Webinar:
Introduction to Nastran Mass and Weight Checks

Tommy Board, ATA Engineering

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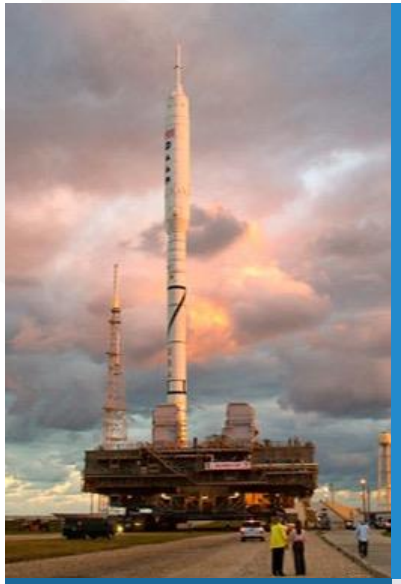

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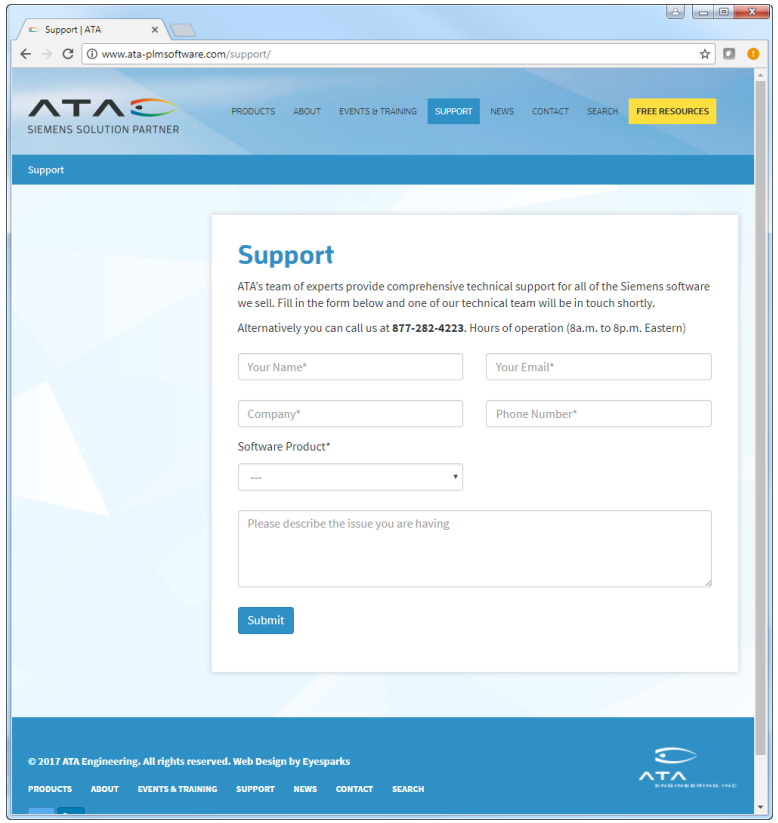

