FIXED	1.000000E+00	
1	CT_AIL	CONTROL SURFACE	FIXED	2.617990E-01	RADIANS
1	ANGLEA	RIGID BODY	FIXED	0.000000E+00	RADIANS
2	SIDES	RIGID BODY	FIXED	0.000000E+00	RADIANS
3	ROLL	RIGID BODY	FREE	8.677795E-02	NONDIMEN. RATE
4	PITCH	RIGID BODY	FIXED	0.000000E+00	NONDIMEN. RATE
5	YAW	RIGID BODY	FIXED	0.000000E+00	NONDIMEN. RATE
6	URDD1	RIGID BODY	FIXED	0.000000E+00	LENGTH/S/S
7	URDD2	RIGID BODY	FIXED	0.000000E+00	LENGTH/S/S
8	URDD3	RIGID BODY	FIXED	0.000000E+00	LENGTH/S/S
9	URDD4	RIGID BODY	FIXED	0.000000E+00	RADIANS/S/S
10	URDD5	RIGID BODY	FIXED	0.000000E+00	RADIANS/S/S
11	URDD6	RIGID BODY	FIXED	0.000000E+00	RADIANS/S/S

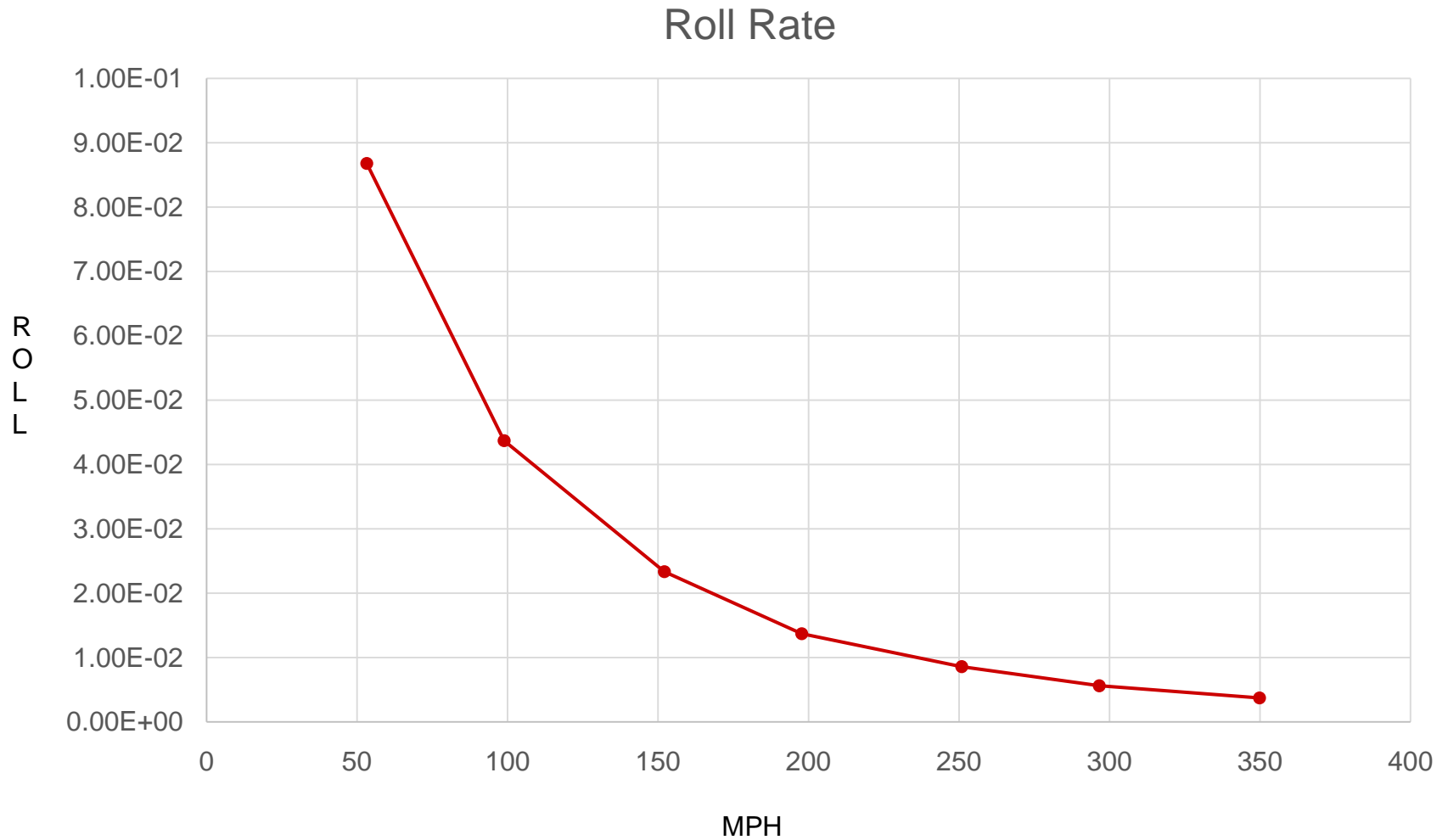
CONTROL SURFACE POSITION AND HINGE MOMENT RESULTS

ACTIVE LIMITS ARE FLAGGED WITH AN (A), VIOLATED LIMITS ARE FLAGGED WITH A (V).

