AMS-02 TCS MAIN RADIATORS CRATES STRUCTURAL ANALYSIS

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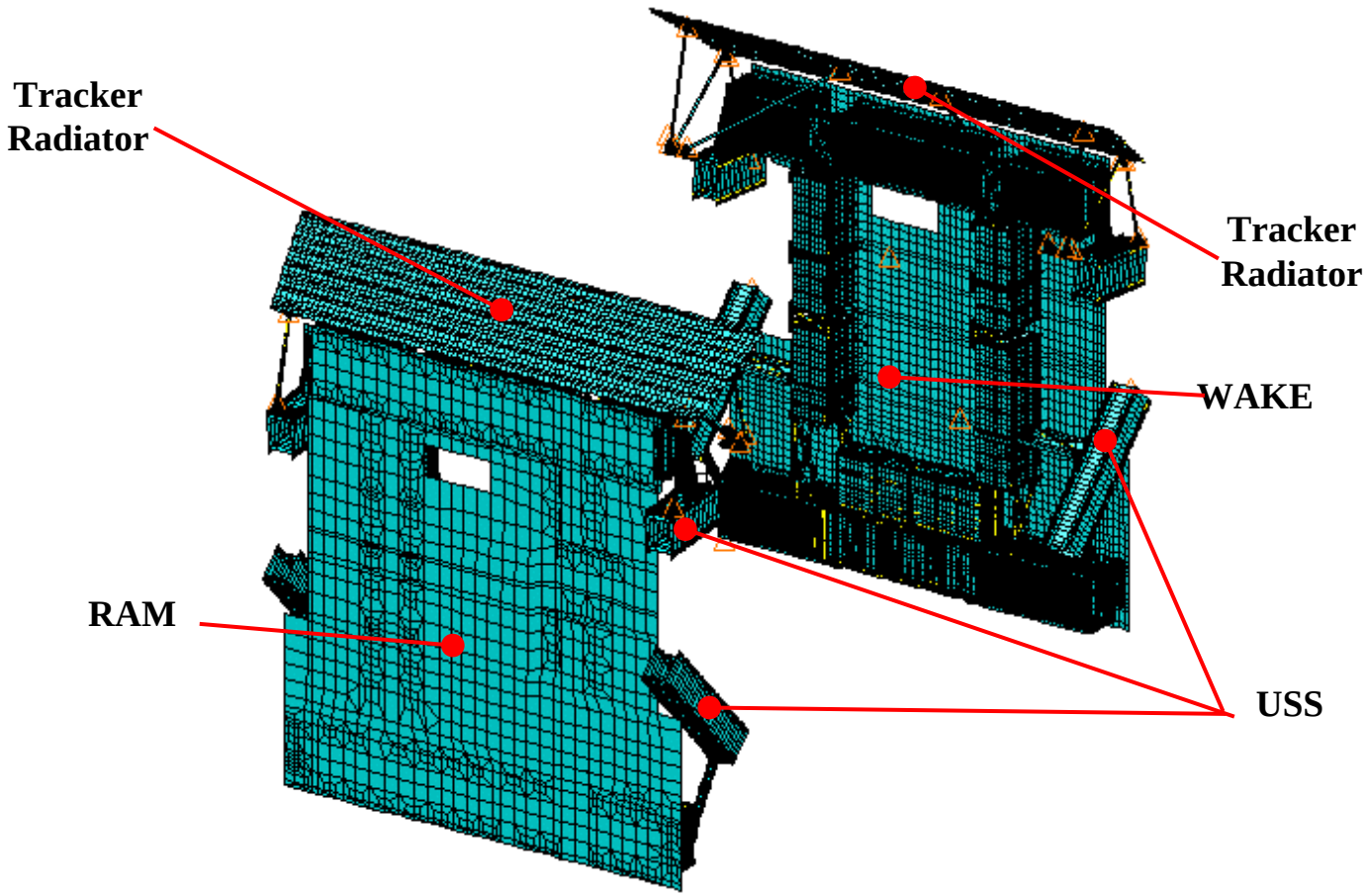
INTRODUCTION