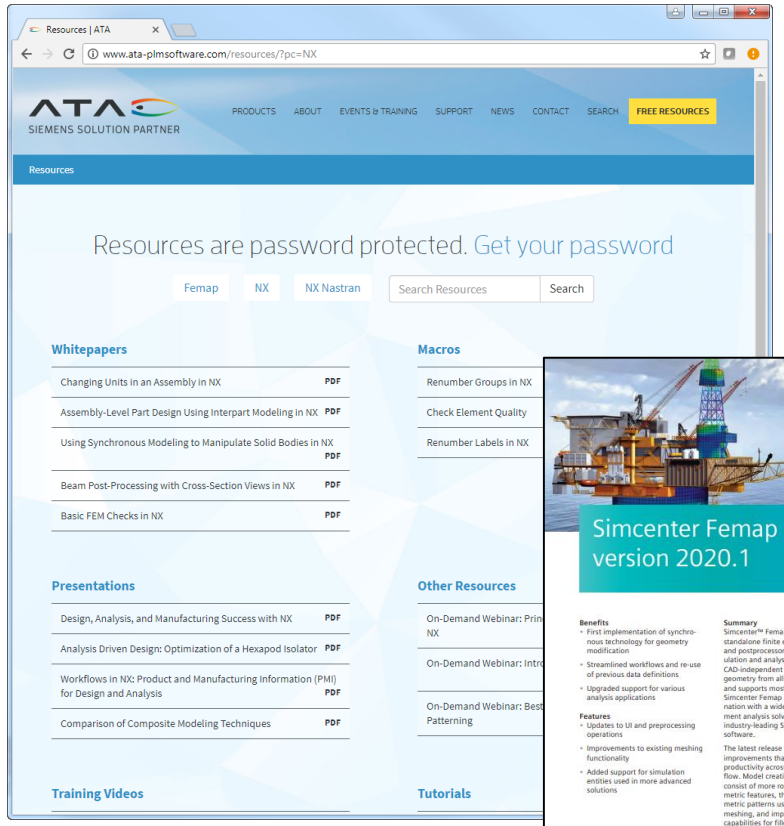

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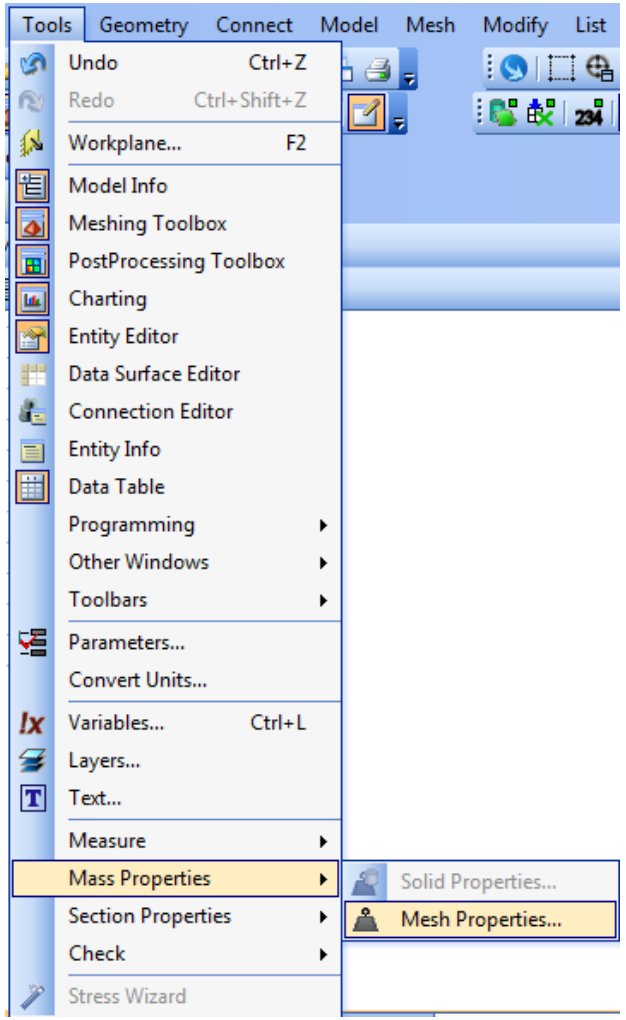
Why do we check mass/weight?

- **Mass checks**: the process of verifying that the mass of each component matches a specified value and adjusting the model as needed
- For dynamic analysis or load cases where acceleration loads are applied, correct mass representation is needed to accurately predict results
- **WEIGHTCHECK**: the Nastran tool that prints out mass properties for different DOF sets
- WEIGHTCHECK tool can provide insight into other modeling errors such as connections between parts and can help you check units

Checking Mass in Simcenter Femap



- Tools → Mass Properties → Mesh Properties
- Select all elements
- Review the message window

Check Mass Properties
15456 Element(s) Selected...

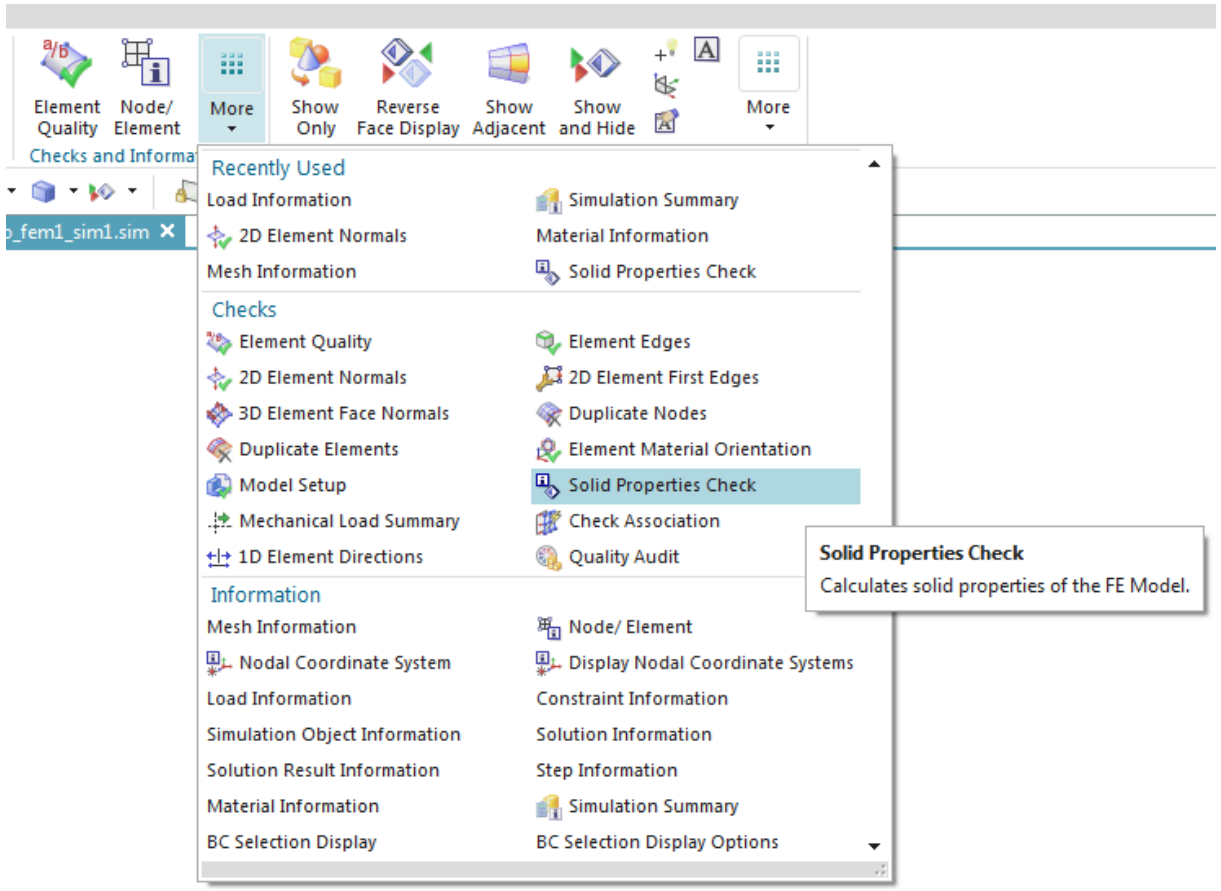
	Mass	Center_of_Gravity_in_CSys_0 X	Y	Z
Structural	3.37261E-7	0.	0.108398	0.
NonStructural	0.	0.	0.	0.
Total	3.37261E-7	0.	0.108398	0.