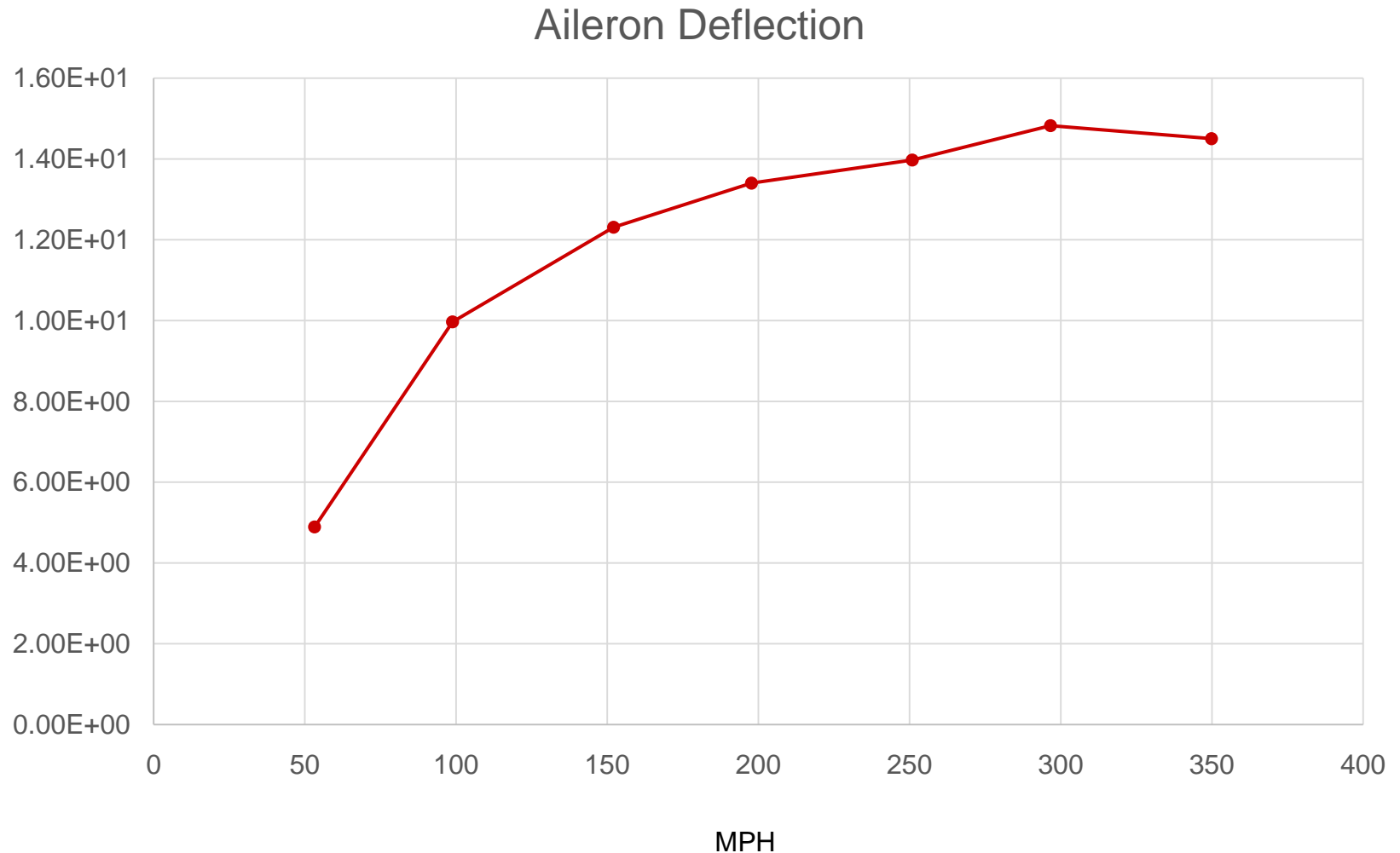
	CONTROL SURFACE	LOWER LIMIT	POSITION VALUE	UPPER LIMIT	LOWER LIMIT	HINGE MOMENT VALUE	UPPER LIMIT
	CT_AIL	-9.000020E+01	2.617990E-01	9.000021E+01	N/A	-1.663455E+01	N/A
1	MSC.NASTRAN AEROELASTIC JOB CREATED ON 02-APR-17 AT 15:52:33				APRIL 2, 2017	MSC Nastran 7/ 3/15	PAGE 16
	DEFAULT						