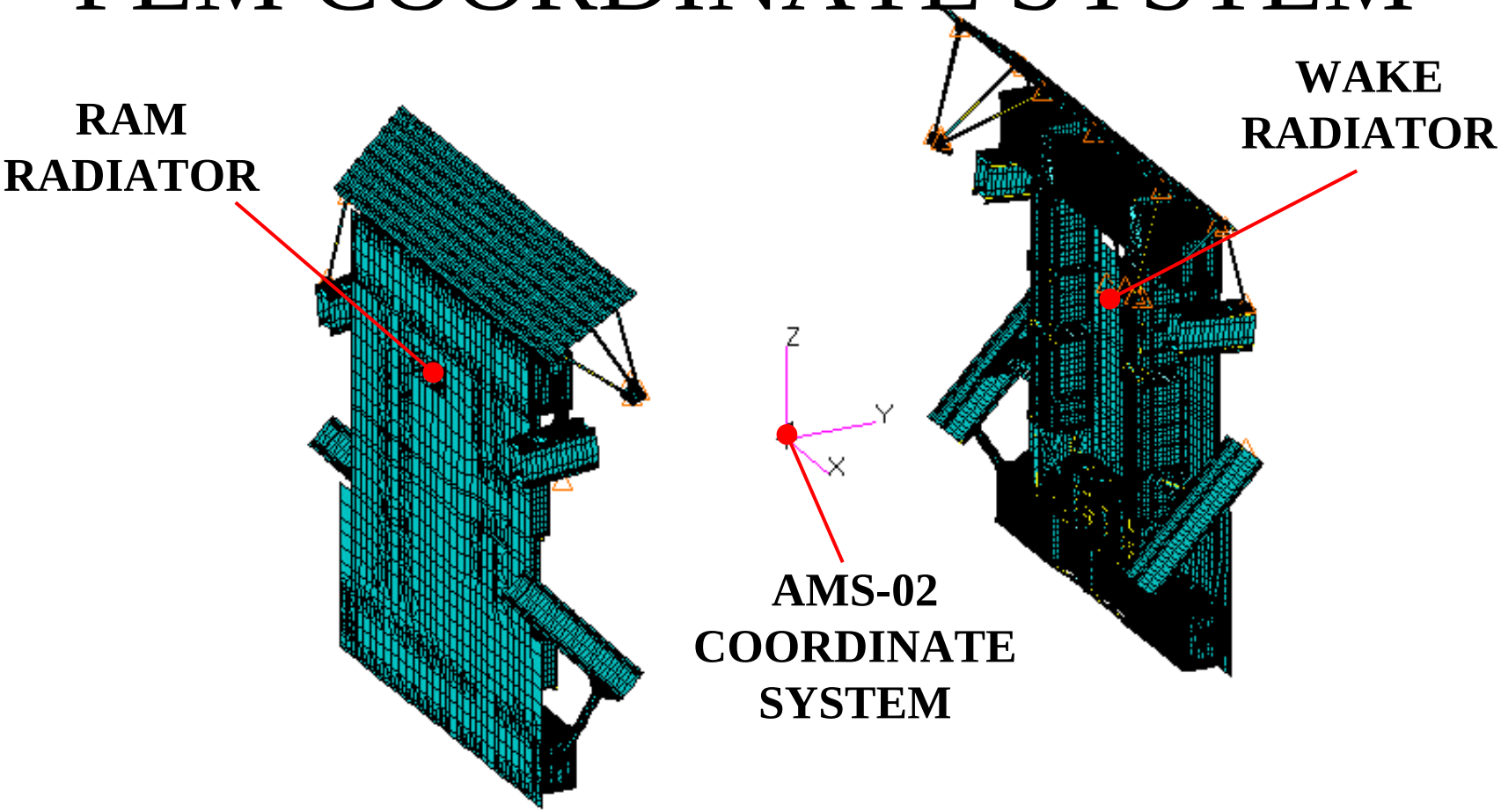
Next slides show the analysis of the structure of the **AMS-02 Main Radiators** (excluding the radiator plates).

- Analysis results are based on CGS **FE Models**:
  - WAKE version 02/2004
  - RAM version 02/2004
- These analyses are based on a preliminary set of 9 load cases (LMSO 2-04) and they are composed by:
  - Inertial Loads (LMSO version 2-04) and
  - Consistent Enforced Displacements (LMSO version 2-04)
- Load Cases 1023, 1042, 1055, 2004, 2005, 2032, 4004, 4005, 4032.

