AMS Star Tracker Support (STS)
Finite Element Analyses

Examination Period: Oct./ 1 / 02 - Oct./ 7 / 02

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CONTENTS

1 Goals of this Study

Each AMS Star Tracker Support (STS) consists of two CFC-Structures. The lower structure is foreseen to be bolted to the conical tracker flange whereas the upper should be fixed to the outer tracker plate. The camera box is connected to the lower structure.

The dynamic behaviour of the STS, i. e. the first natural frequencies, has to be determined with respect to the foreseen bolting pattern. Therefore a Finite Element Modal Analysis has to be performed. Also the forces at the bolting positions caused by acceleration loads for secondary structures, according to the AMS-02 Structural Verification Plan for the Space Transportation and the International Space Station – Rev. B – Nov.2001, have to be evaluated by the appropriate static Finite Element Analysis (FEA).

2 Model Description

The FE-Model, s. plot sts01, which simulates the STS, is based on the geometrical data given in the CAD-drawings of R. Becker INTst01 and INTst03. Modifications, e.g. due to manufacturing requirements, are made always with regard to the geometrical limiting envelope.

The Finite Element Type is a linear elastic shell with isotrop material properties. Two Model versions, charcterized by different stiffnesses, i. e. different fibre types, are analysed. With these shell-elements the stiffness and in consequence the dynamic behaviour is well represented.

The lower support structure, s. plot sts02, which consists of different plates bonded together before assembly, is bolted to the conical tracker flange.

In the bolting positions the FE-Model is constrained in all translational degrees of freedom.

In general the wall-thicknesses of the support structure amount to 3 mm for both model versions, except for version 1, where some plates of the lower support structure, shown in plot sts03, have a thickness of 4 mm.

The upper structure consists of only one plate, which is bolted to the outer tracker plate as well as to the lower support structure. The bolting of the tracker plate is simulated analogous to the bolting of the tracker flange, whereas the connection of the two support structure parts is realised by FE-Model continuity in the discrete bolting positions.

The box containing camera and electronics, s. plot sts04, is represented by volume elements with constant density. So the FE-Analysis considers the resulting mass of 1,5 kg with its real lever arm. The bolting of the camera box to the support plates is represented by FE-Model continuity in the discrete bolting postions.

The light shielding has not to be modelled because it is mounted to the magnet separately.

3 Material Properties

For the CFC support structure, isotropic, linear elastic material properties are presumed, characterized by a Poisson Ratio ν = 0,3 and a Modulus of Elasticity:

Version 1: E = 62 GPa, corresponding to Composite T300J/EP with biaxial layup,

Version 2: E = 100 GPa, corresponding to Composite HM40/EP with biaxial layup,

The Density of ρ = 1,6 kg/cm³ results in a mass of 0,85 kg for Version 1 and 0,80 kg for Version 2 for each STS.

The properties of the camera box are: E = 70 GPa and ν = 0,34. The density is chosen appropriate to a resulting mass of 1,5 kg per camera box.

4 Boundary Conditions

Plot sts05 shows the simulated bolt patterns. The global cartesian coordinates (AMS-System) of the bolts between STS and outer tracker plate are:

X = 670 mm; Y = +/- 18,25 mm and +/- 54,75 mm; Z = Z(Outer Plate).

In case of the static FE-Analyses the following acceleration loading according to the AMS-02 Structural Verification Plan for the Space Transportation and the International Space Station –Rev. B – Nov.2001 for secondary structures is applied to the FE-Model:

Acceleration = {Nx; Ny; Nz} = {40 g; 10 g; 10 g},

i.e. 40 g acceleration in the main direction and 25 % of 40 g in each other direction.

5 Results of the Modal Analysis

Modal Analysis of Model Version 1 (E = 62 GPa):

First Natural Eigenfrequency = 49,5 Hz. The corresponding mode shape is shown in plots sts06 (with undeformed structure overlaid) and sts07.

Modal Analysis of Model Version 2 (E = 100 GPa):

First Natural Eigenfrequency = 58,9 Hz. The corresponding mode shape is shown in plots sts08 (with undeformed structure overlaid) and sts09.

For both analyses the succeeding frequencies lay comfortably above 300 Hz, so that they have not to be regarded in more detail.

6 Results of the Static Analyses

The acceleration load = {Nx; Ny; Nz} = {40 g; 10 g; 10 g} represents the worst case with respect to the maximum bolt forces and causes displacements as shown in plot sts10. Following maximum forces arise at the bolt positions for model version 2:

Bolting to the outer tracker plate:

transverse force F_t = 760 N; longitudinal force F_l = 52 N.

Bolting to the conical tracker flange:

transverse force F_t = 1205 N; longitudinal force F_l = 164 N.

7 Conclusion and Prospect

The first natural frequency of the Star Tracker Support model, reflecting the current state of developement, of nearly 50 Hz is acceptable high, esp. in regard of the possiblity, of choosing a stiffer fibre type with an appropriate composite layup, increasing the first natural frequency to comfortable nearly 59 Hz.

The appearing forces at the bolt positions could be beared by an appropriate Insert-Bolting combination analogous to the connection of the outer tracker plate an the conical tracker flange.

Other acceleration load combinations where also checked, but the resulting forces are smaller then those given above.