- The roll rate value needs to be noted for each subcase to create a Graph of the Roll at analysed Speed

Roll Rate

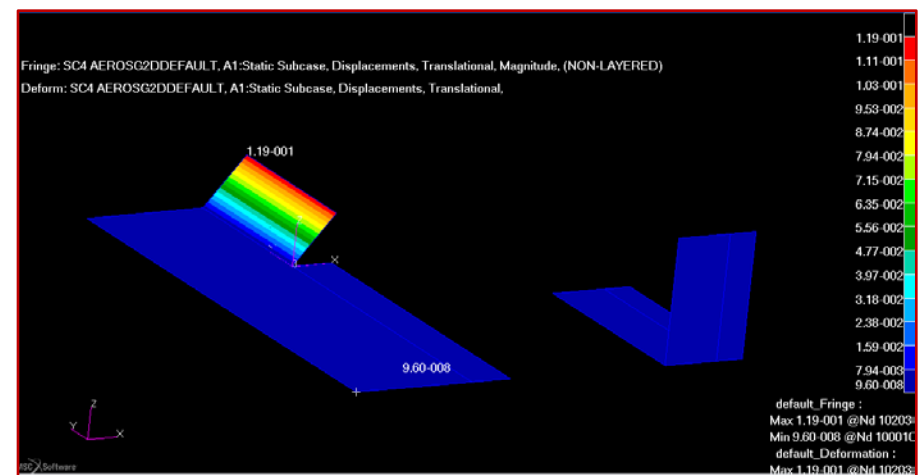
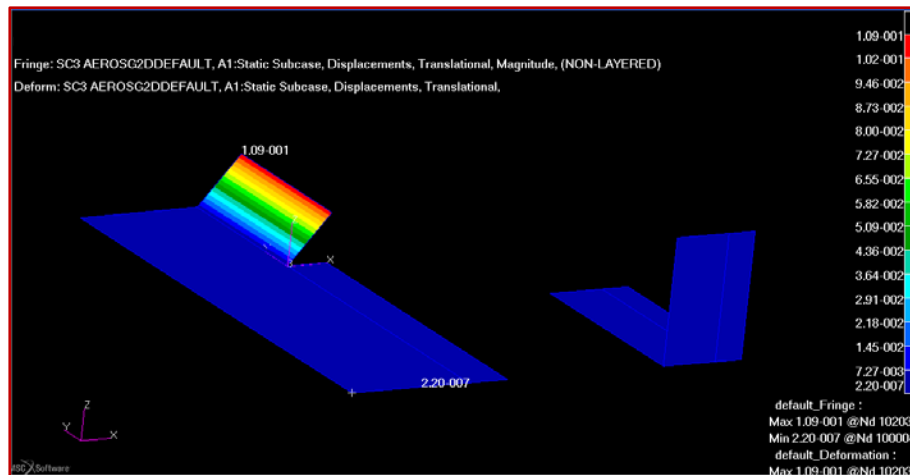
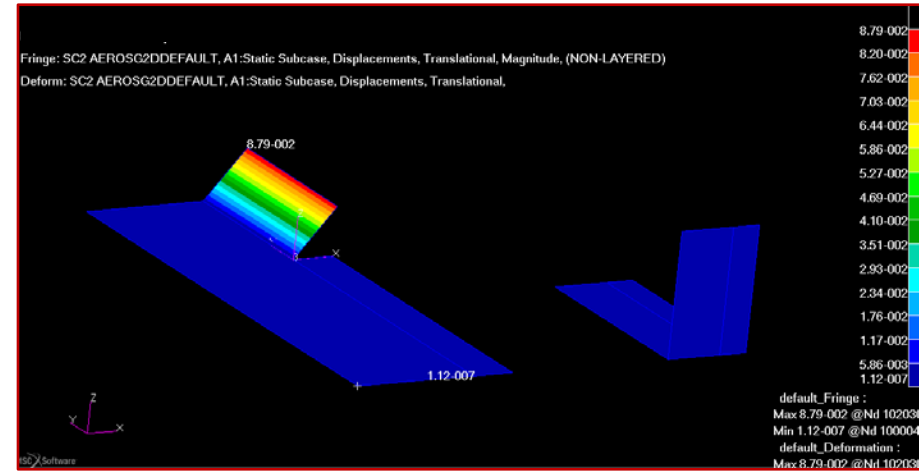
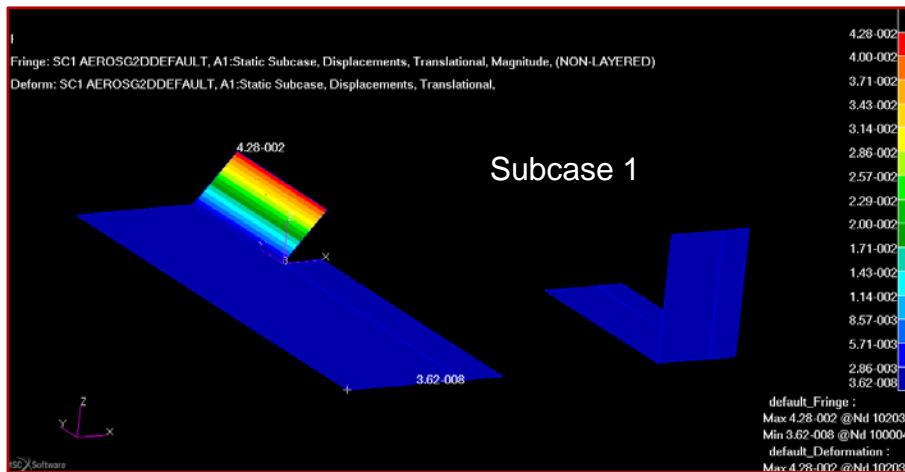


