NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Aviation Engineering Division
Washington, DC 20594

December 5, 2003

ADDENDUM NUMBER 4 TO THE STRUCTURES GROUP CHAIRMAN'S FACTUAL REPORT

DCA02MA001

A. ACCIDENT

Location:	Belle Harbor, NY
Date:	November 12, 2001
Time:	09:16:14 EST
Aircraft:	American Airlines Flight 587, Airbus Model A300-605R, N14053 Manufactures Serial Number (MSN) 420

B. STRUCTURES GROUP

Chairman:	Brian K Murphy National Transportation Safety Board Washington, DC

C. AIRBUS REPORT

1. "AAL587 Airbus Structure Investigation, FEM Global to Local analysis details"

AIRBUS	Technical Note	

Report Nr.: TN – ESGC – 1019/03

Author:
Department.:

Title

AA587 Airbus Structure Investigation

FEM Global to Local model analysis details

Date: 08.12.2003

Summary:

This report describes the Airbus procedure for transferring the results of the 2D global NASTRAN VTP model [linear static] with embedded 3D LHS & RHS rear main lug to the local ANSYS 3D RHS contact analysis model [nonlinear contact].

Public Docket	Issue	Date	No. of page	Revised pages	Valid from/for
	1	10.11.2003	14		
	2	02.12.2003	14	Format change DINA4 to LETTER	
	3	08.12.2003	14		

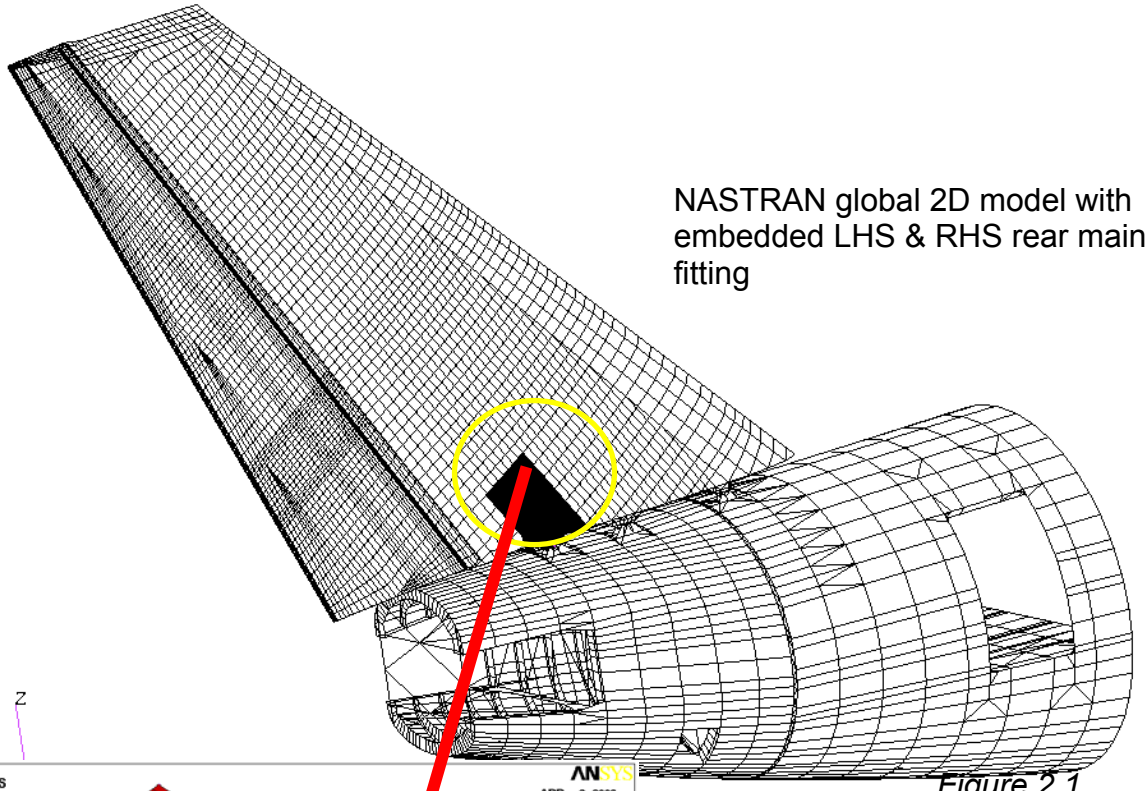
Table of contents

1. Introduction

This report describes the Airbus procedure for transferring the results of the 2D global NASTRAN VTP model [linear static] with embedded 3D LHS & RHS rear main lug to the local ANSYS 3D RHS contact analysis model [nonlinear contact].

