ATA ENGINEERING, INC.

Webinar:
Grounding and Groundchecks

Michelle DeRienzo, ATA Engineering

March 17th, 2020

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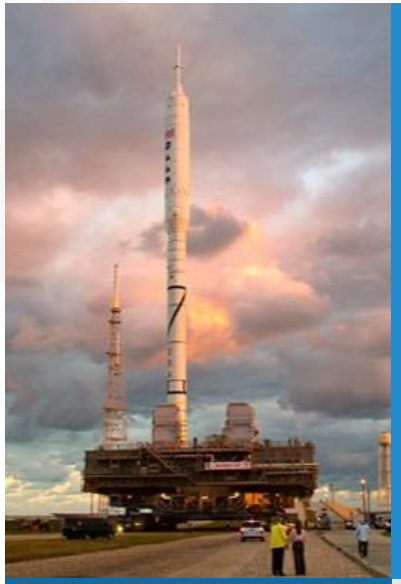

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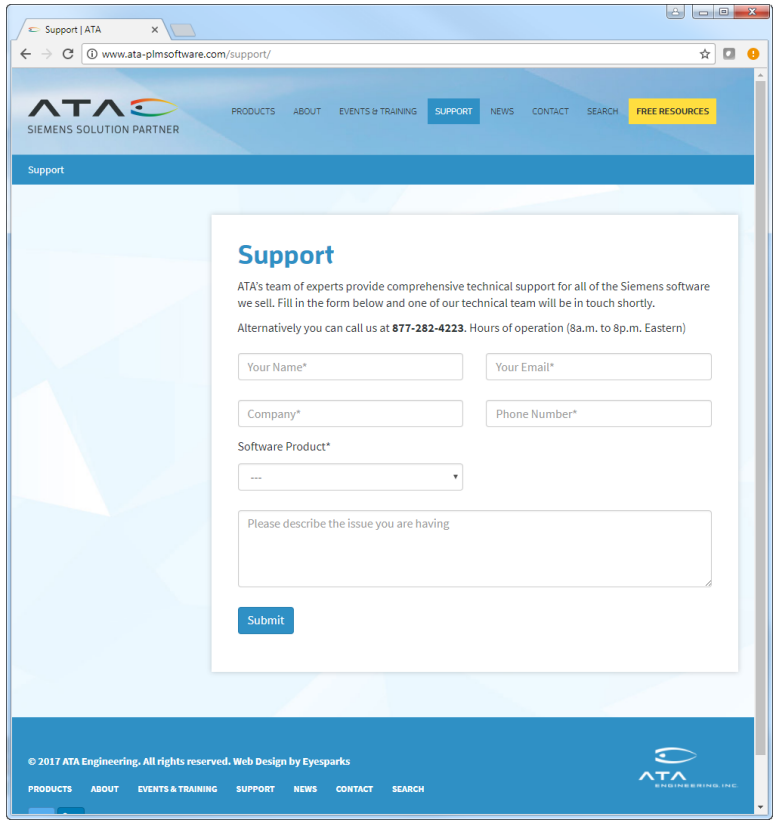