MAIN RADIATORS FE MODEL



FEM COORDINATE SYSTEM



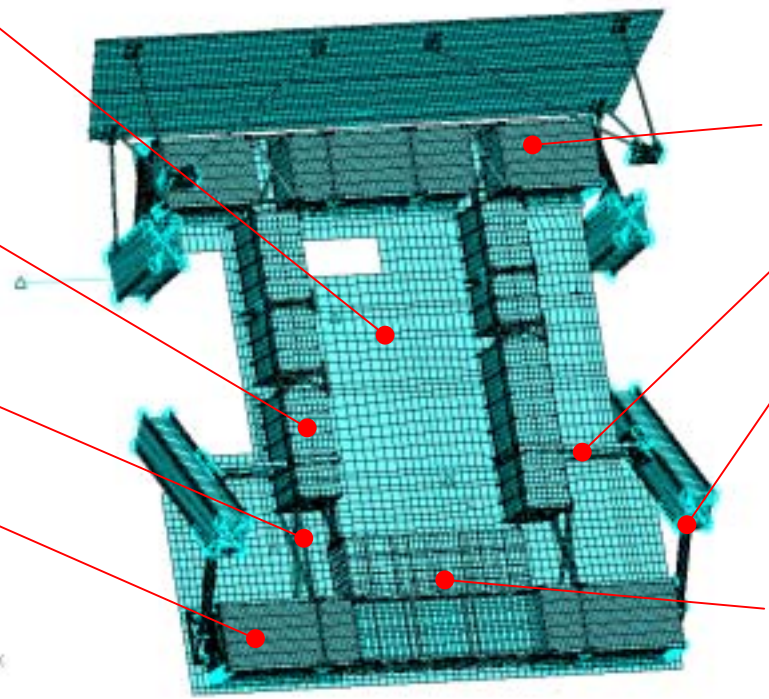
WAKE RADIATOR (version 02/2004)

Radiator Panel
ROHACELL &
Al 2024 T81

XPD
(Al 7075 T7351)
(FR4)

Links
(Al 7075 T7351)

CRATE
(Al 7075 T7351)
(FR4)



BOLTS
(A286 160 KSI)

Upper bracket
(Al 7075 T7351)

Mid bracket
(Al 7075 T7351)

Lower Rod
(Al 7075 T7351)
(steel)

PDS
(Al 7075 T7351)
(FR4)

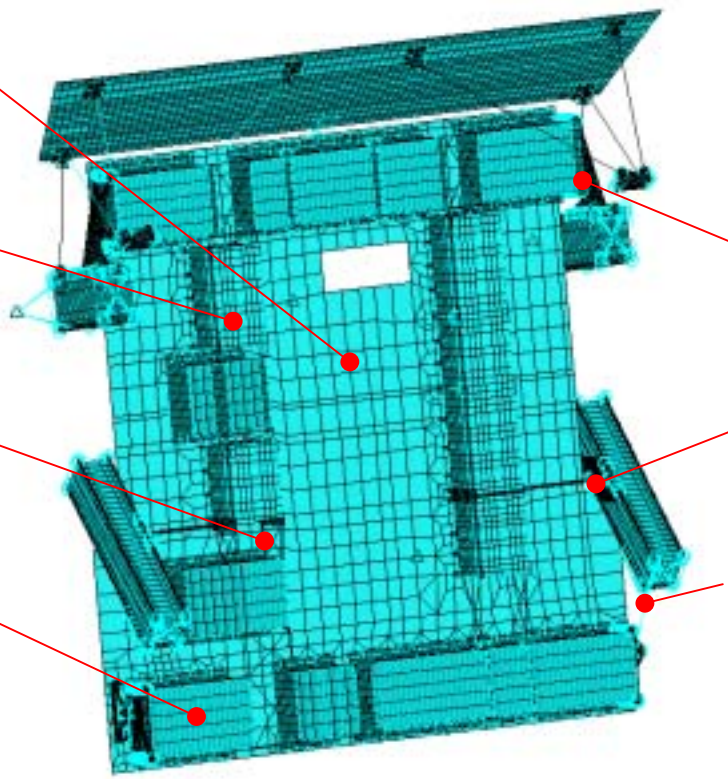
RAM RADIATOR (version 02/2004)

Radiator Panel
ROHACELL &
Al 2024 T81

XPD
(Al 7075 T7351)
(FR4)

Links
(Al 7075 T7351)

CRATE
(Al 7075 T7351)
(FR4)



BOLTS
(A286 160 KSI)

Upper bracket
(Al 7075 T7351)