Aileron Deflection



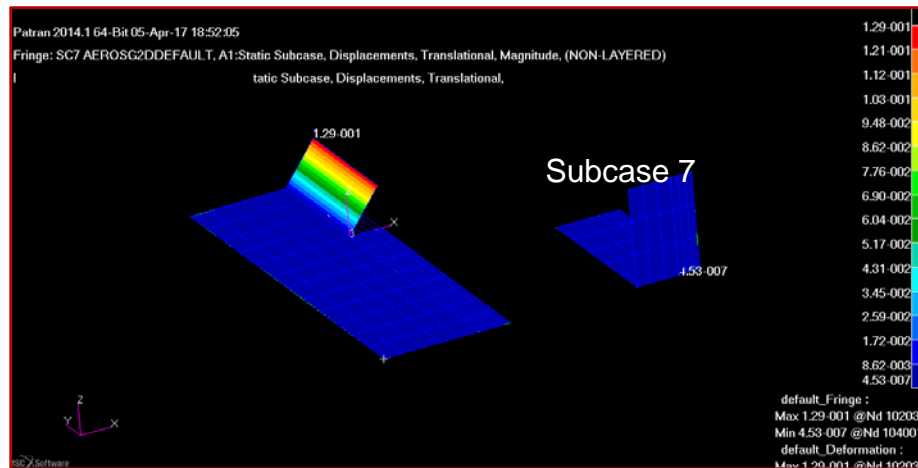
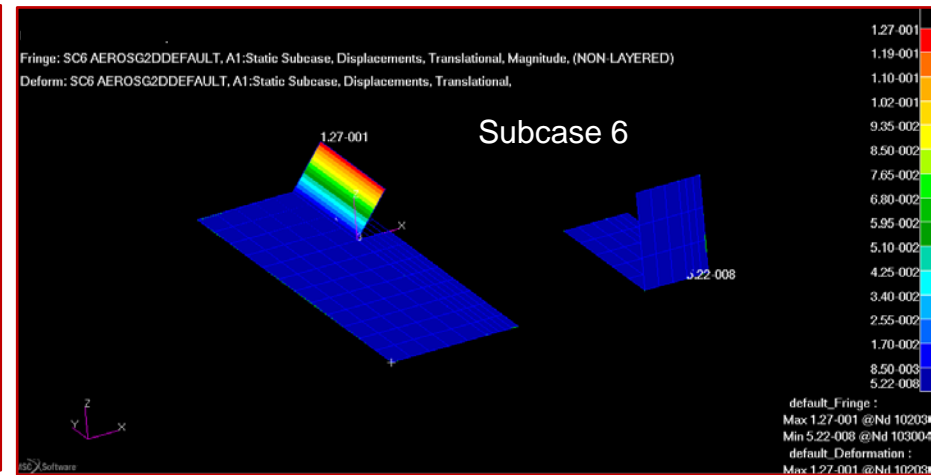
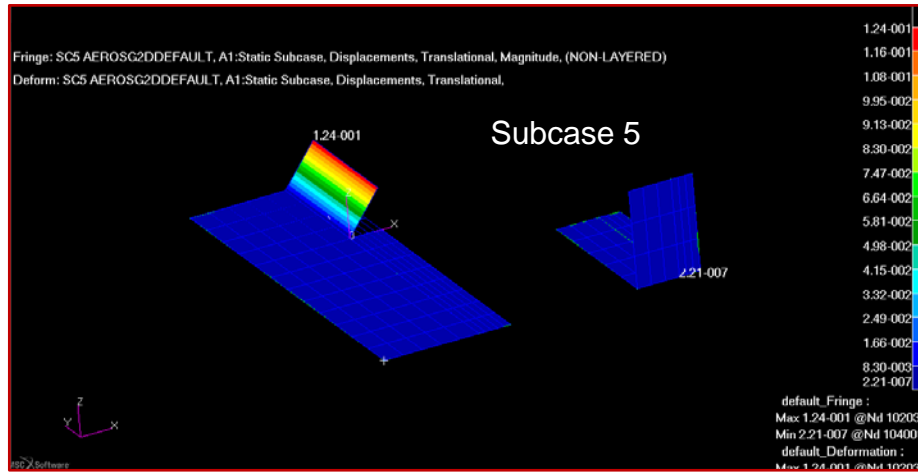
This values can be got by measuring the deflection angle of aileron wrt flat surface. Procedure for doing this has been added as an appendix section.