More detailed analyses could regard in addition the stiffness of the adjacent components, i. e. the outer tracker plate and tracker flange or even the complete tracker and/or can regard a more detailed anisotropic layup.

8 Plots

FE-Model, Support w/o Camera Box sts01

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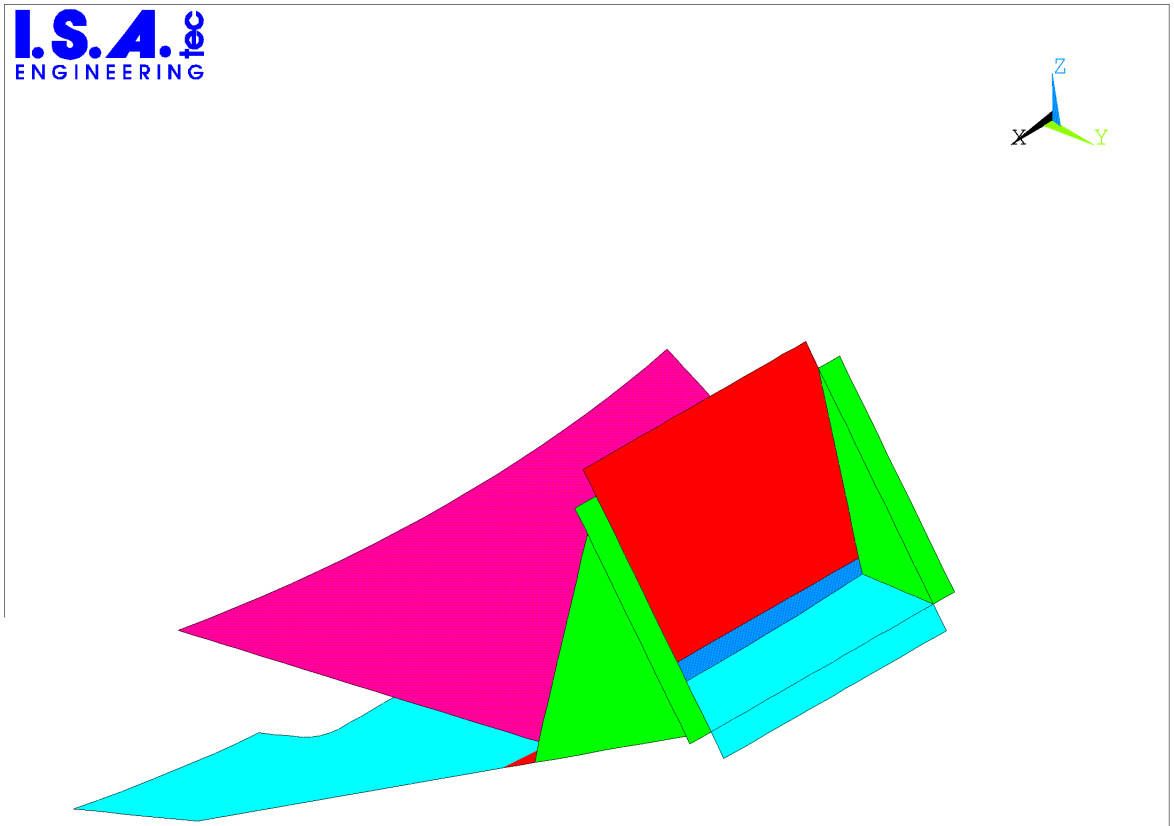