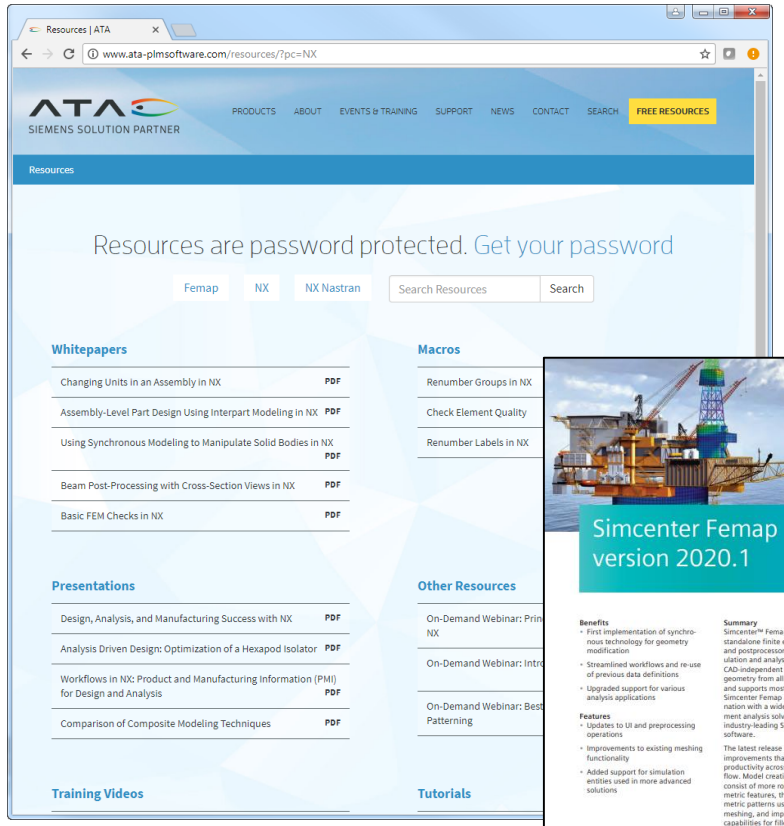

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Introduction

- Ground checks are standard model checks that should be performed on every model
- This presentation is a “deep dive” into grounding
- Goal is to explain grounding and ground checks in detail, so even experienced users might learn something new

What is Grounding?

- If the model cannot move without straining, then you have grounding.
- Sometimes you want grounding!
  - Ex: boundary conditions
- Sometimes you don't…
  - It could indicate that the model has artificial internal loads
  - Then your model can give inaccurate results
- A model has grounding if it has:
  - Constraints
  - Bad element formulation/quality
  - Poorly defined connections
  - Matrix ill-conditioning
  - Artificial internal loading in a FEM from motion

Examples of What Can Cause Grounding

- Springs
  - Coincident springs are not exactly coincident
  - CELAS springs have non-coincident nodes (use CBUSH or make nodes coincident)
  - CELAS springs have incompatible displacement coordinate systems (use CBUSH)
- Anything that is too stiff
  - Including springs, bars, beams
  - Remember: bar stiffness depends on both geometry & material props
- External stiffness matrices (DMIG/OUTPUT4/etc.)
  - DMIG interface is not specified exactly the same way as when the DMIG was created
  - Some grounding is almost inevitable with DMIG cards due to truncation of significant figures
    - This can be avoided by sending DMIG to OUTPUT2
- Incorrect MPC equations
  - Shows up in N-set check (not G-set)
- Very poorly formed elements
  - Check element quality

Nastran Groundcheck: What does it do?

- Identifies constraints and ill-conditioning in the stiffness matrix
- Performs a series of rigid body translations and rotations of the structure
  - Multiplies the stiffness matrix by the rigid body transformation matrix

$$[F] = [K][\Phi_{RB}]$$

- Internal force due to rigid body vectors should be zero for unconstrained structure
- Compares strain energies resulting from six rigid body displacements against a specified threshold

$$se_i = \frac{1}{2}\{\phi_i\}^T \underbrace{[K]}_{[F]}\{\phi_i\}$$

- If the structure is connected properly and not artificially restrained, the structure will "PASS" the rigid body displacement check in all six directions

Nastran Groundcheck: How to Set It Up

Use GROUNDCHECK card in Nastran:

```
$*$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$*
$* CASE CONTROL
$*
$*$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$$
$*
ECHO = NONE
GROUNDCHECK(PRINT,SET=(ALL),GRID=1481786,DATAREC=YES)=YES
```