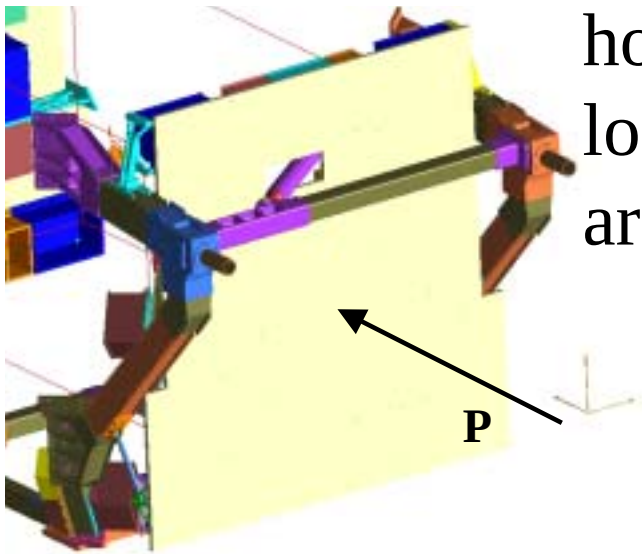
Mid bracket
(Al 7075 T7351)

Lower Rod
(Al 7075 T7351)
(steel)

LOADS

- THIS ANALYSIS IS PERFORMED COMBINING THE **INERTIAL LOADS** WITH THE **ENFORCED DISPLACEMENT** OF THE CONSTRAINTS (FROM LMSO, VERSION 2-04).
- THE ANALYSES WILL BE UPDATED WITH:
  - **ACOUSTIC LOADS (superimposed);**
  - **EVA LOADS;**
  - **THERMAL LOADS;**
  - ~~**TEST LOADS (OPTIONAL)**~~.

ACOUSTIC LOADS (TBC)



Equivalent Pressure (normal to the panel) obtained with the Mass of the honeycomb panel times acoustic load factor (SVP), divided by the area of the panel.

$$P=\frac{Mass_{HCpanel}*3g}{Area_{HCpanel}}$$

FEM MASS BUDGET

WAKE RADIATOR

TYPE	MASS	CONT 10%	#	TOT	REMARK
S	5.63	6.19	2	12.38	
U	8.25	9.07	1	9.07	
T	11.14	12.26	4	49.03	
UG	6.40	7.04	1	7.04	
TT	4.00	4.40	1	4.40	
TSPD	8.39	9.23	1	9.23	
UPD	5.79	6.37	1	6.37	
TPD	6.51	7.16	2	14.32	
TTPD	2.60	2.86	1	2.86	
UGPD	4.80	5.28	1	5.28	
TEPD	9.85	10.83	1	10.83	
SRPD	5.32	5.85	1	5.85	
PDS	52.01	57.22	1	57.22	
SHV	3.40	3.74	2	7.48	
TOT BOX				**201.36**	
UP BKT	2.86	3.15	2	6.29	
MID BKT	3.13	3.44	2	6.88	
LOW BKT	2.82	3.10	2	6.19	
LINKS	4.64	5.10	1	5.10	
TOTAL BRACKET				**24.47**	
RADIATOR panel	27.40	30.14	1	30.14	
DOUBLER	0.50	0.55	1	0.55	
HARNESS	25.00	27.50	1	27.50	
INSERT	0.00	0.00	1	0.00	in panel
MLI	2.00	2.20	1	2.20	
BOLT	0.02	0.02	176	3.87	
TOT PANEL				**64.26**	
TRACKER	16.47	16.47	1	16.47	
TRUNION	60.20	60.20	1	60.20	
OTHER				**76.67**	
TOT WAKE FEM				**366.76**	