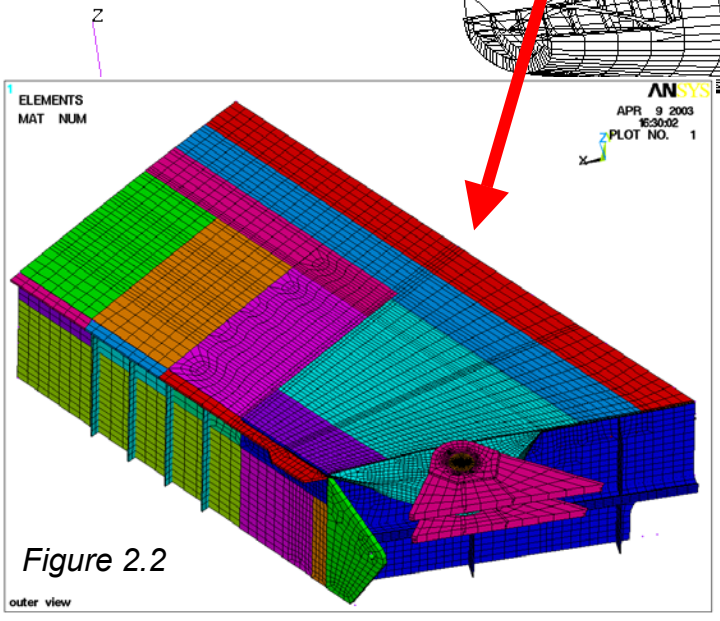
2. Global Overview

The linear global NASTRAN VTP FEA-model is used to calculate the displacements at the interface of the 2D/3D-model (see figure 2.1). These displacements are applied as enforced displacements and are the boundary conditions for the ANSYS contact model analysis (see figure 2.2).



NASTRAN global 2D model with embedded LHS & RHS rear main fitting

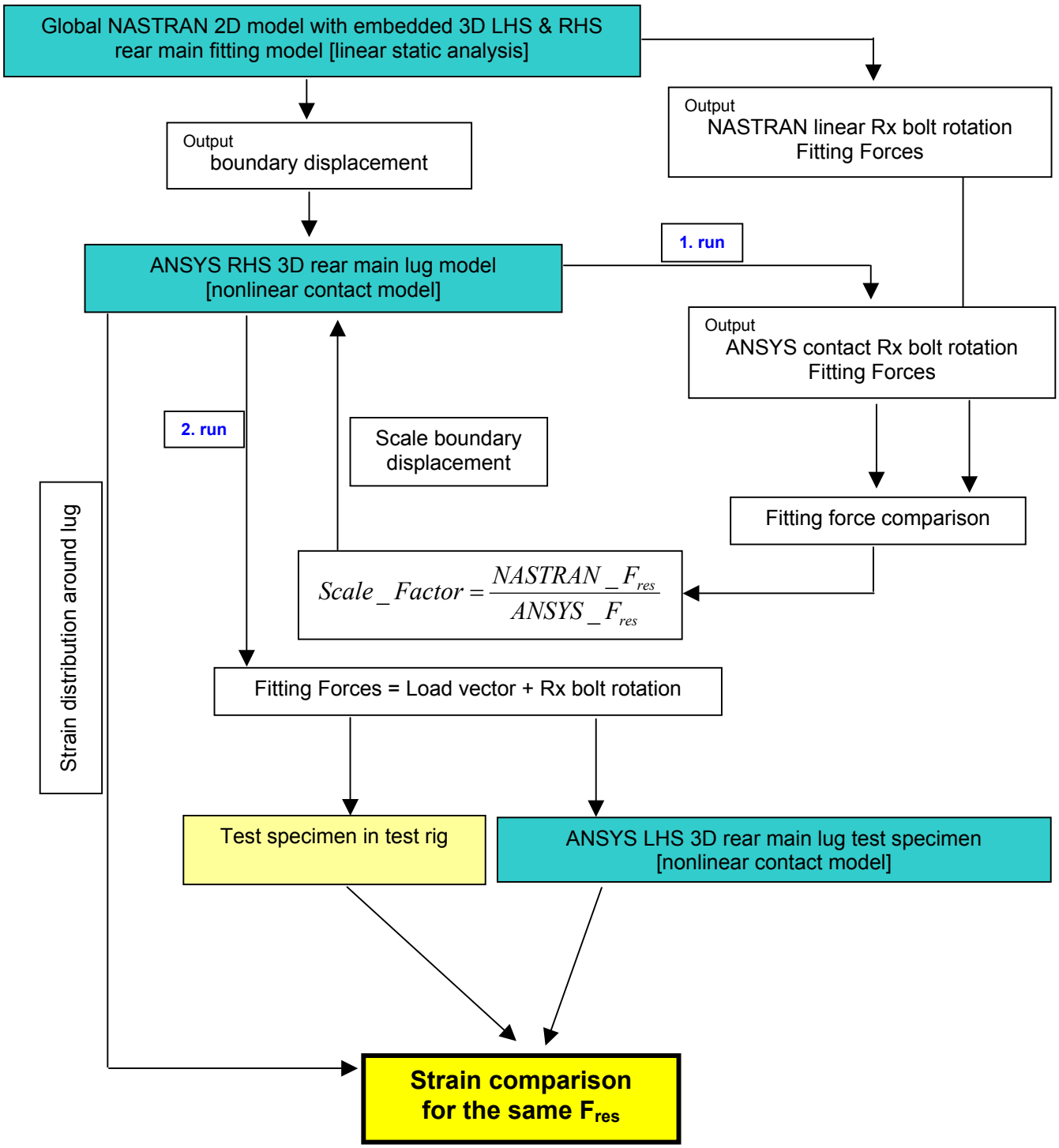
Figure 2.1



ANSYS RHS rear main fitting contact model

Figure 2.2

3. Airbus procedure from global to local model



4. Bolt bonding conditions in the NASTRAN & ANSYS models

4.1 Connection bolt bonding conditions for NASTRAN model

In the first step of the NASTRAN analysis procedure the bolt in the LHS & RHS 3D embedded model are completely (360°) bonded (see table 4.1). With the so called bonding condition ***Cond I*** the angle of the resultant main fitting force relative to rib 1 was calculated (see figure 4.1).