Enable DATAREC=YES to print the data recovery of grounding forces

Print groundcheck results to the .f06 file

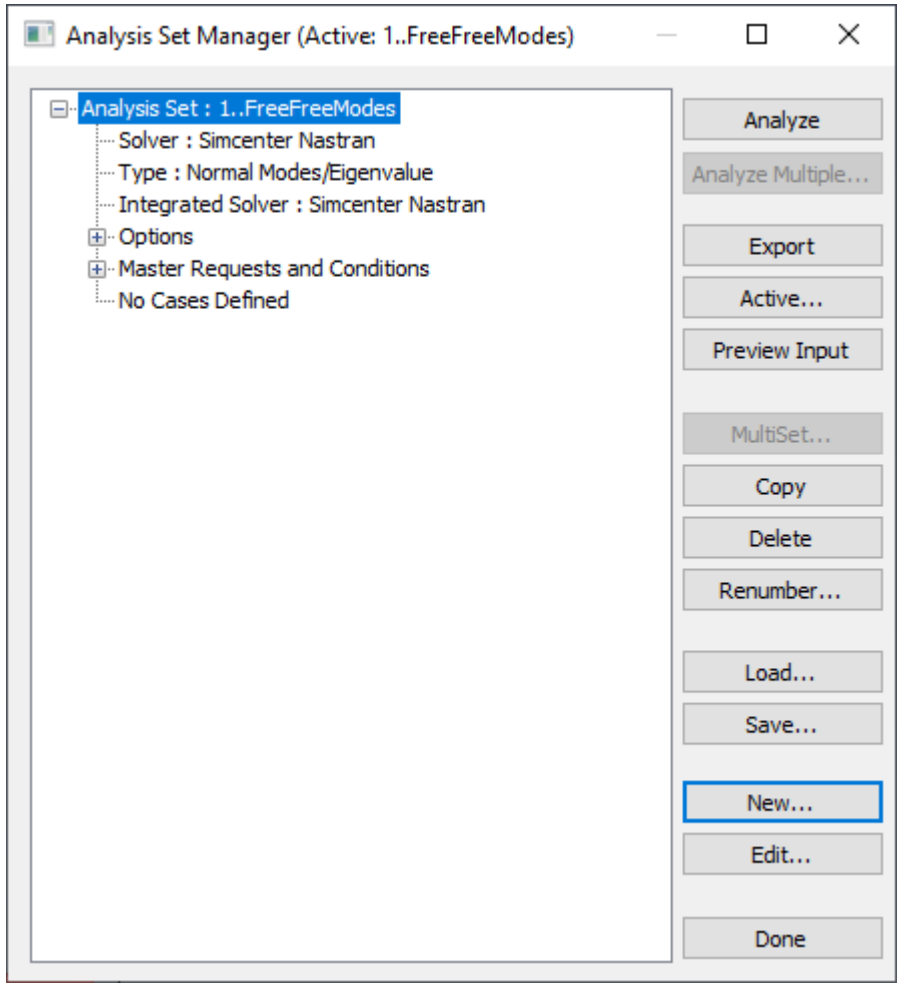
At a minimum, check G and N sets, but all sets are available in Nastran for this check

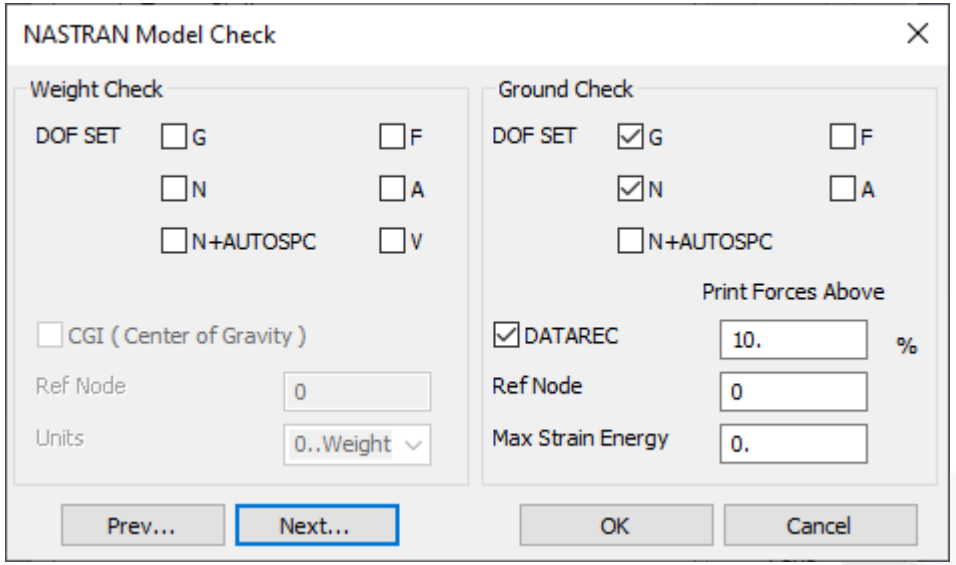
Groundcheck depends on a reference location

- If no grid is specified, unit rotations are checked about the origin of the Nastran basic CSYS
- If the origin is far from the center of the mesh, specify a different grid ID near the geometric center of the assembly