Results → Displacements

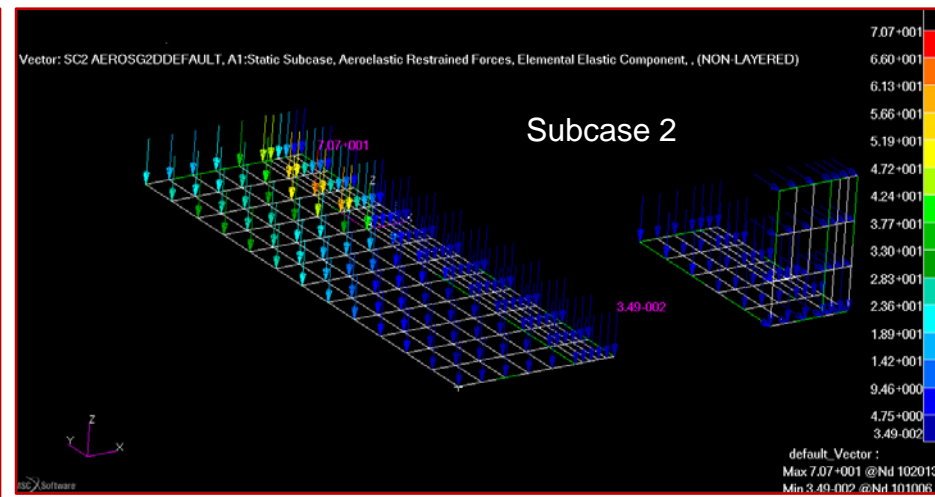
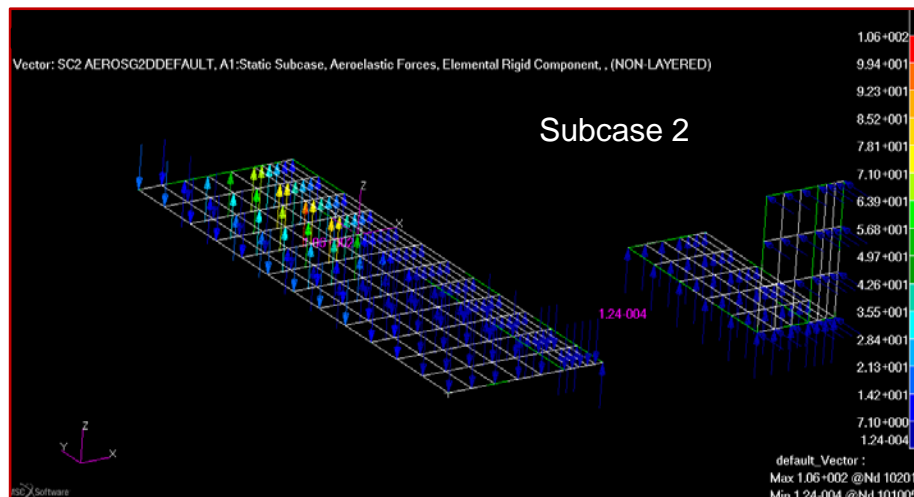
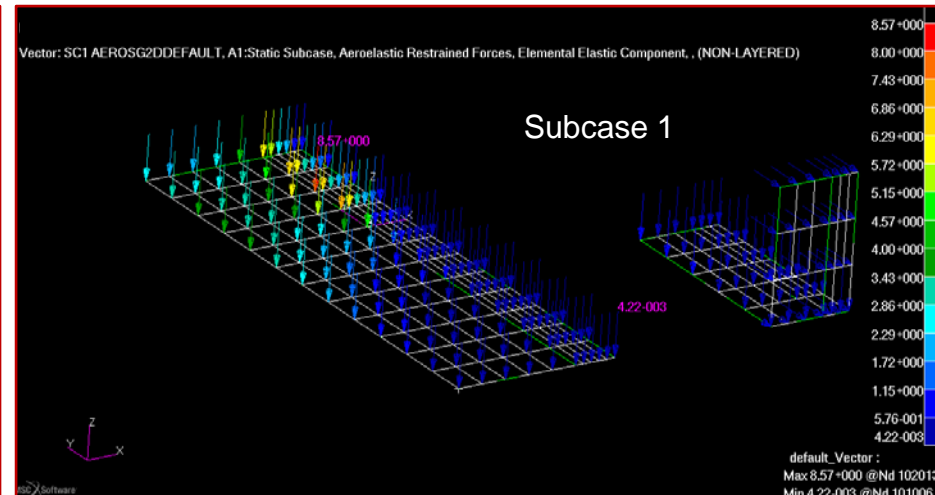
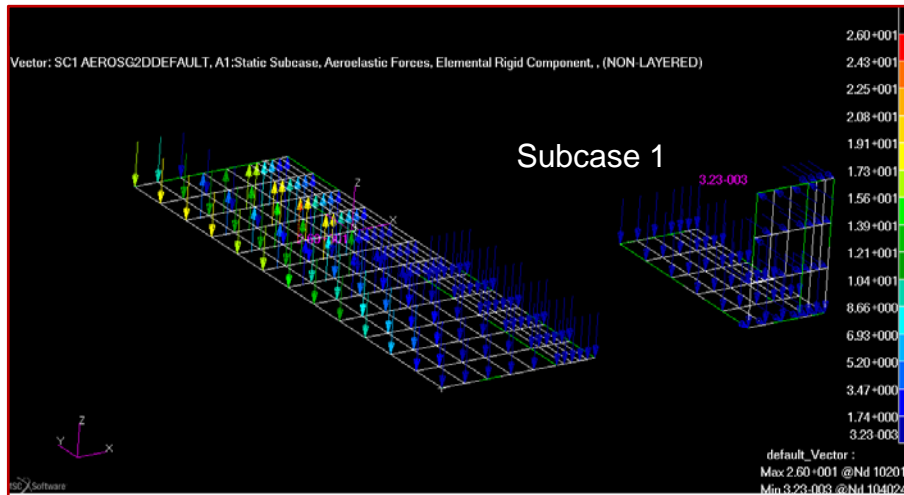