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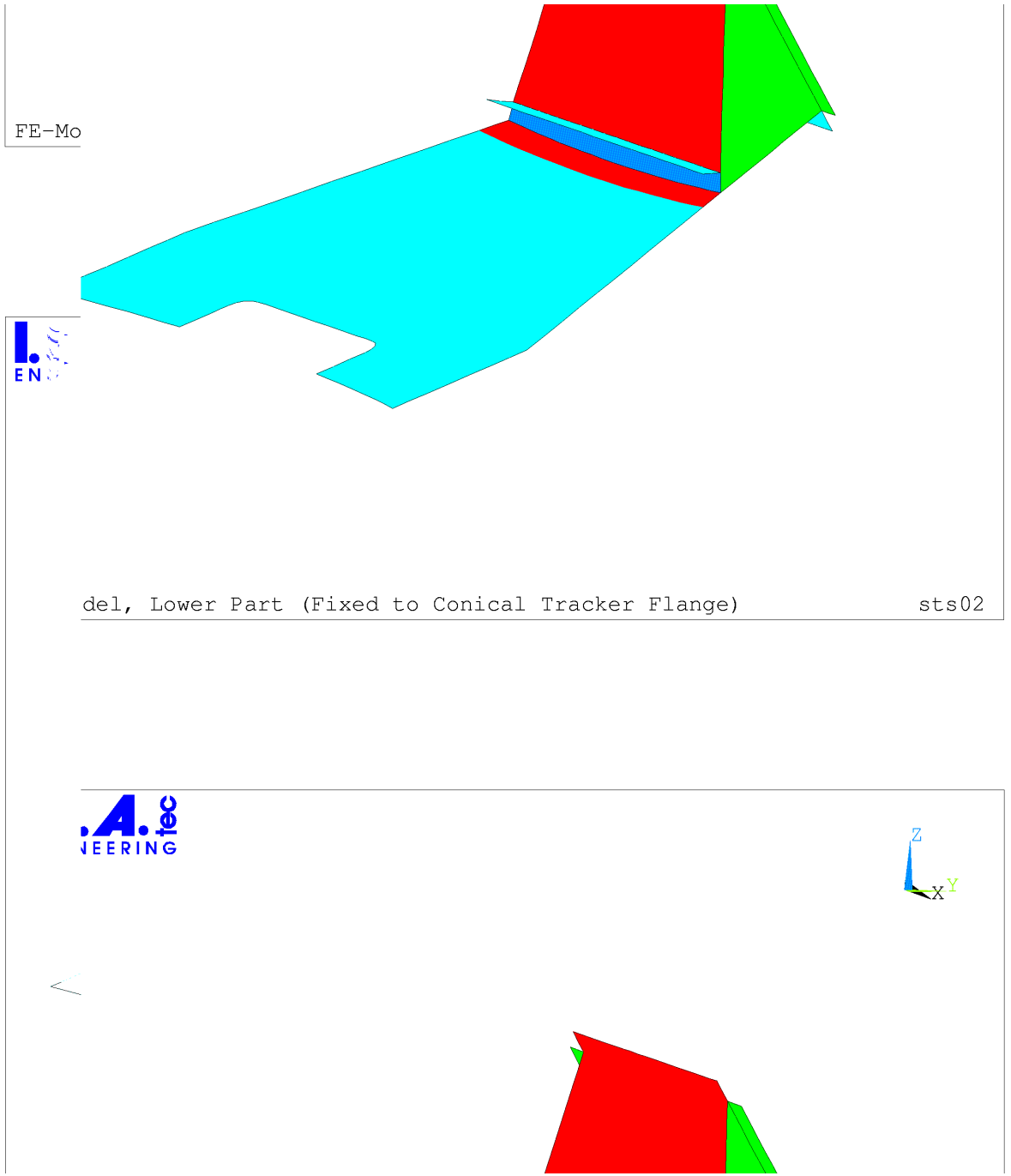
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Star Tracker Support

Version 1
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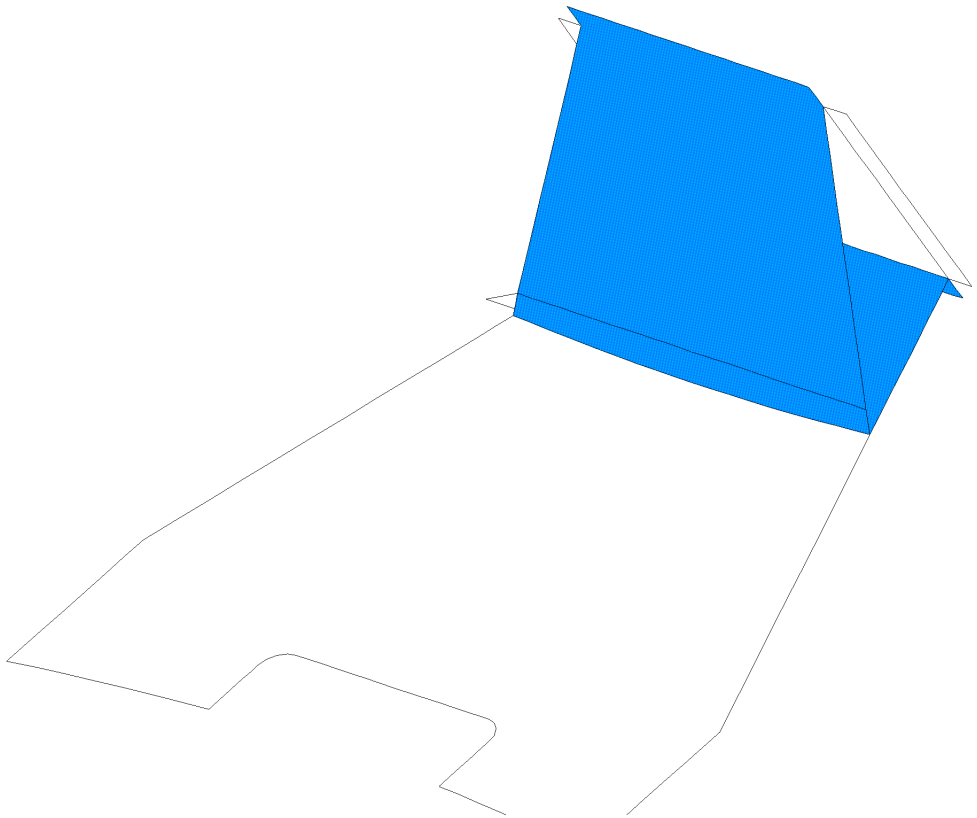