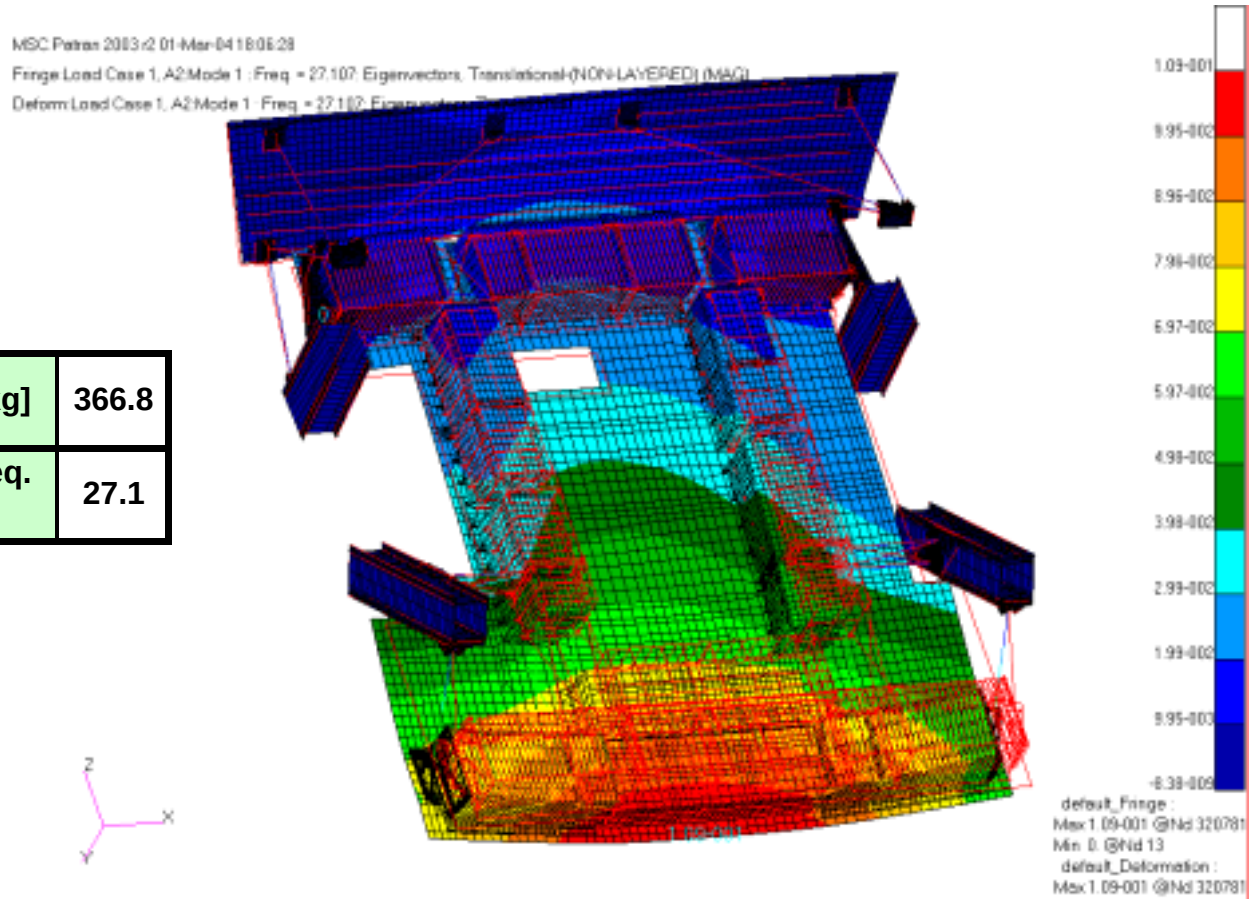
RAM RADIATOR

TYPE	MASS	CONT 10%	#	TOT	REMARK
S	5.63	6.19	2	12.38	
U	8.25	9.07	1	9.07	
M	7.35	8.09	1	8.09	
JT	5.60	6.16	1	6.16	
CCEB	11.55	12.70	1	12.70	
J	14.09	15.50	1	15.50	
JPD	9.15	10.07	1	10.07	
ERPD	5.32	5.85	1	5.85	
TSPD	9.85	10.83	1	10.83	
UPD	5.79	6.37	1	6.37	
TMPD	8.39	9.23	1	9.23	
TPD	6.51	7.16	1	7.16	
TSPD	8.39	9.23	1	9.23	
T	11.14	12.26	4	49.03	
SHV	3.40	3.74	2	7.48	
GPS	1.50	1.65	1	1.65	
TOT BOX				**180.79**	
UP BKT	2.86	3.15	2	6.29	
MID BKT	3.13	3.44	2	6.88	
LOW BKT	2.82	3.10	2	6.19	
LINKS	5.45	6.00	1	6.00	
TOTAL BRACKET				**25.37**	
RADIATOR panel	33.02	36.32	1	36.32	
DOUBLER	0.50	0.55	1	0.55	
HARNESS	25.00	27.50	1	27.50	
INSERT	0.00	0.00	1	0.00	in panel
MLI	2.10	2.31	1	2.31	
BOLT	0.02	0.02	176	3.87	
TOT PANEL				**70.55**	
TRACKER	16.47	16.47	1	16.47	
TRUNION	85.62	85.62	1	85.62	
OTHER				**102.09**	
TOT RAM FEM				**378.81**	