Inertias_in_CSys_0	Ixx	Iyy	Izz	Ixy	Iyz	Izx
About_CSys	8.08073E-9	2.11068E-9	6.07354E-9	0.	0.	0.
About_CG	4.11788E-9	2.11068E-9	2.11068E-9	0.	0.	0.

Total_Length (Line_Elements_only) = 0.
Total_Area (Area_Elements_only) = 0.
Total_Volume (All_Elements) = 0.00132842

Checking Mass in Simcenter 3D

You can access this tool from the .fem or the .sim



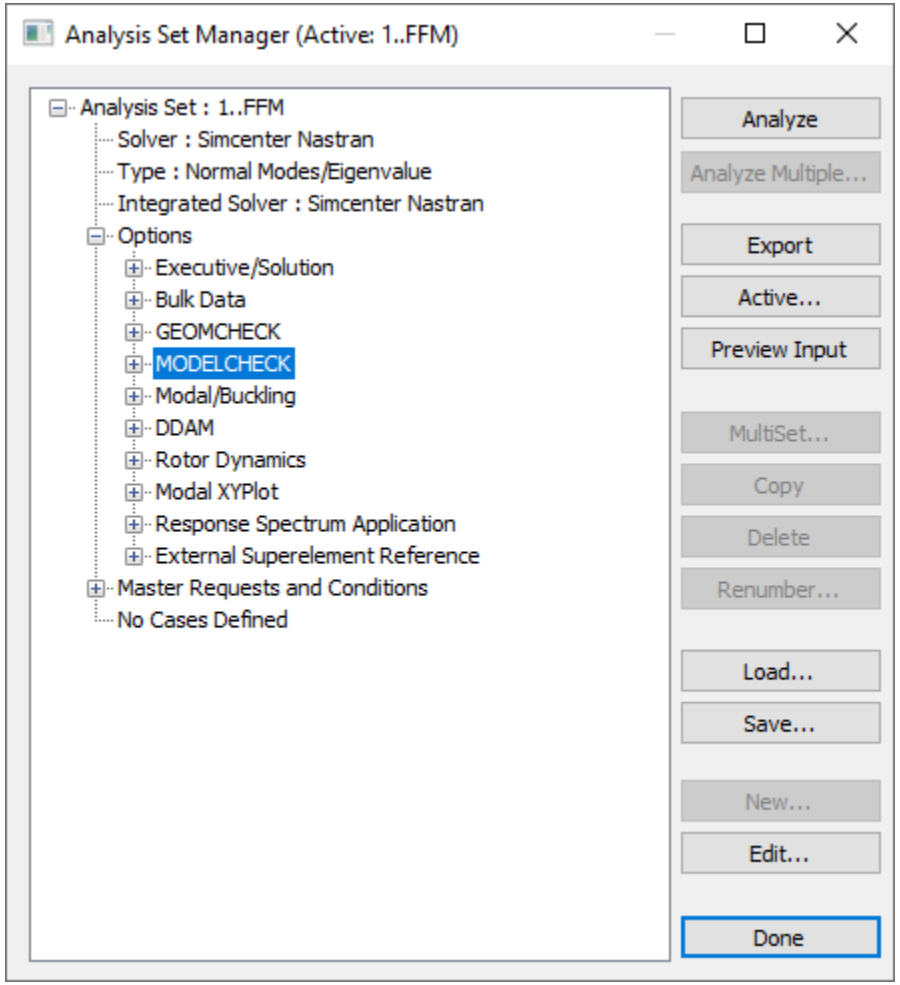
- On the Home ribbon, More → Solid Properties Check
  - Select all elements
  - Turn on all options
- Review the message area contents:
  - Mass, Volume, CG, Inertia, etc.
- Note: Don't include CONM1 elements in pre-processor mass checks. CONM1 mass is direction dependent, so NX will automatically exclude these elements from the Solid Properties Check. WEIGHTCHECK will correctly calculate the directional mass.