Only Aero-Mesh Posted

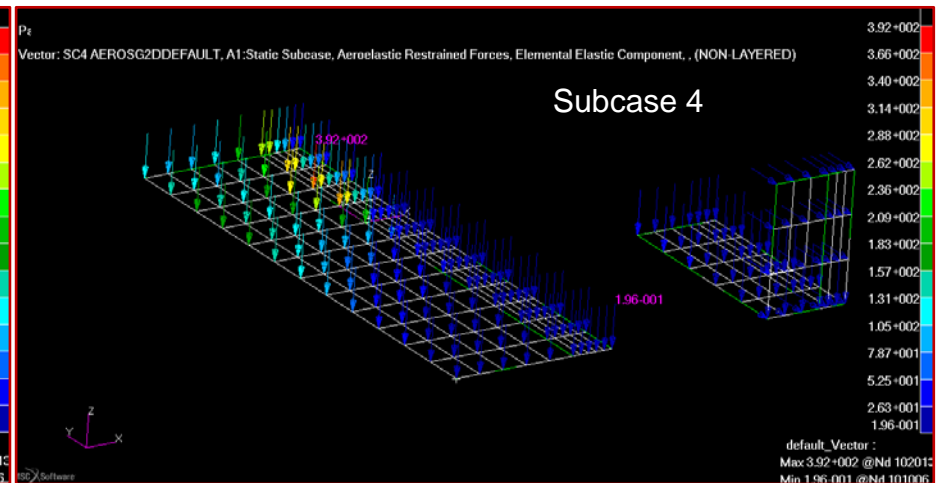
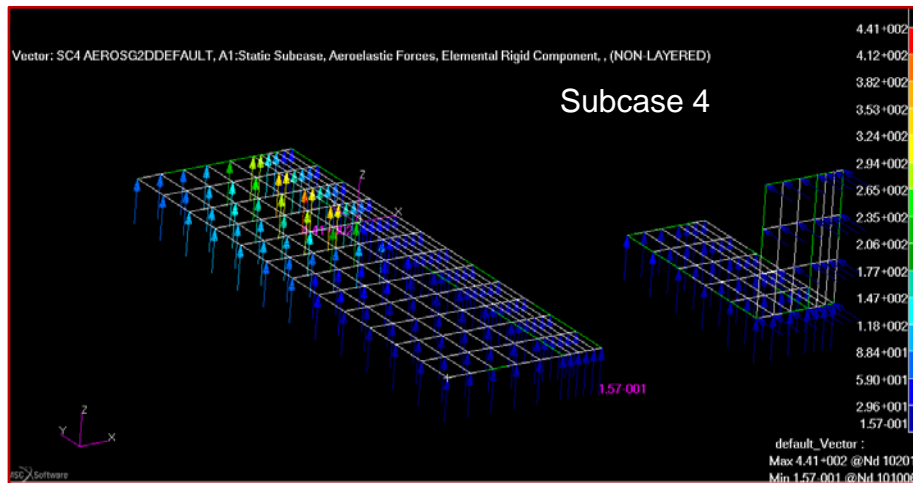