10% contingency included

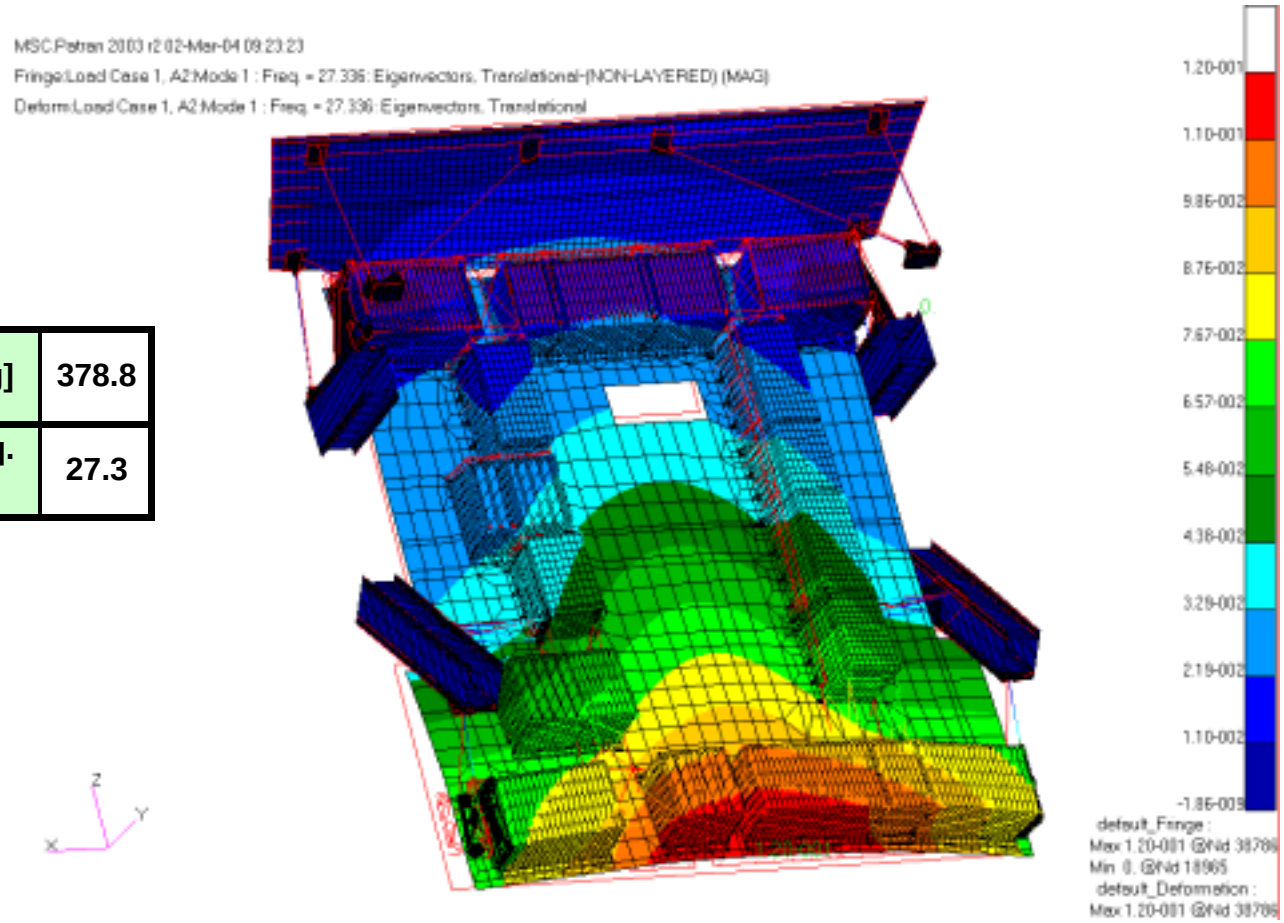
WAKE DYNAMIC ANALYSIS

Mass [kg]	**366.8**
First Freq. [Hz]	**27.1**



RAM DYNAMIC ANALYSIS

Mass [kg]	**378.8**
First Freq. [Hz]	**27.3**



STRESS ANALYSIS RESULTS

The following items are verified:

- Upper Bracket
- Mid Bracket
- Lower Bracket
- Electronic Crates &XPDs
- Links
- BOLTS/Lugs

In this analysis only the **Von Mises** stress (Plates) and the **Maximum Combined** stress (Bars) are evaluated.