Nastran Groundcheck: How to Set It Up (Femap)

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





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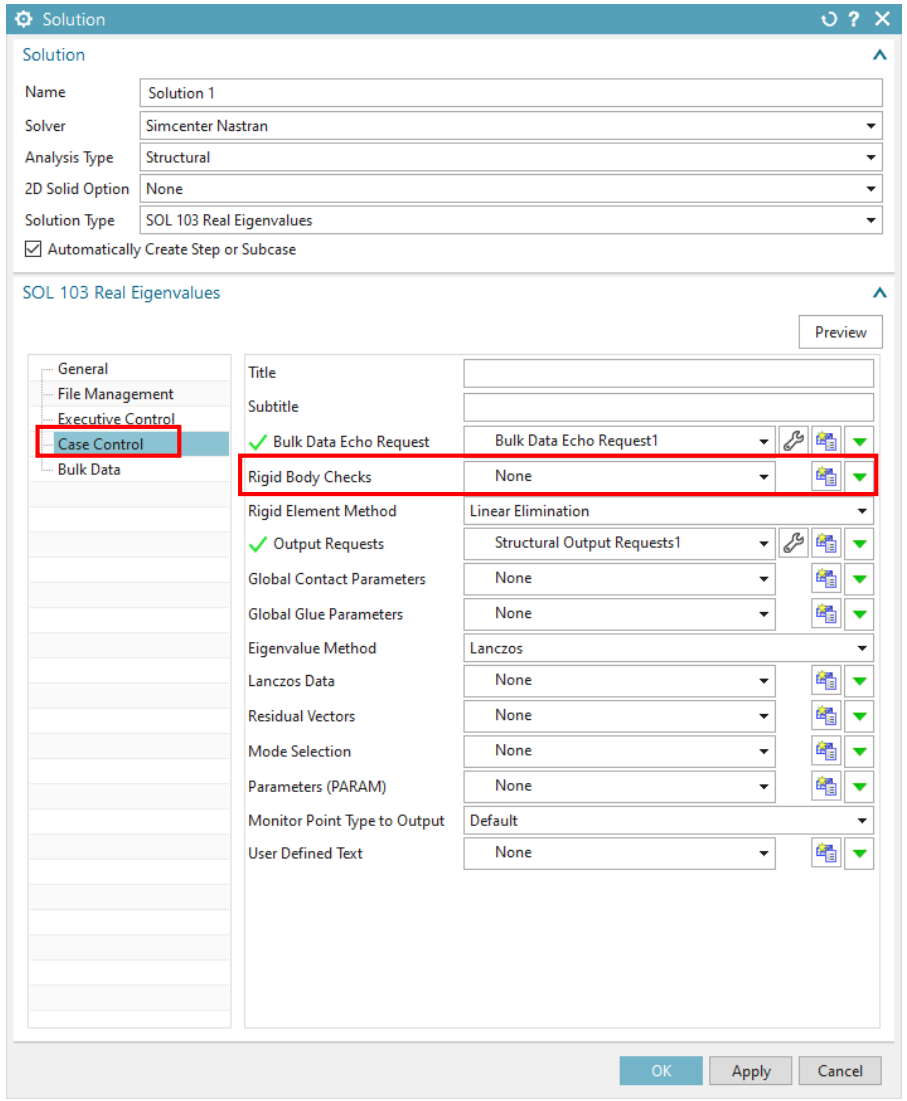
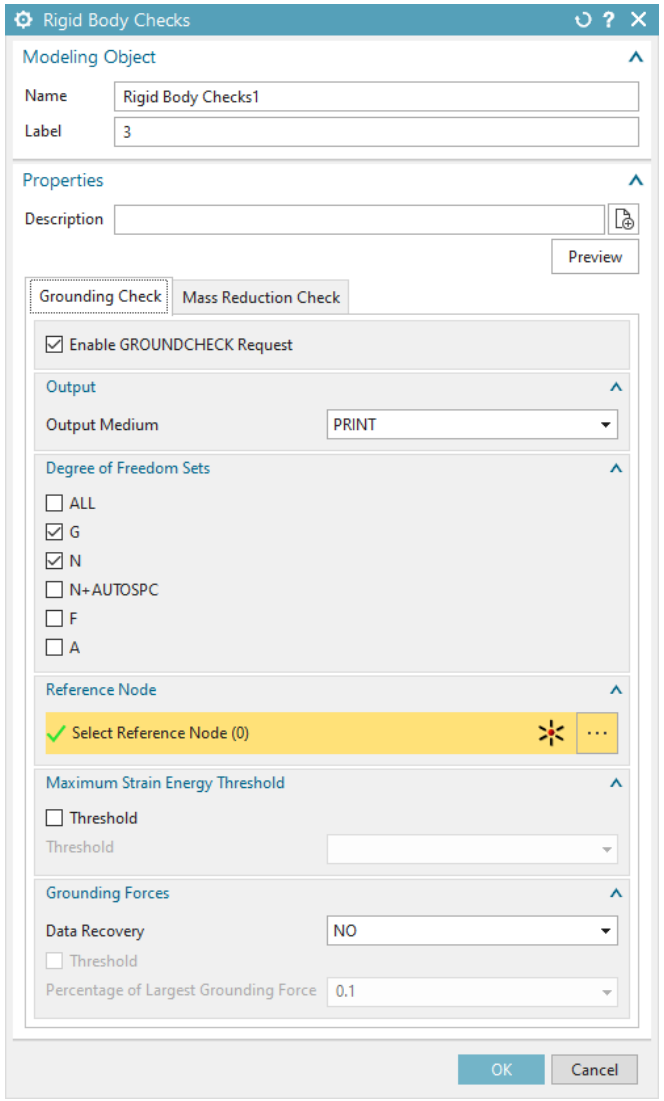
Nastran Groundcheck: How to Set It Up (Simcenter)