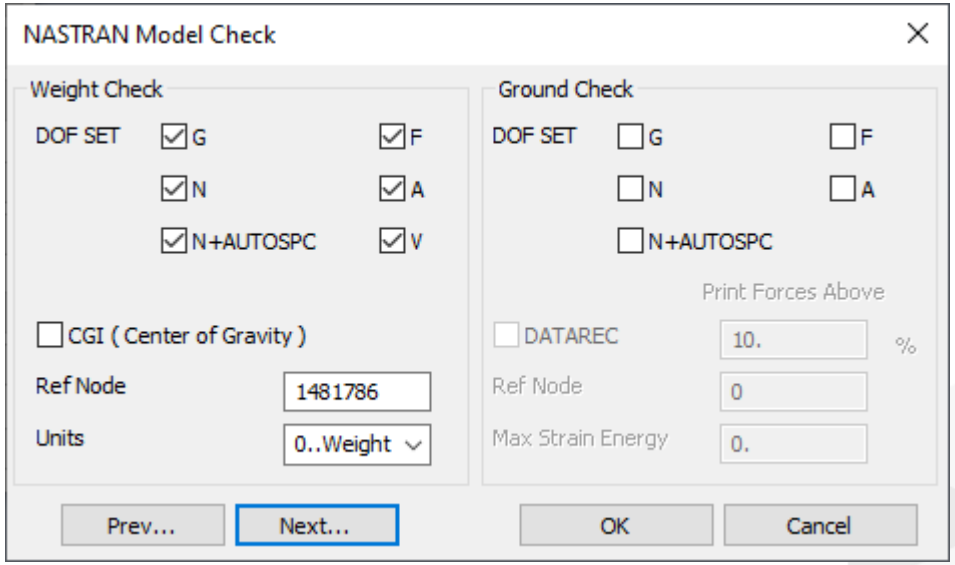
How Much Mass Checking Should I Do?

- Minimal check: List the mass of the entire model. Verify against expected mass.
- Best Practice: List mass by group or component. Verify against expected mass and CG of each component.
  - A FEMAP macro has been created that lists mass, CG, etc. based on groups
  - https://www.ata-plmsoftware.com/resources/print-femap-group-summary-to-excel/
- Different ways to do mass matching
  - Adjust density of the material
  - Add non-structural mass to a mesh

Nastran WEIGHTCHECK: How to Set It Up in Femap

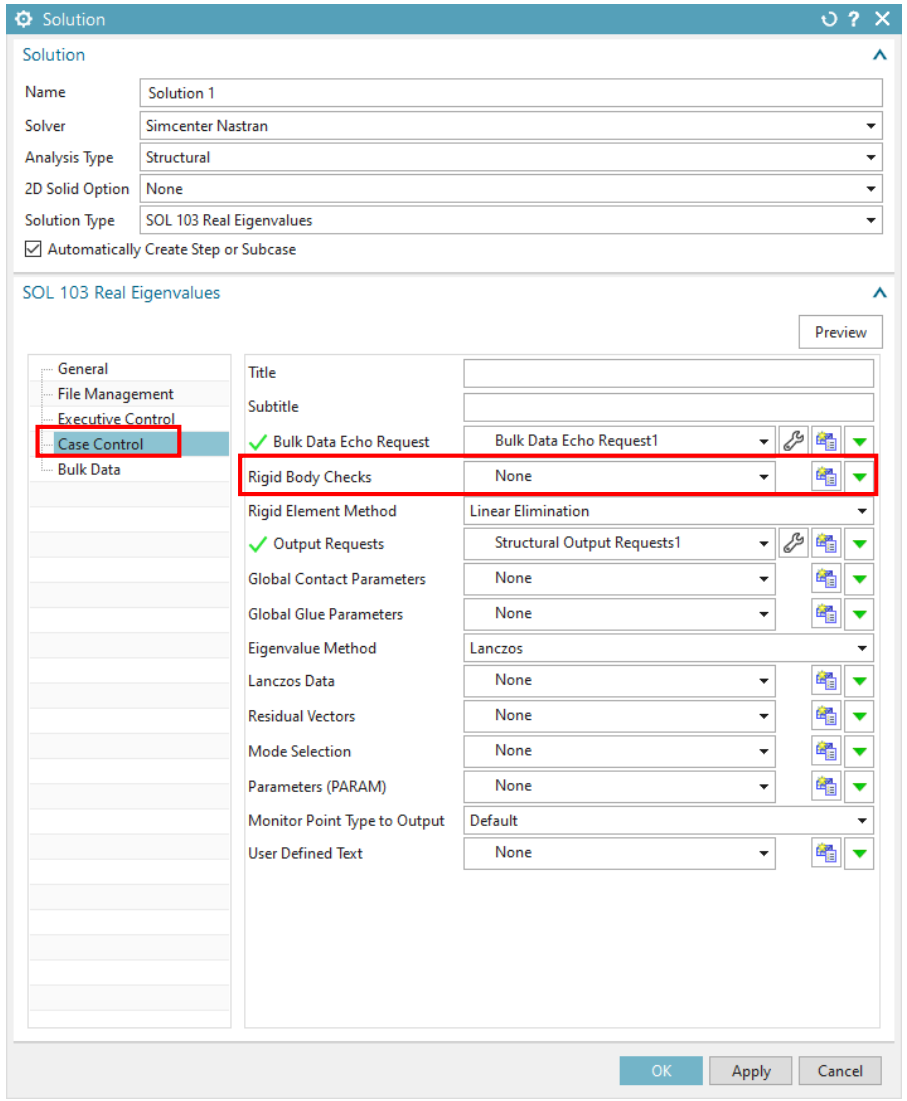
In Femap, weight check is available in the Analysis Set Manager