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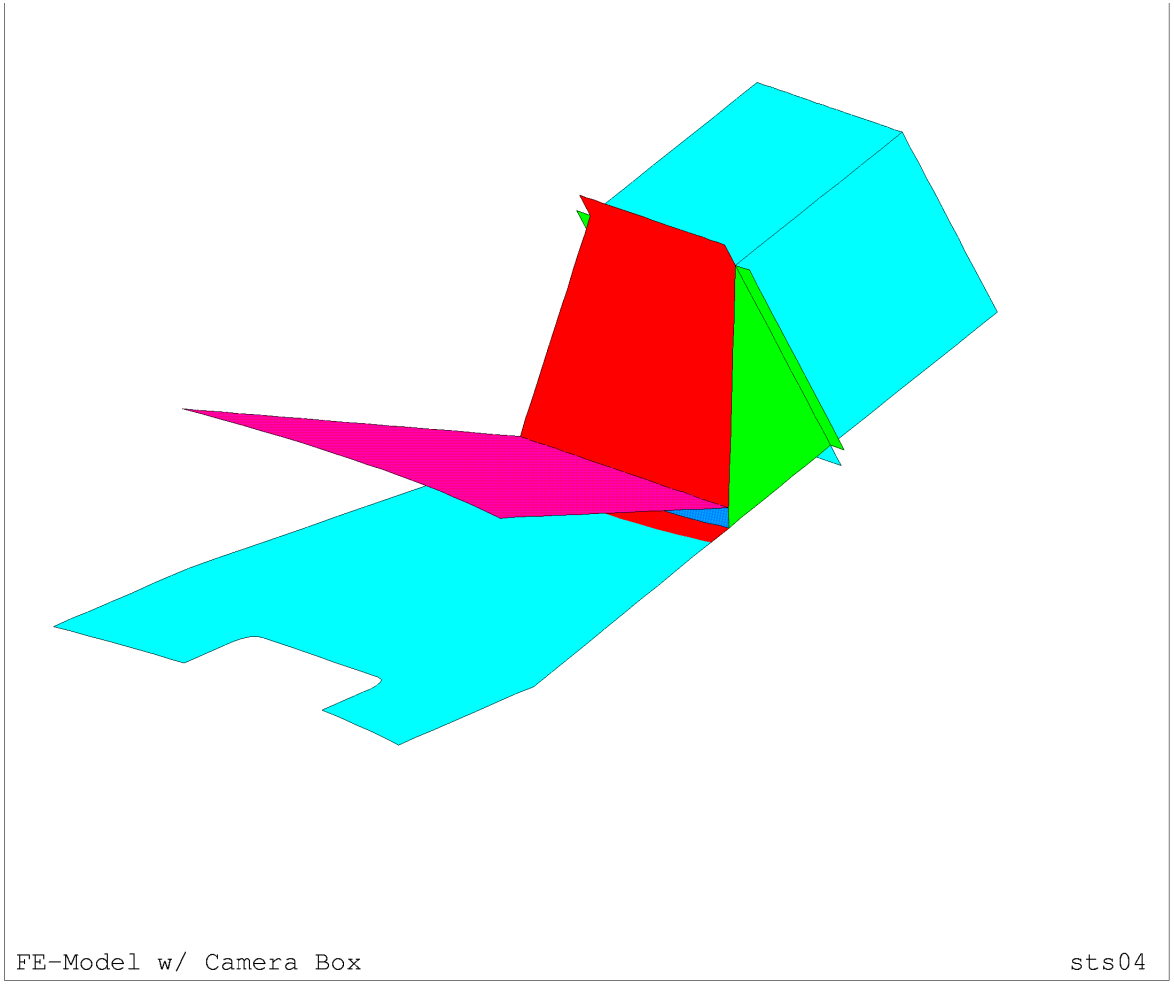
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