In Simcenter, ground check is available in the Solution window





Nastran Groundcheck: What to look for in .f06 file

- By default, the strain energy threshold is set to model's largest diagonal stiffness x 10^{-10}
  - Stiff springs can increase threshold
  - You can specify your own threshold in the GROUNDCHECK card in Case Control
  - If you choose the default threshold, verify that it is less than 1
- Typically a good model has strain energies <~0.1, grounding forces <1.0 N, and moments <0.5 N-m.

```
 *** USER INFORMATION MESSAGE 7570 (GPWG1D)
     RESULTS OF RIGID BODY CHECKS OF MATRIX KGG       (G-SET)  FOLLOW:
     PRINT RESULTS IN ALL SIX DIRECTIONS AGAINST THE LIMIT OF   1.000000E-02
           DIRECTION        STRAIN ENERGY        PASS/FAIL
           ---------        -------------        ---------
             1               2.000007E-05         PASS
             2               4.000005E-05         PASS
             3               1.000002E-04         PASS
             4               4.985046E+01         FAIL
             5               4.464892E+01         FAIL
             6               8.216817E+01         FAIL
     SOME POSSIBLE REASONS MAY LEAD TO THE FAILURE:
       1. CELASI ELEMENTS CONNECTING TO ONLY ONE GRID POINT;
       2. CELASI ELEMENTS CONNECTING TO NON-COINCIDENT POINTS;
       3. CELASI ELEMENTS CONNECTING TO NON-COLINEAR DOF;
       4. IMPROPERLY DEFINED DMIG MATRICES;
```

```
1    GROUNDCHECK EXAMPLE                                    DECEMBER  28, 2005  NX NASTRAN 10/15/04   PAGE    12

                                                                                 DIRECTION        4
                          G R O U N D   C H E C K   F O R C E S   ( G - S E T )

      POINT ID.   TYPE          T1            T2            T3            R1            R2            R3
            1      G      0.0           0.0           -1.000000E+05   0.0           0.0           0.0
            2      G      0.0           0.0            1.000000E+05   0.0           0.0           0.0
1    GROUNDCHECK EXAMPLE                                    DECEMBER  28, 2005  NX NASTRAN 10/15/04   PAGE    16

                                                                                 DIRECTION        5
                          G R O U N D   C H E C K   F O R C E S   ( G - S E T )

      POINT ID.   TYPE          T1            T2            T3            R1            R2            R3
           44      G      0.0           0.0           -4.410524E+03  -1.344394E+03   1.326177E+03   0.0
           45      G      0.0           0.0            4.436500E+03   0.0            1.330224E+03   0.0
           48      G      0.0           0.0            4.436886E+03  -1.316576E+03   0.0            0.0
           49      G      0.0           0.0           -4.462862E+03   0.0            0.0            0.0
```