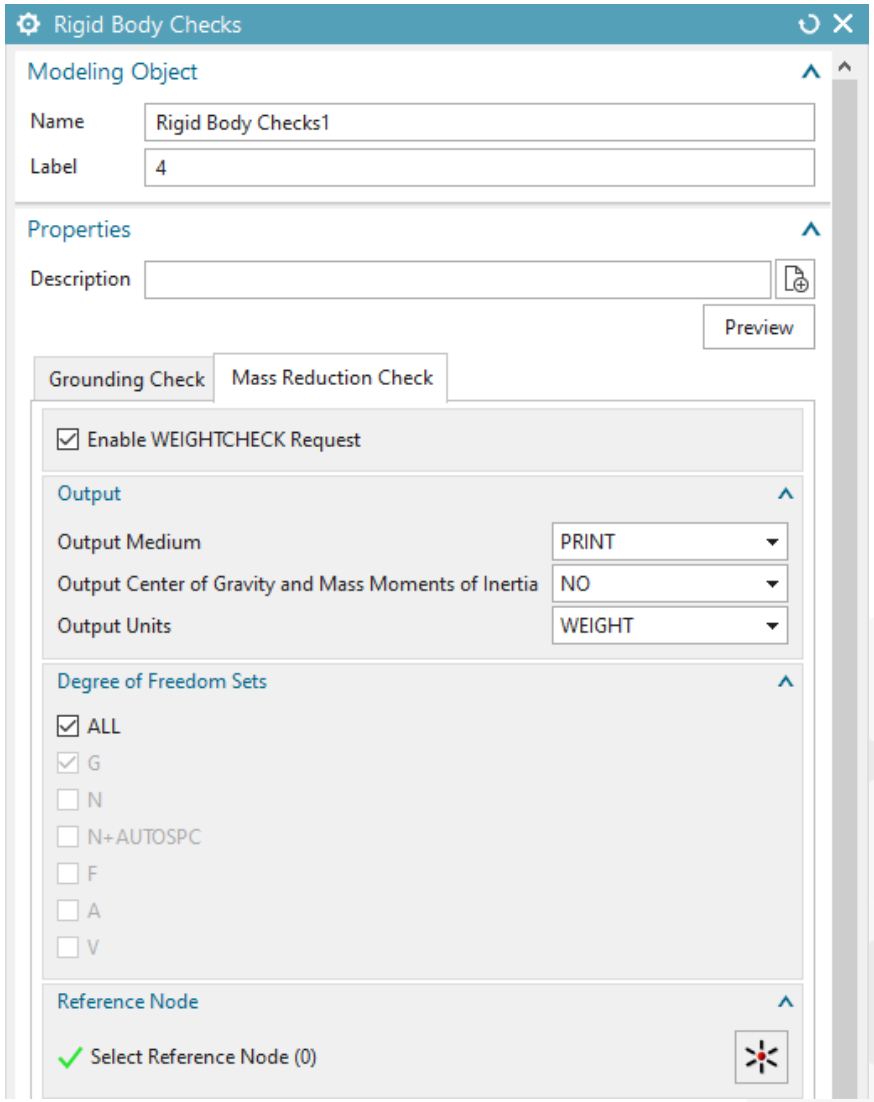




How to Set Up WEIGHTCHECK in Simcenter 3D

In Simcenter, weight check is available in the Solution window





How to Set Up WEIGHTCHECK in Nastran

- WEIGHTCHECK reports the mass properties of a part, including mass moment of inertia and center of mass

```
WEIGHTCHECK(PRINT,SET=(ALL),GRID=1481786,CGI=NO,WEIGHT)=YES
```

Print weightcheck results to the .f06 file

Check at least the G, N, and A sets, and make sure the mass is the same across sets

Requests CG and inertia data (if NO, this data is only printed for G set)

Can choose results in weight or mass units

Weightcheck depends on a reference location

- If no grid is specified, origin of the Nastran basic CSYS is used
- If the origin is far from the center of the mesh, specify a different grid ID near the CG of the assembly