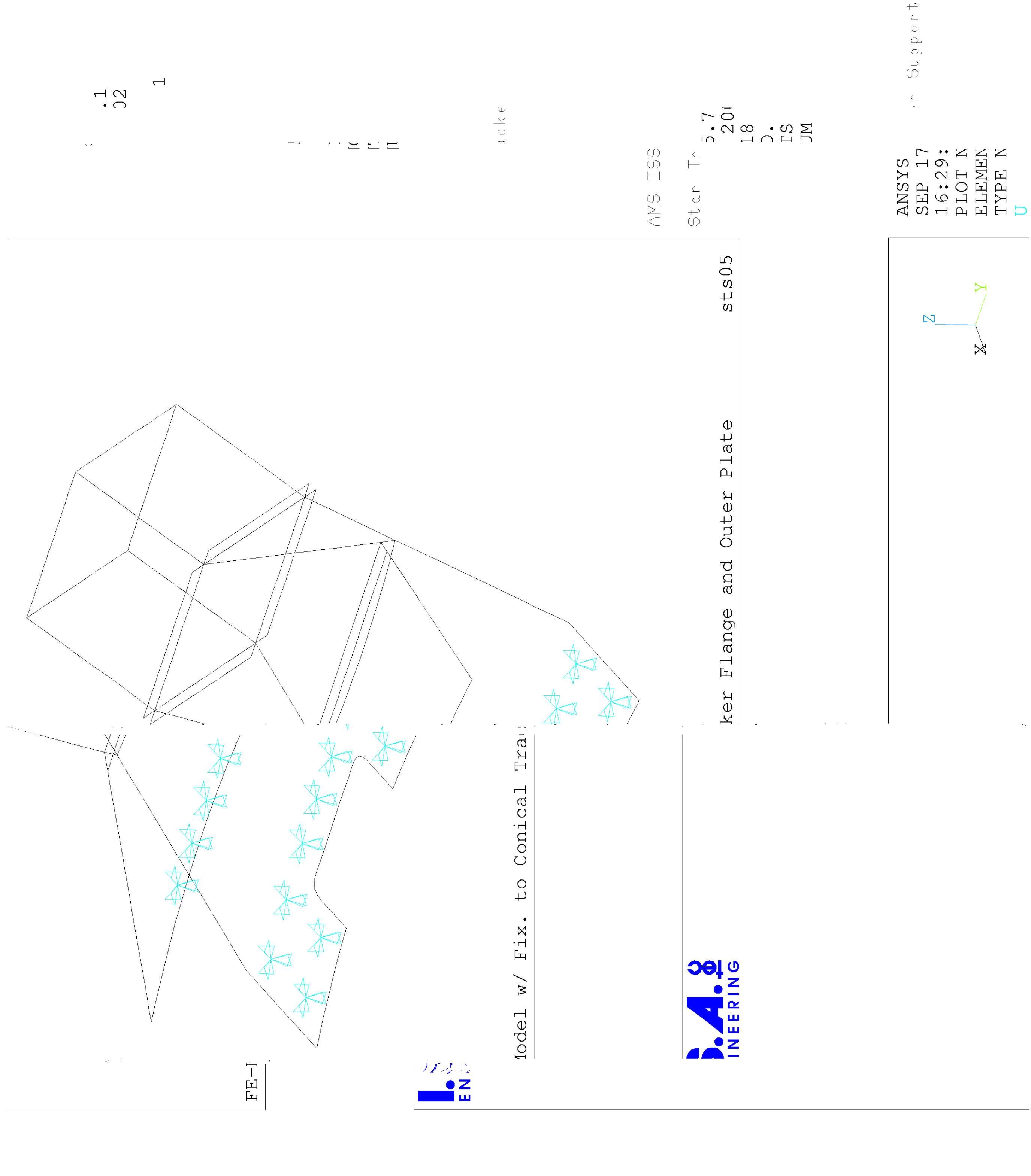
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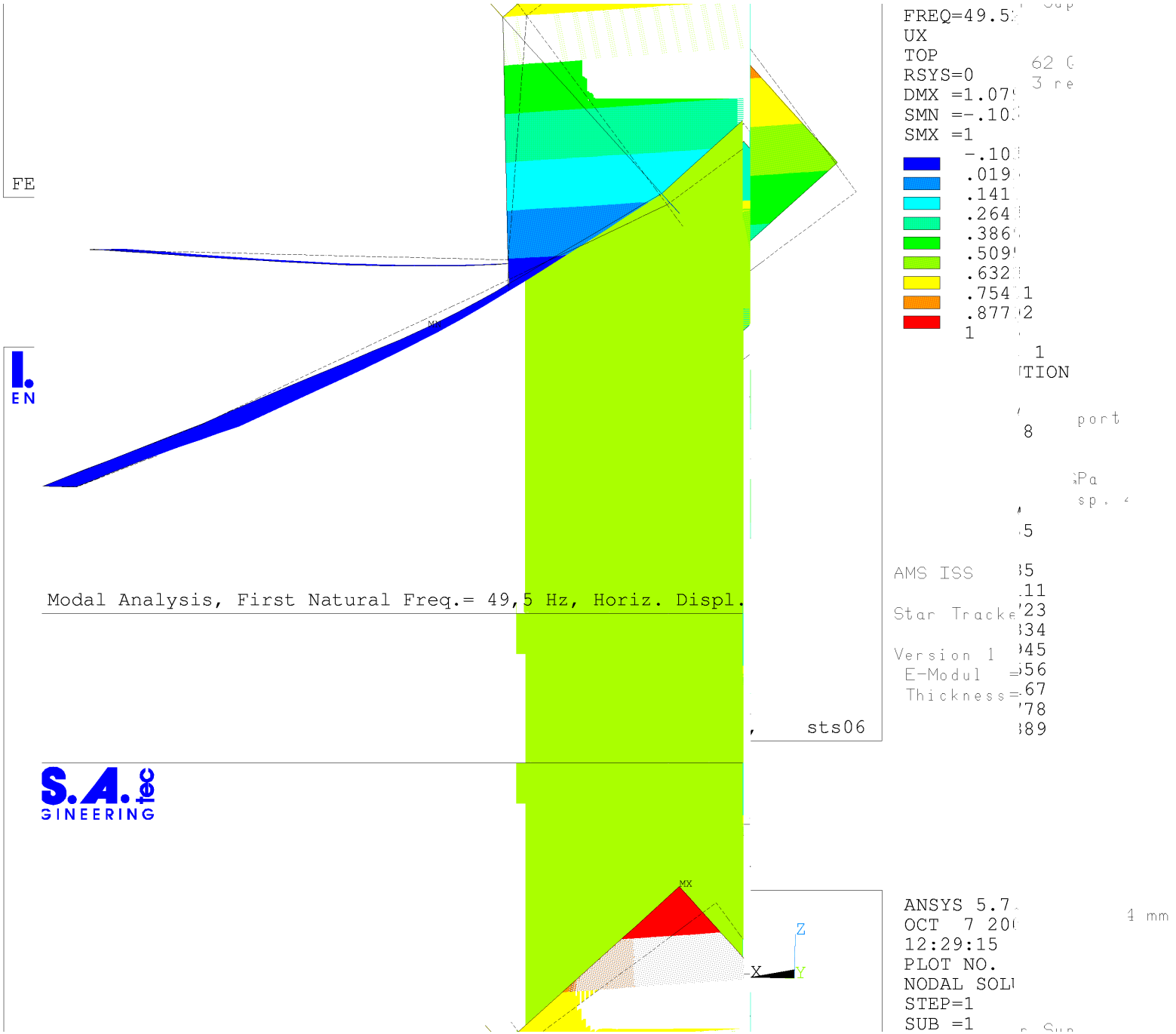