Table 4.1

	Cond I	**Cond II *)**
Fuselage clevis to bolt	360°	180°
Bolt to bushing	360°	180°
Bushing to CFRP lug	360°	180°

*) connection angle perpendicular to the resultant force direction

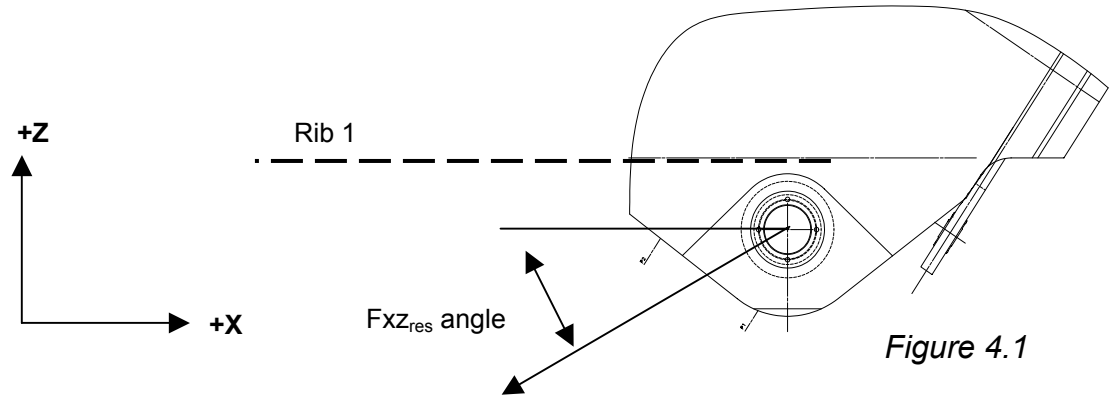


Figure 4.1

In the second NASTRAN analysis step the bolt is only bonded over 180°-degree corresponding to the Fres direction (see figure 4.2 on the next page). Due to the tension and compression area of the connection different nodes have to be bonded. The figure on the next page shows the necessary bonding procedure exemplary for a tension force at the rear main lug.

The 180°-degree bonding will be the best approach to model the contact situation. Taking into account this bonding configuration, called ***Cond II***, the boundary displacement conditions for the ANSYS model and the local lug reactions are recalculated again.

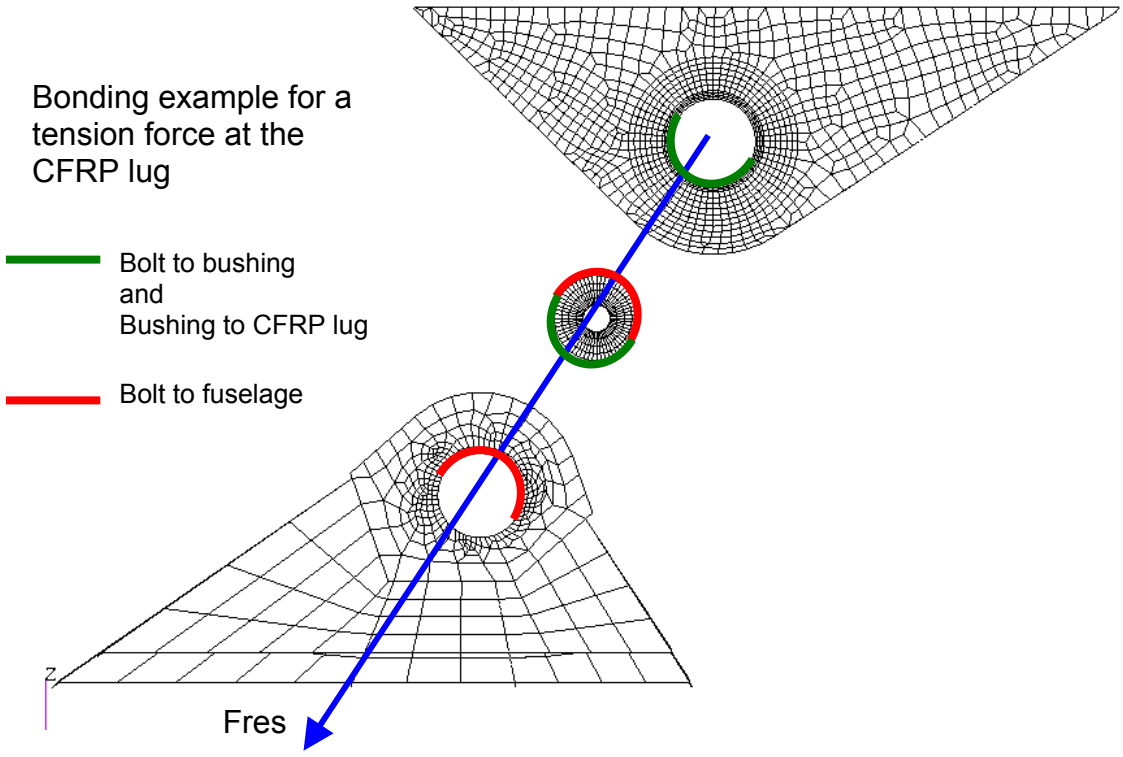


Figure 4.2

4.2 ANSYS contact surface definition

The contact surface definition are the same for all ANSYS models (see figure 4.3 to 4.6). The ANSYS contact surface allows physically opening and closing gaps between the meshes of the contact borders with a friction coefficient of 0.3.