See next slide for more information about sets

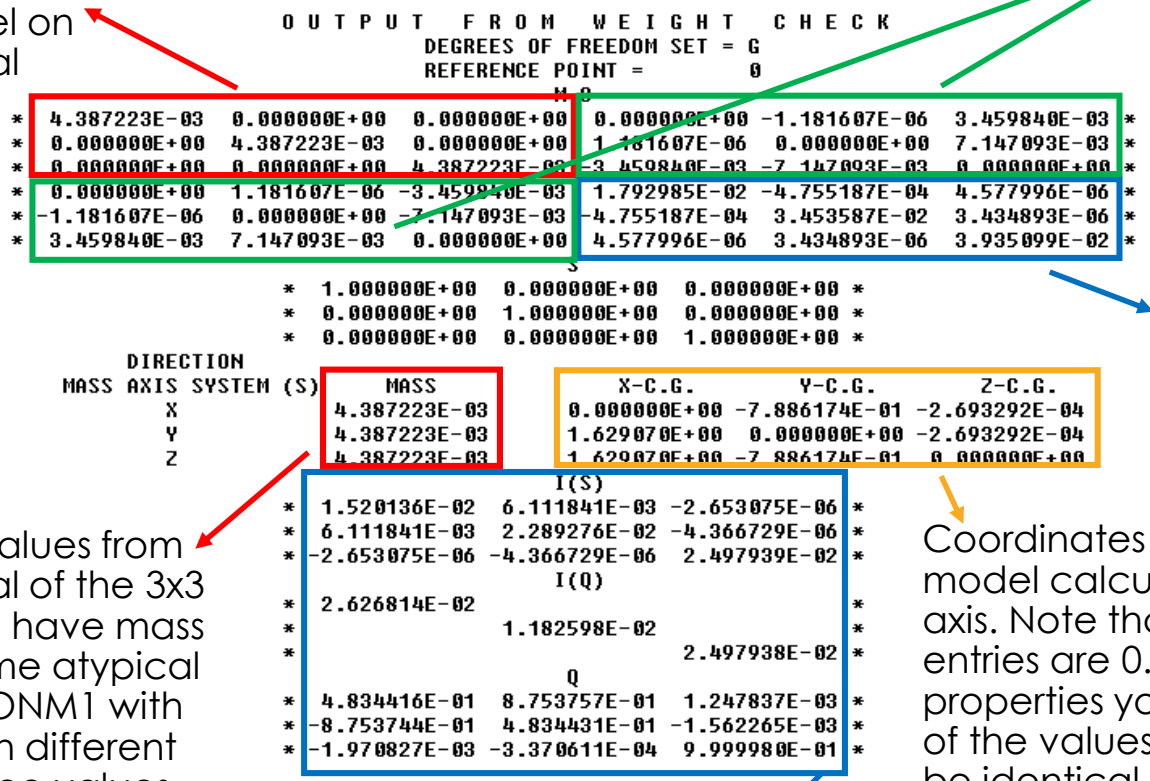
Understanding Nastran Sets

- Response of a FEM defined in terms of DOF
  - 6 DOF per GRID, 1 DOF per SPOINT/EPOINT
- All DOF in Nastran placed in sets
  - G-set: All DOF (except EPOINTs)
  - M-set: All dependent DOF (RBE2, RBE3, MPC)
  - N-set: G-set minus M-set (all independent DOF)
  - S-set: All restrained DOF (user and AUTOSPC)
  - F-set: All free DOF (N-set minus S-set)
  - O-set: Interior or "Omitted" DOF
  - A-set: Solution DOF (F-set minus O-set)
  - Q-set: Modal DOF
  - B-set: Physical DOF held fixed in CMS modal solution
  - C-set: Physical DOF free to vibrate in CMS modal solution

Sample Output from WEIGHTCHECK

3x3 matrix that lists the mass of the model on the main diagonal

Matrices used in the calculation of the center of gravity (CG) with respect to the reference point



```
                    O U T P U T   F R O M   W E I G H T   C H E C K
                                 DEGREES OF FREEDOM SET = G
                                 REFERENCE POINT =        0
                                          M O
*  4.387223E-03   0.000000E+00   0.000000E+00   0.000000E+00  -1.181607E-06   3.459840E-03 *
*  0.000000E+00   4.387223E-03   0.000000E+00   1.181607E-06   0.000000E+00   7.147093E-03 *
*  0.000000E+00   0.000000E+00   4.387223E-03  -3.459840E-03  -7.147093E-03   0.000000E+00 *
*  0.000000E+00   1.181607E-06  -3.459840E-03   1.792985E-02  -4.755187E-04   4.577996E-06 *
* -1.181607E-06   0.000000E+00  -7.147093E-03  -4.755187E-04   3.453587E-02   3.434893E-06 *
*  3.459840E-03   7.147093E-03   0.000000E+00   4.577996E-06   3.434893E-06   3.935099E-02 *
                                          S
                    *  1.000000E+00   0.000000E+00   0.000000E+00 *
                    *  0.000000E+00   1.000000E+00   0.000000E+00 *
                    *  0.000000E+00   0.000000E+00   1.000000E+00 *
          DIRECTION
     MASS AXIS SYSTEM (S)       MASS              X-C.G.          Y-C.G.          Z-C.G.
               X              4.387223E-03    0.000000E+00   -7.886174E-01   -2.693292E-04
               Y              4.387223E-03    1.629070E+00    0.000000E+00   -2.693292E-04
               Z              4.387223E-03    1.629070E+00   -7.886174E-01    0.000000E+00
                                          I(S)
                    *  1.520136E-02   6.111841E-03  -2.653075E-06 *
                    *  6.111841E-03   2.289276E-02  -4.366729E-06 *
                    * -2.653075E-06  -4.366729E-06   2.497939E-02 *
                                          I(Q)
                    *  2.626814E-02                                *
                    *                 1.182598E-02                 *
                    *                                2.497938E-02 *
                                           Q
                    *  4.834416E-01   8.753757E-01   1.247837E-03 *
                    * -8.753744E-01   4.834431E-01  -1.562265E-03 *
                    * -1.970827E-03  -3.370611E-04   9.999980E-01 *
```

Inertia properties of the model with respect to the reference point

Repeat of mass values from the main diagonal of the 3x3 matrix (unless you have mass elements with some atypical properties, like CONM1 with different masses in different directions, the three values should all be the same)