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Nastran Sets and What They Mean for Groundchecks

- All degrees of freedom are placed into one or more sets
  - Ex: G set contains all nodes, N set contains G set minus RBE2s, RBE3s, and MPCs
  - More info on next slides
- Grounding beyond the N-set is usually not of concern
  - AUTOSPC process can introduce artificial grounding in N+AUTOSPC set
  - Constraints introduce grounding in F-set and A-set
    - Ex: if you run groundchecks on a fixed modes run, you would expect to fail for F and A sets because the constrained DOFs are not included in these sets
  - Almost all user-created grounding problems are identified on G- and N-set

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

Definition of Supersets from QRG

mutually exclusive sets:

m = constrained by MPCs

s = constrained by SPCs

o = omitted from a-set

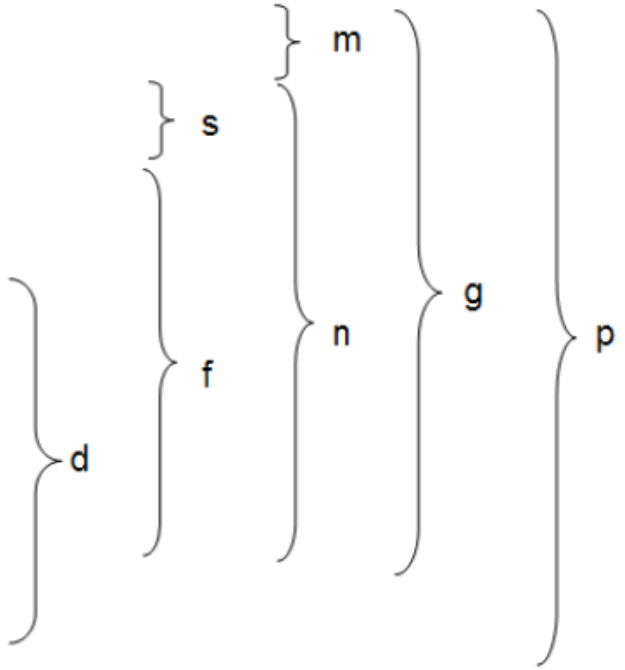
q = generalized (modal) dofs

r = rigid-body supports

c = free a-set

b = fixed a-set

e = extra points for dynamics



supersets:

p = physical set = (g + e)

g = global set = (m + n)

n = independent (not MPCd)

f = free dofs = (o + a)