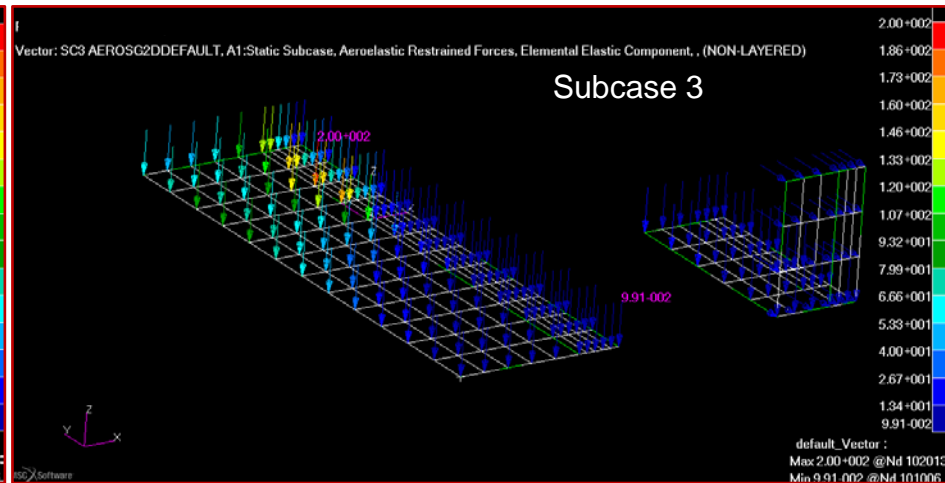
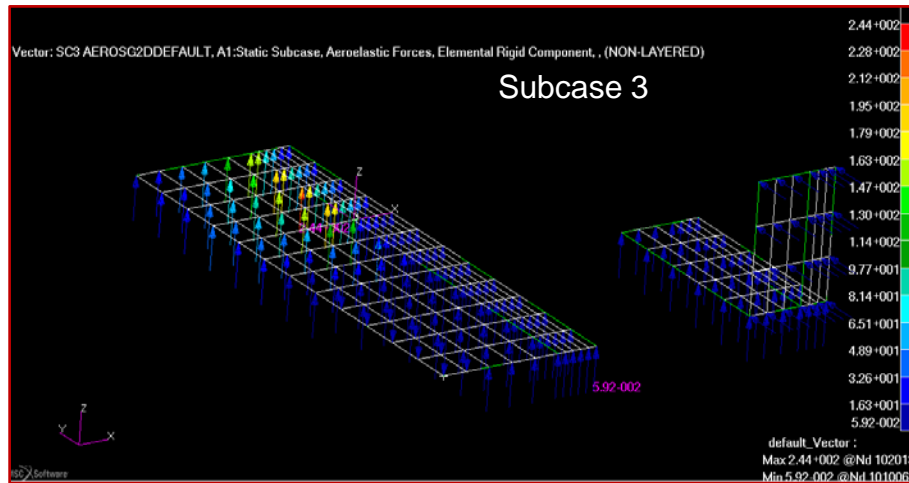
Results → Displacements (Cont.)