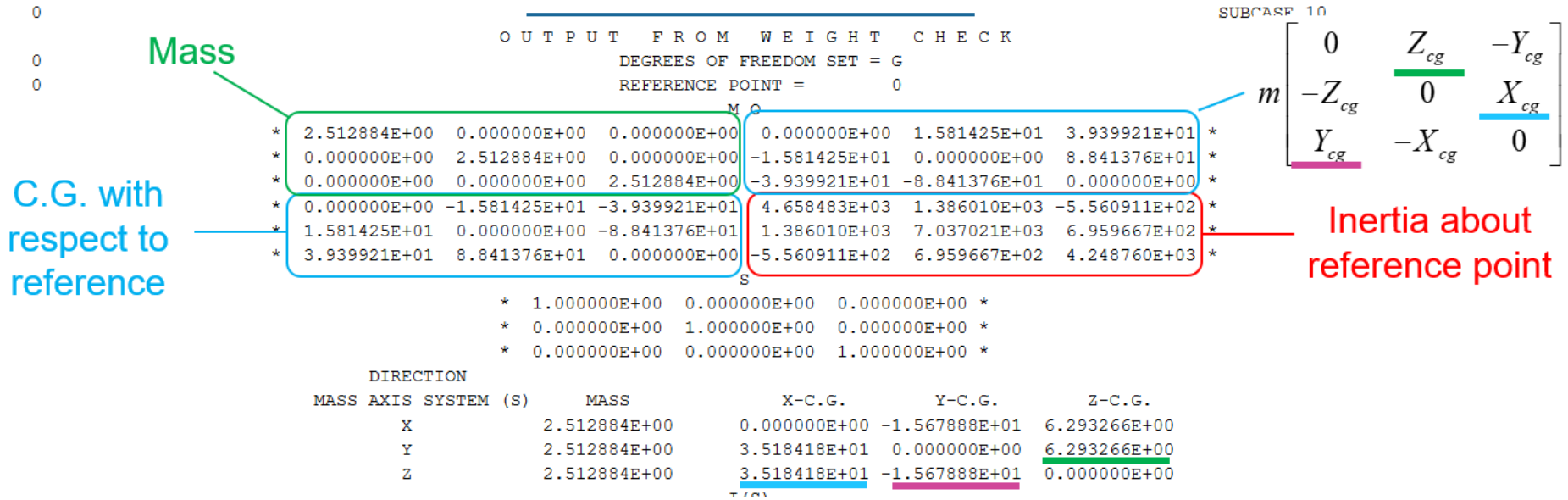
Coordinates of the CG of the model calculated about each axis. Note that the diagonal entries are 0. With no atypical properties you would expect two of the values in each column to be identical, providing the corresponding component of the C.G. location.

I(S): inertia about the CG

I(Q): principal inertias

Q: principal axes (axes that the model prefers to spin about)

More About WEIGHTCHECK Output



How do the CG coordinates get calculated?

- Blue matrix in top right is equivalent to this matrix:

$$m\begin{bmatrix} 0 & Z_{cg} & -Y_{cg} \\ -Z_{cg} & 0 & X_{cg} \\ Y_{cg} & -X_{cg} & 0 \end{bmatrix}$$

- If you divide blue matrix by mass, you will get the CG coordinates

What to Look for in WEIGHTCHECK Output

- Check if the mass matches your expectations
  - This will help you check if all material properties are correct (both values and units!)
  - Compare to mass measured by pre-processor
  - Compare to mass estimated based on CAD volume and material density
  - Check whether you are using WTMASS parameter – is WEIGHTCHECK printing out masses or weights, and does this match your expectations?
- If your deck contains DMIG mass matrices, the mass will not match the pre-processor
  - You should still compare mass to pre-processor to verify it matches expectations
- Check if the mass is the same between sets
  - Changes in mass between sets are not common but typically indicate a modeling error
  - What could cause this? See next slide
  - What to do if the mass changes between sets? Review other standard model checks, including:
    - Check what is being restrained
    - Do ground checks
    - Review all AUTOSPCs

Examples of Masses Changing Across Different DOF Sets

- Mass on boundary conditions
  - i.e. lumped mass on an SPC
- Mass regions that have been AUTOSPCed
- Model grounding
- Lumped mass in the O-set
  - i.e. there is a model reduction
- Example Scenario:
  - One component of a large assembly was replaced with a lumped mass
  - Original model had small lumped mass elements that were not reconnected
  - Nastran AUTOSPCed the disconnected elements
  - When the AUTOSPC's were added (in between the N set check and A set check), the model mass changed