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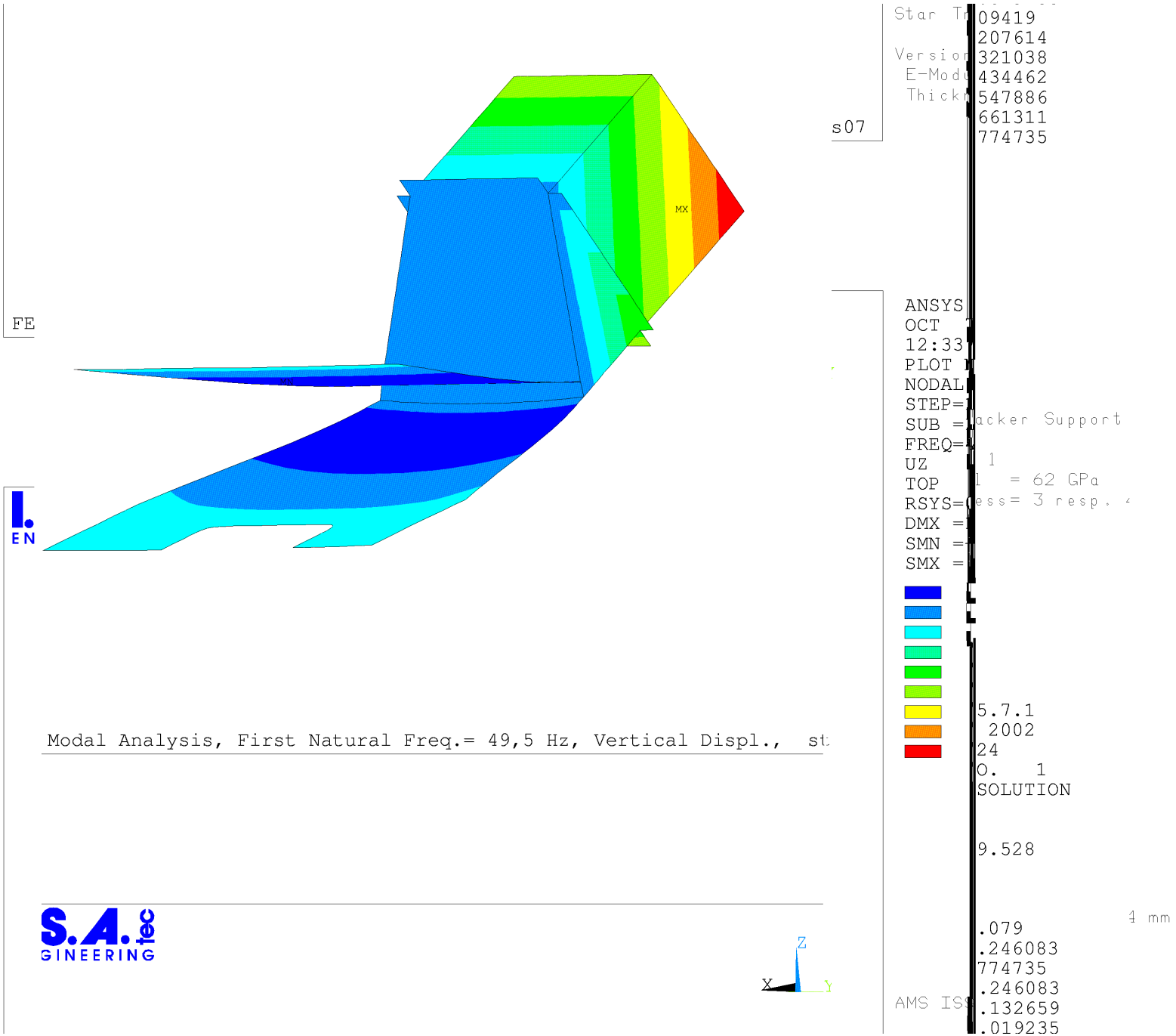
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