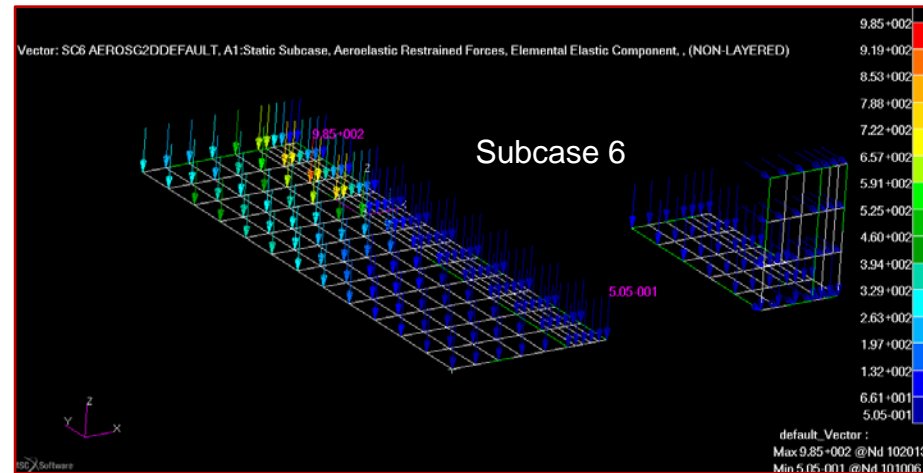
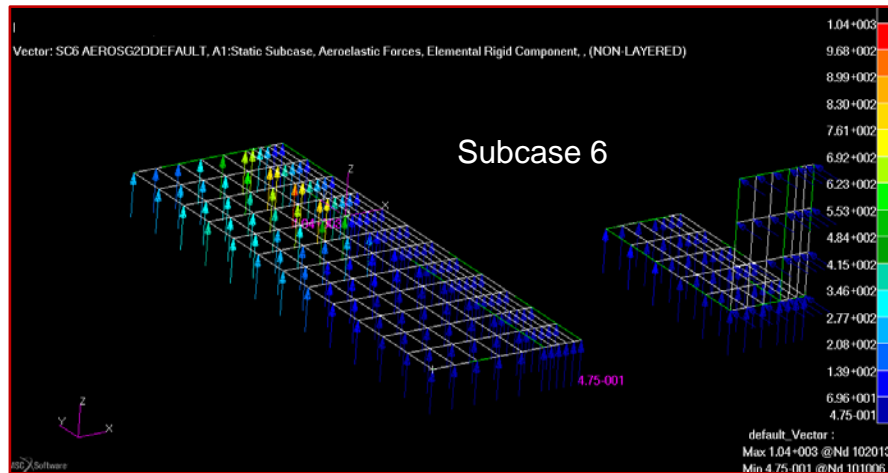
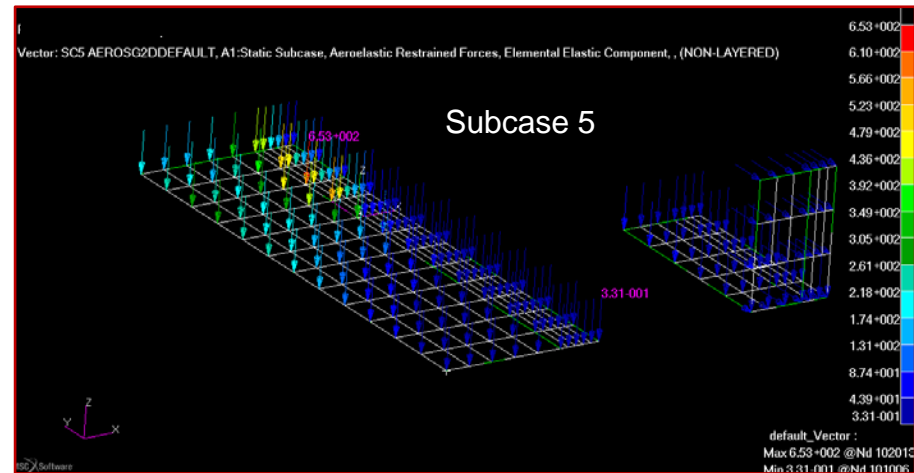
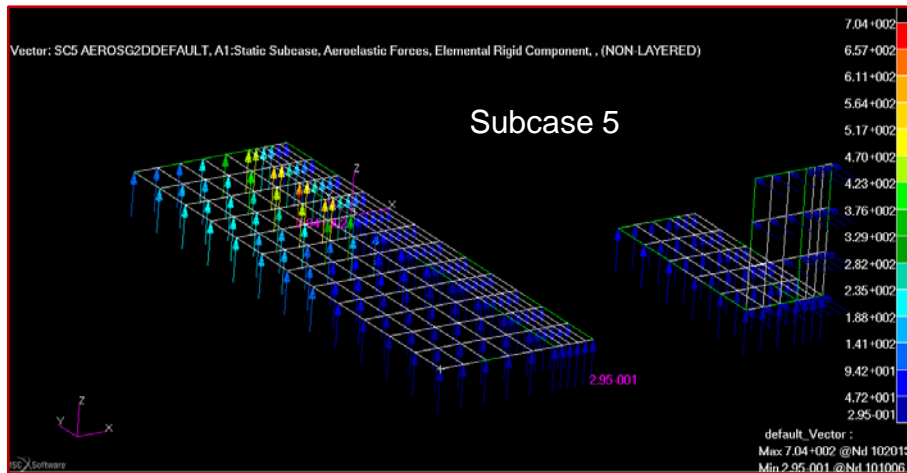
Results → Aero Forces, Elemental Rigid & Aero Restrained Forces, Elemental Elastic



Results → Aero Forces, Elemental Rigid & Aero Restrained Forces, Elemental Elastic



Results → Aero Forces, Elemental Rigid & Aero Restrained Forces, Elemental Elastic



Results → Aero Forces, Elemental Rigid & Aero Restrained Forces, Elemental Elastic