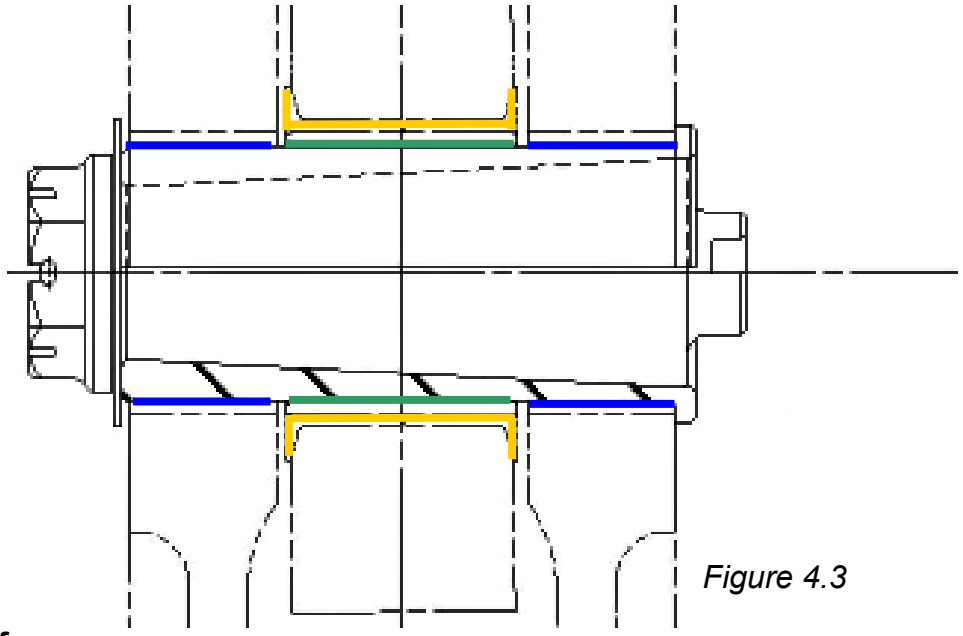


Figure 4.3

Contact surfaces:

Bushing to CFRP lug surface

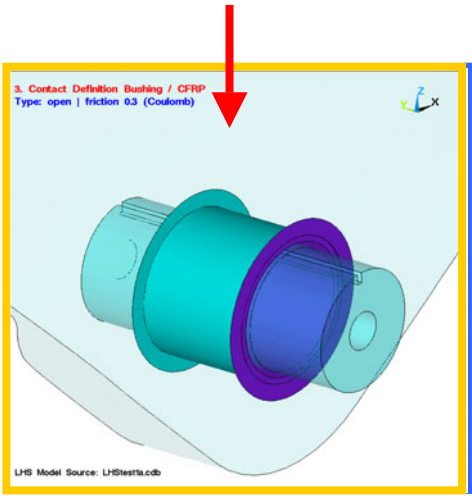


Figure 4.4

Fuselage clevis to bolt surface

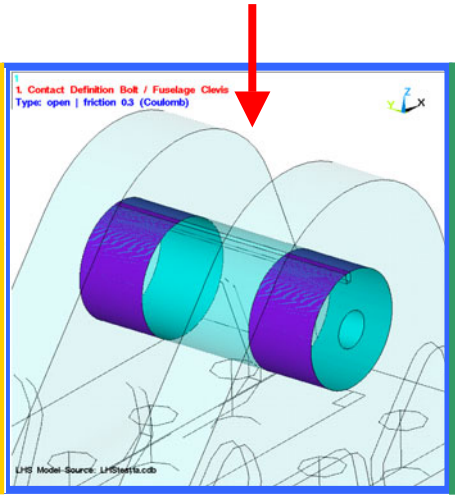


Figure 4.5

Bolt to bushing surface

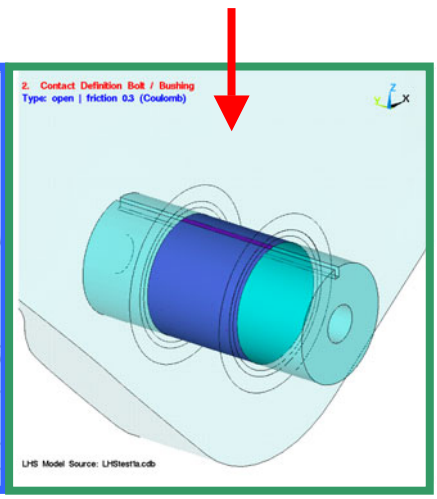


Figure 4.6

5. Local lug reactions

5.1 Reaction force & moment calculation in NASTRAN [linear static]

To calculate the main fitting reaction forces & moments the grid point force balance at the nodes of the clevis to fuselage interface are used (see figure 5.1 and 5.2).