Check Mass Using Reaction Forces

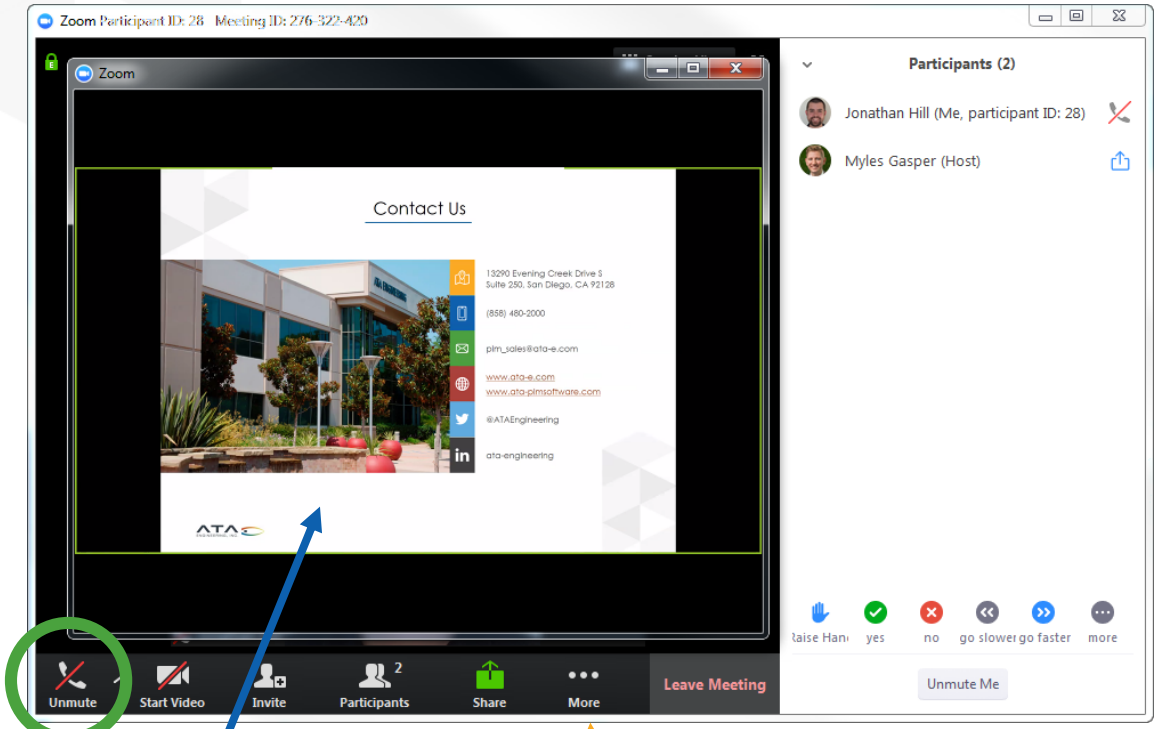
An Alternative to Weight Checks

- If acceleration loads are applied, look at the net reaction forces
- Compare the sum of the reaction forces to the FEM total mass times the applied acceleration
  - You should get F=ma
  - If not, there is an issue with the model setup
- Nastran WEIGHTCHECK tool is preferred method, but checking the reaction forces can be a good additional check and can be used for other solvers like ANSYS

Questions?

Submit questions in the chat or unmute yourself now

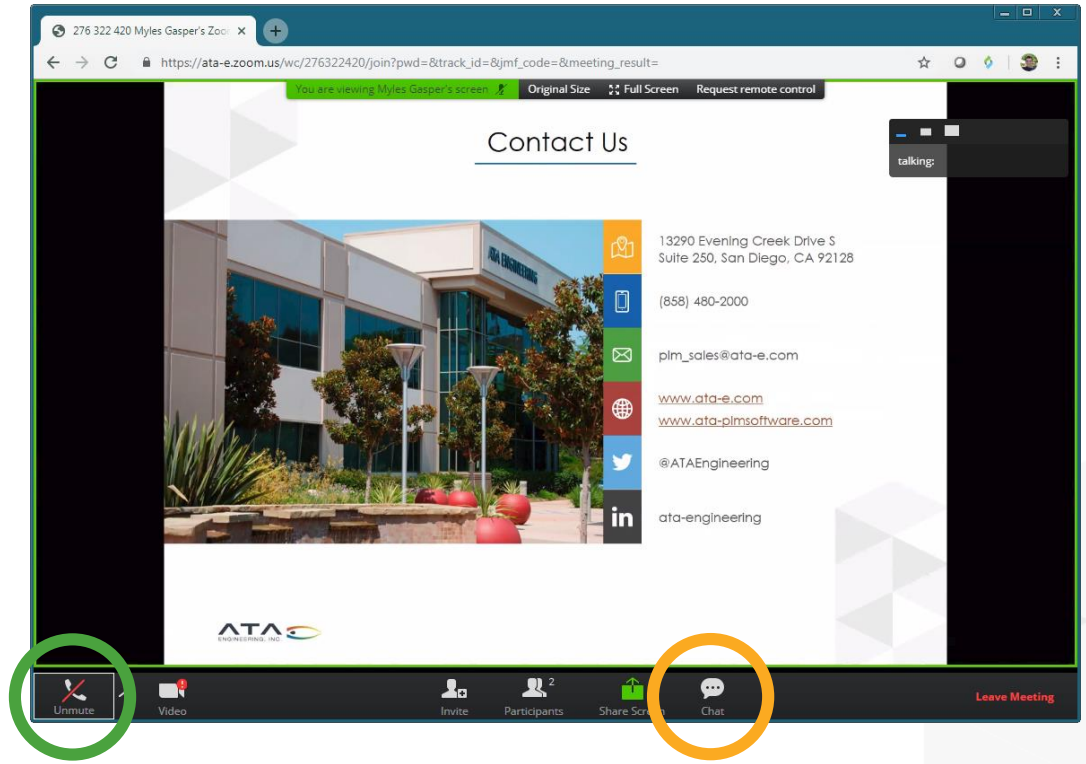
Zoom Application



Screenshare in separate window

Chat is available under More

Web Interface



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