d = dynamic analysis set

a = analysis set

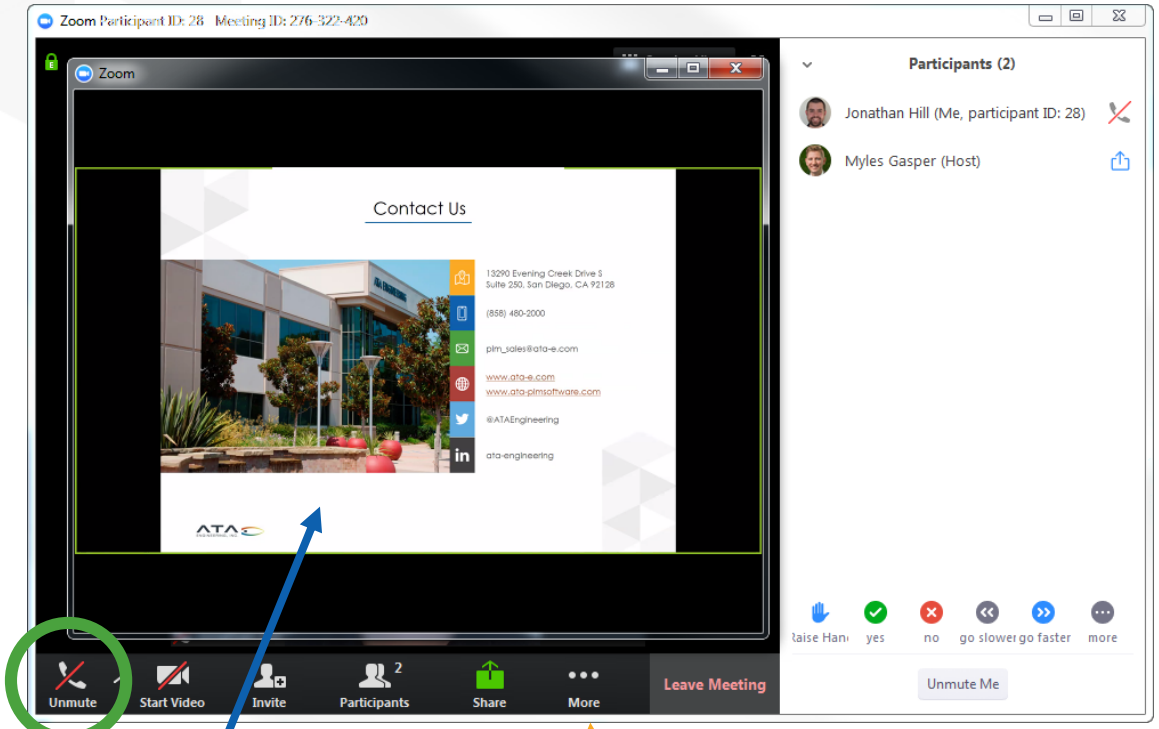
t = total physical boundary dofs

L = boundary dofs left over

Questions?

Submit questions in the chat or unmute yourself now

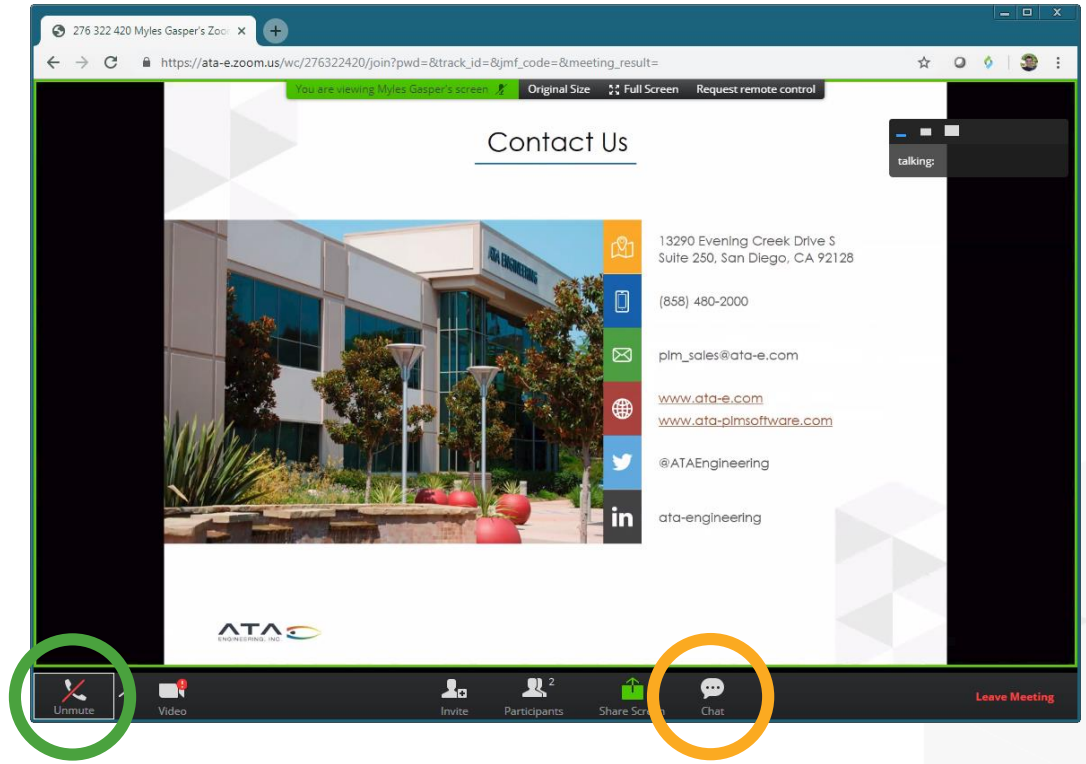
Zoom Application



Screenshare in separate window

Chat is available under More

Web Interface



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