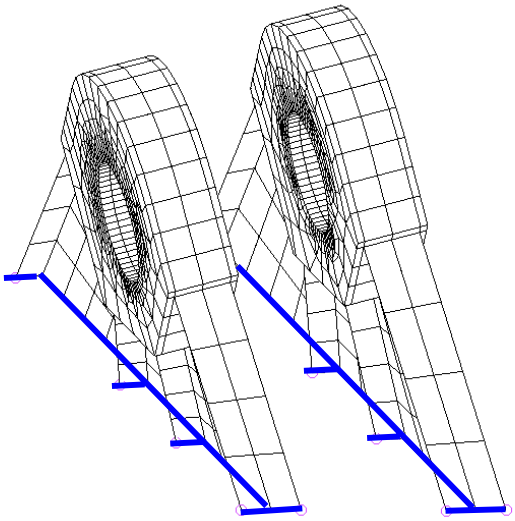


Figure 5.1

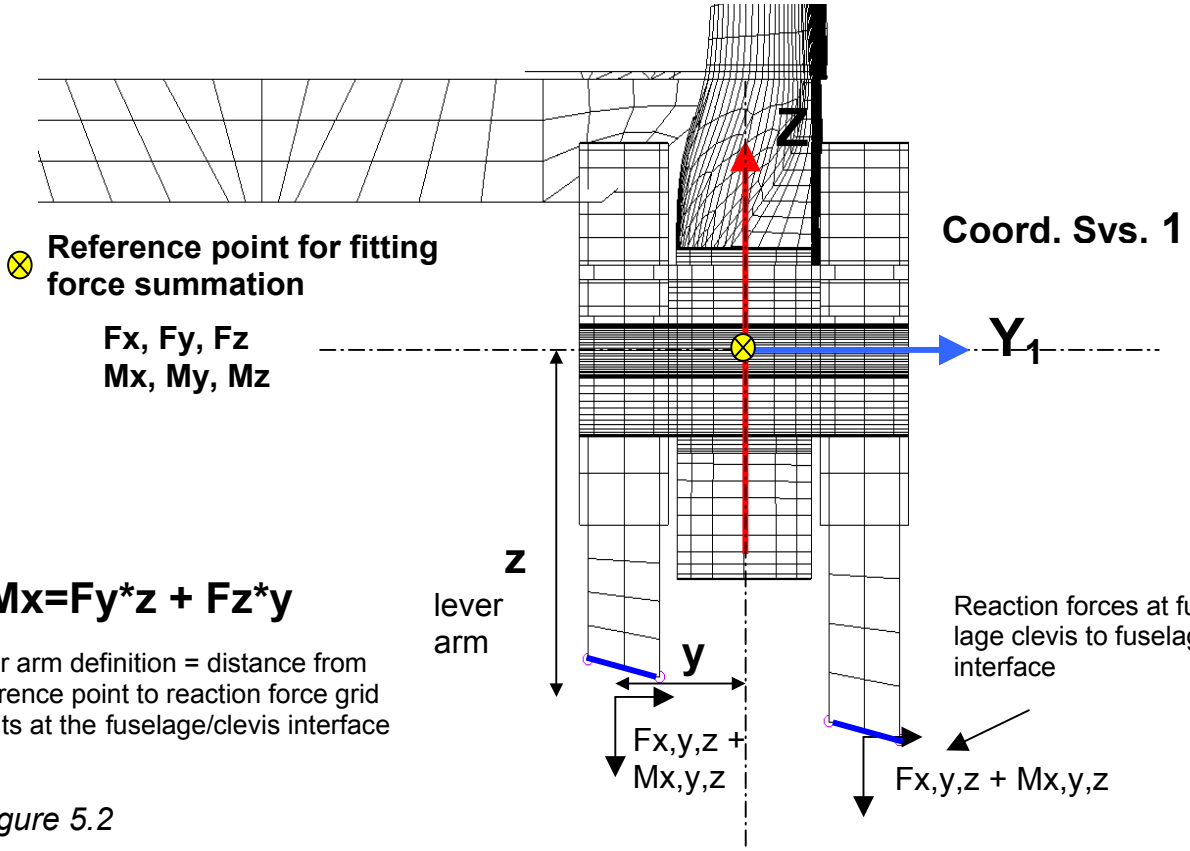


Figure 5.2

5.2 Reaction force & moment calculation in ANSYS [nonlinear contact]

The local lug reactions are calculated in the ANSYS model for every load step. At a defined cut through the fuselage clevis (see figure 5.3) the summation of the grid point force balance in this cut gives the local lug reaction including respective forces and moments. Also the deformation of the complete bolt area is taken into account for this procedure.