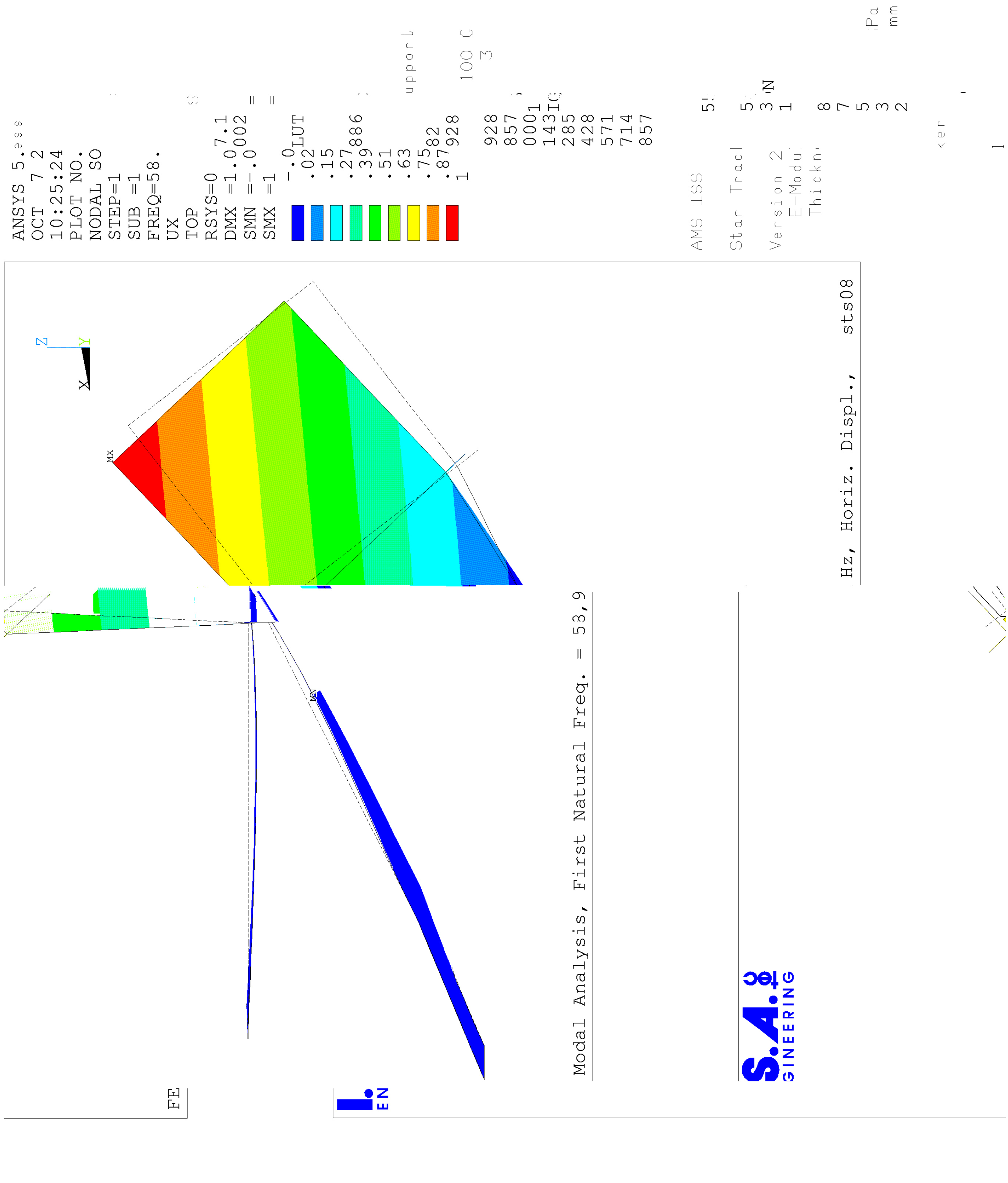
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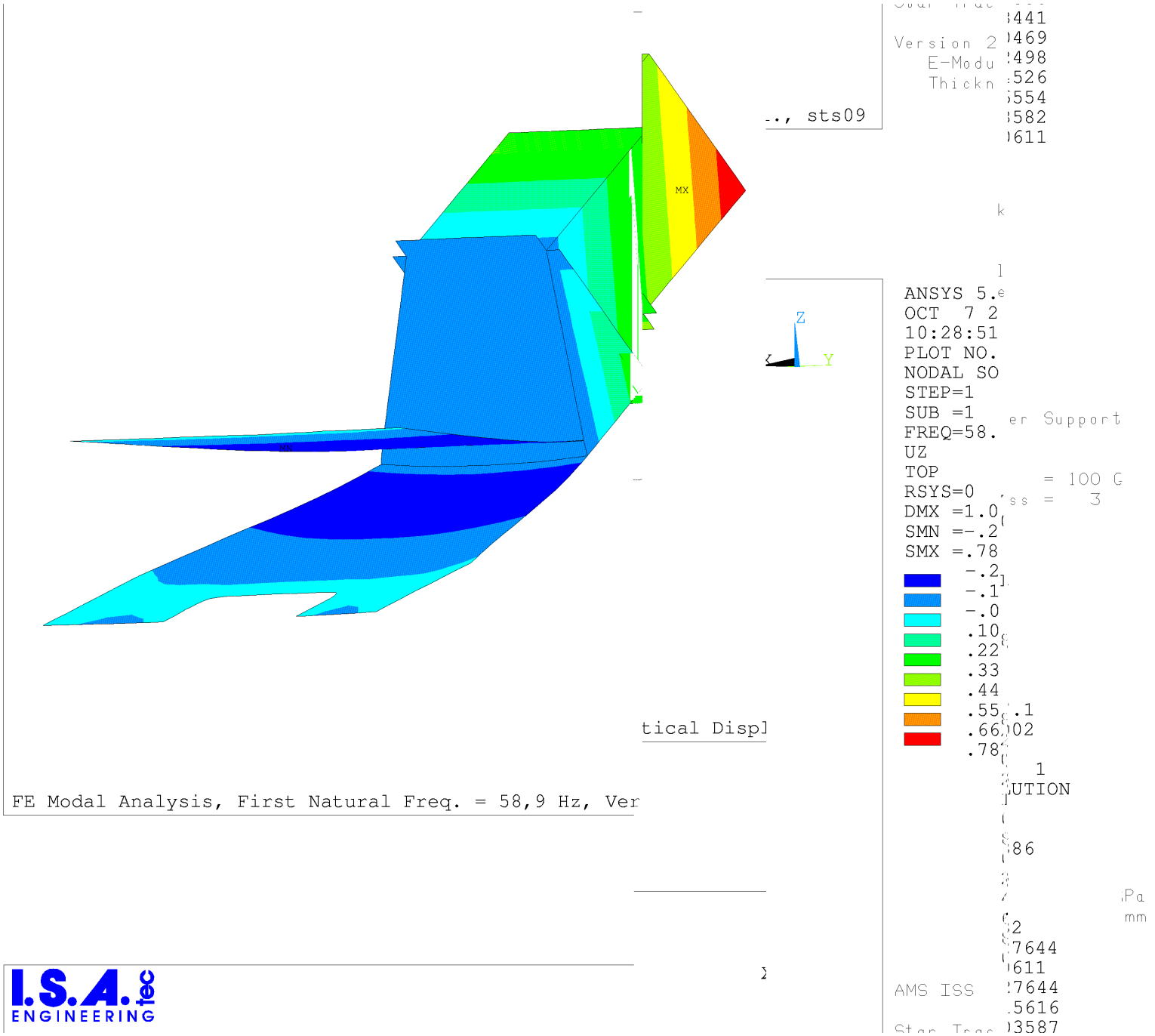