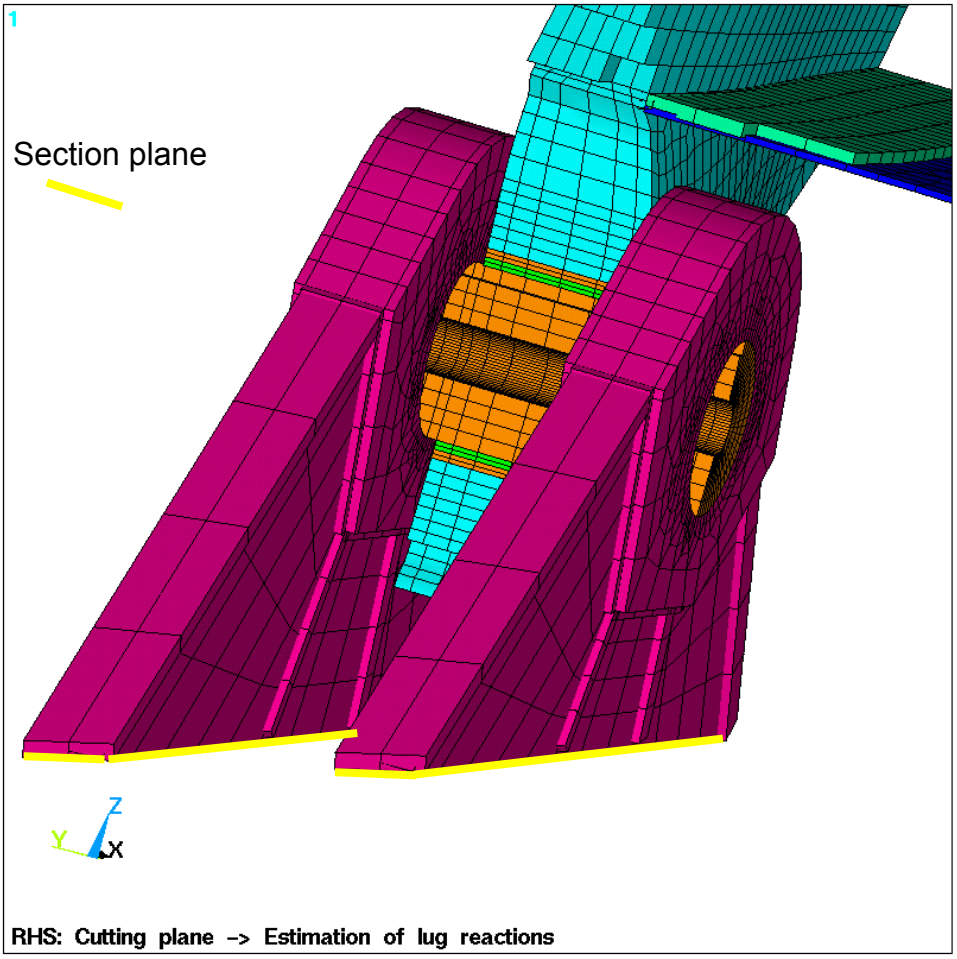
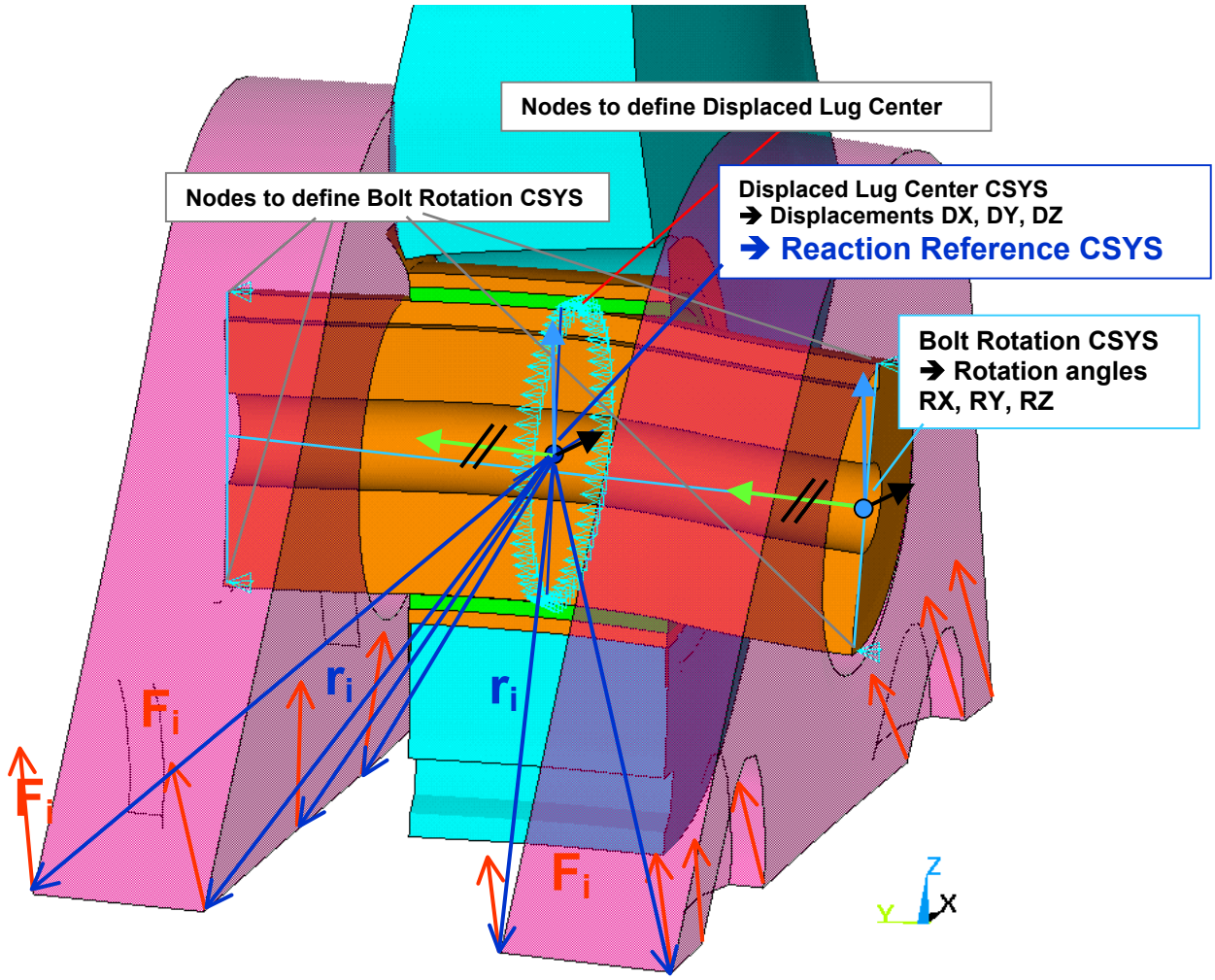