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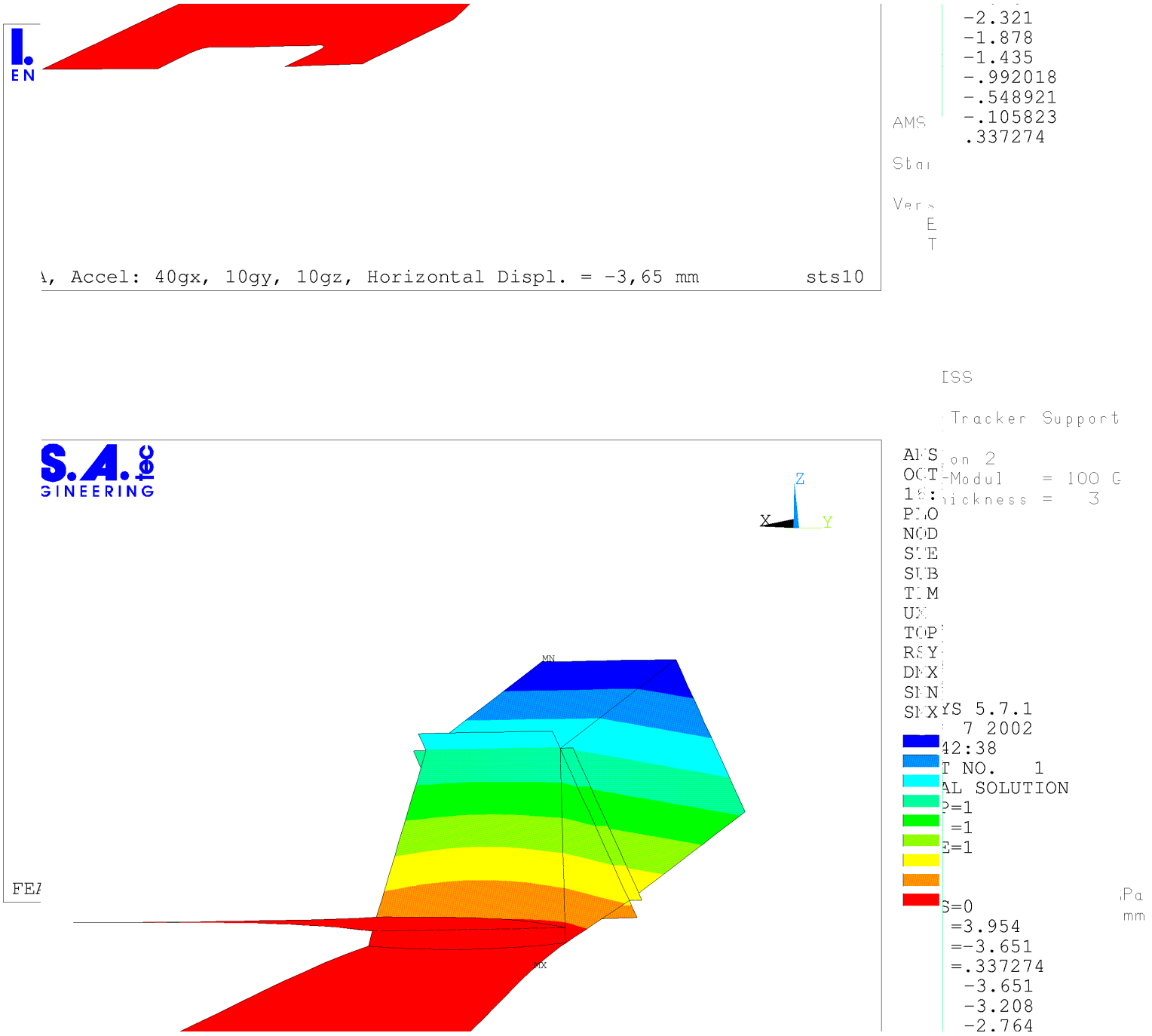
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