Figure 5.3

The calculation of bolt rotation and lug reactions on deformed lug center (See figure 5.4) was made with user written subroutine in ANSYS (APDL).



Deformed structure! (Displacements scaled by a factor 10)

Figure 5.4

➔ Reactions in Displaced Lug Centre:

$$M_{RsP} = SUM(r_i \times F_i) \qquad F_{RsP} = SUM(F_i)$$

6. Bolt rotation relative to rib 1

The calculation of the bolt displacement and rotation relative to rib1 in the NASTRAN and ANSYS model takes into account the complete deformed structure. A plane was defined through the edge nodes of the rib1 and relative to this plane the bolt rotation was calculated. The figure 6.1 below shows the ANSYS procedure for the bolt rotation calculation.

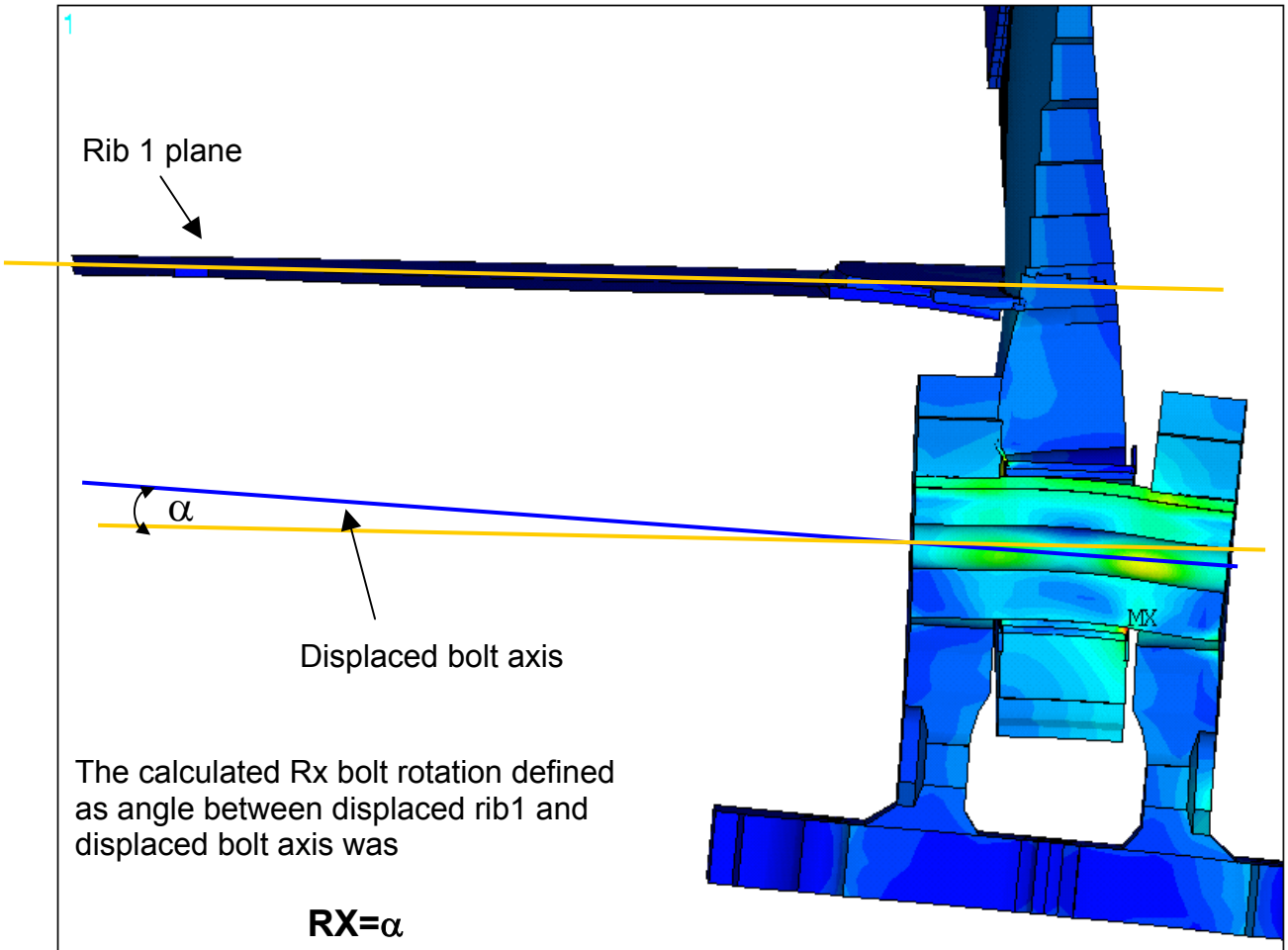


Figure 6.1

Calculation of bolt displacements and rotation relative to rib 1 as shown in figure 6.2.

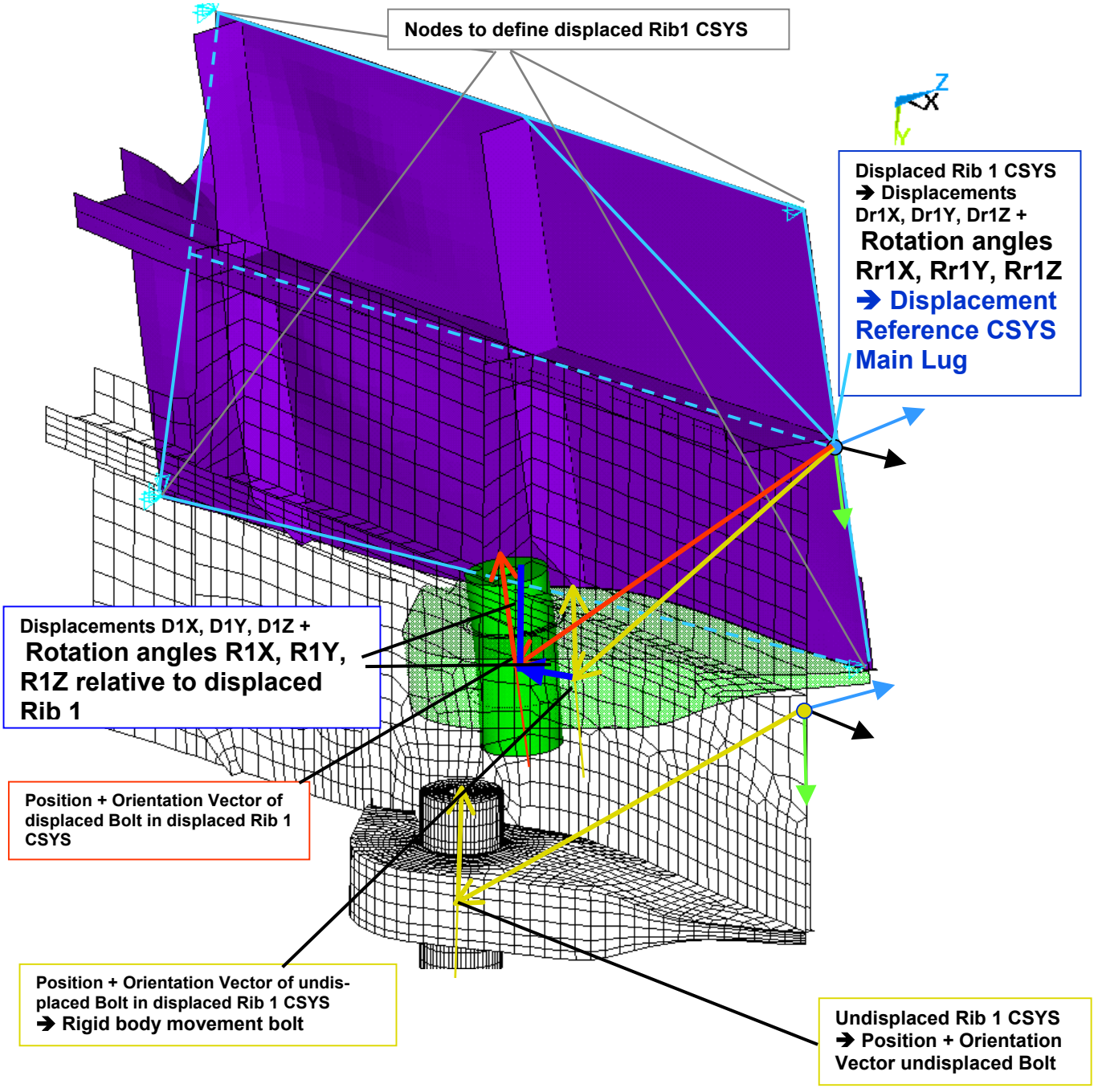


Figure 6.2

7. Summary

It was found out that the nonlinear ANSYS contact analysis is some percent softer in the stiffness than the partially bonded and embedded NASTRAN model. Therefore the Fres is smaller than in the global calculation.
The contact element idealization is different compared to the partially bonded element connection:

a) It is more accurate because the contact regions are established between the integration points of the contact elements (twice as many integration points available than nodes!) and the target element planes.
b) Tangential sliding of the contact surfaces before settling into closed contact status is considered! To calculate contacts with a geometric nonlinear analysis it is necessary to take into account the shifts of the lever arms.

The force distribution and small shifts of lever arms due to the nonlinear calculation have an influence on the results.
The examination of the contact pressure distribution and the deformation of the fuselage clevis, bolt and CFRP connection delivered reasonable results.
The approach to scale the ANSYS contact results to the level of Fres from the 3D NASTRAN results, is based on the assumption that the introduced contact method leads to higher deflection in the fitting areas while the global force distribution between the front center and rear main fitting remains nearly unchanged.