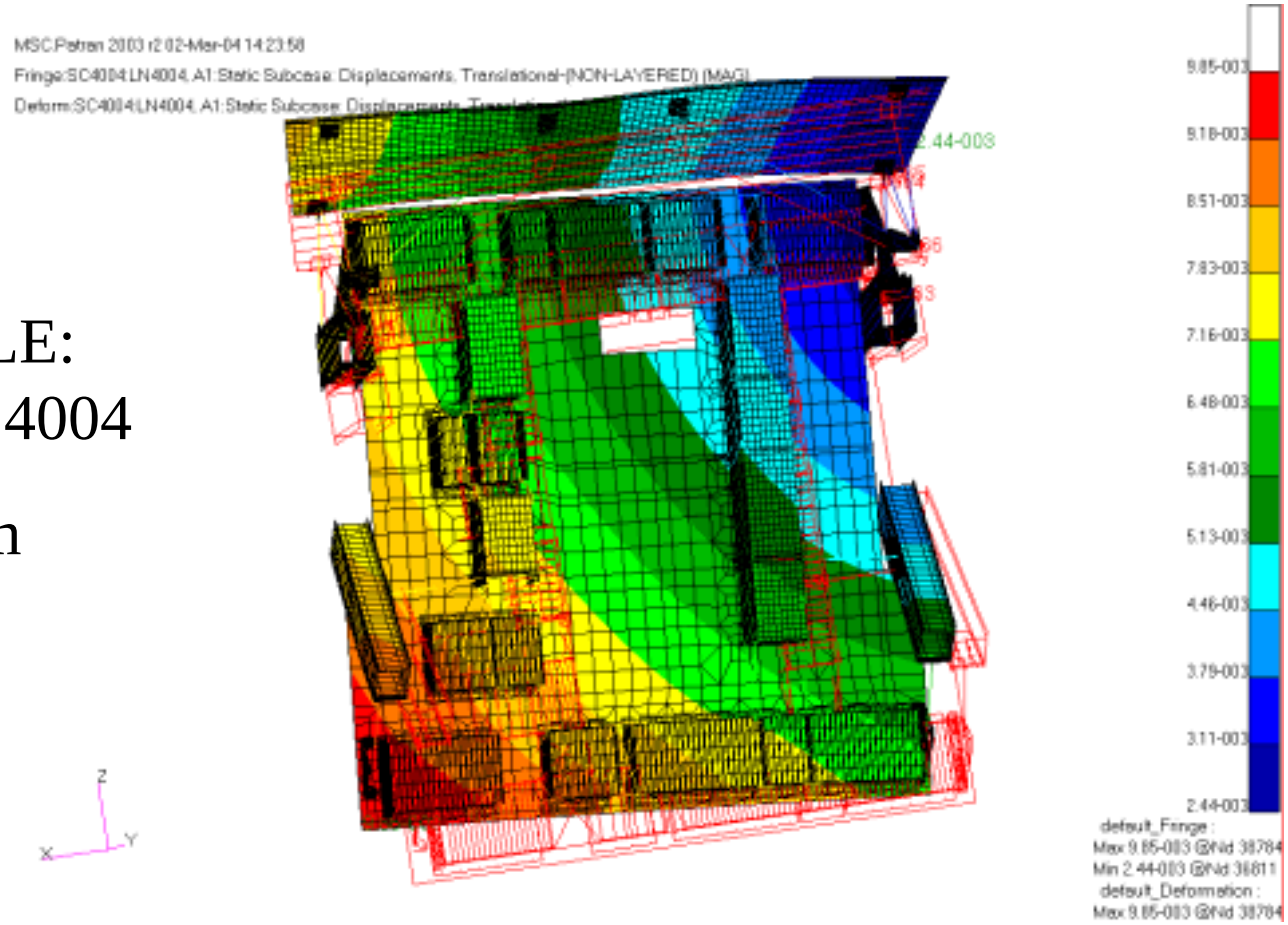
Additional analyses needed: **Buckling** for the **plates**, **bars** and **rods**.

In the following slides the results of the static analysis for both WAKE and RAM radiator FE Models are presented.

RAM DISPLACEMENTS

EXAMPLE:
SUBCASE 4004

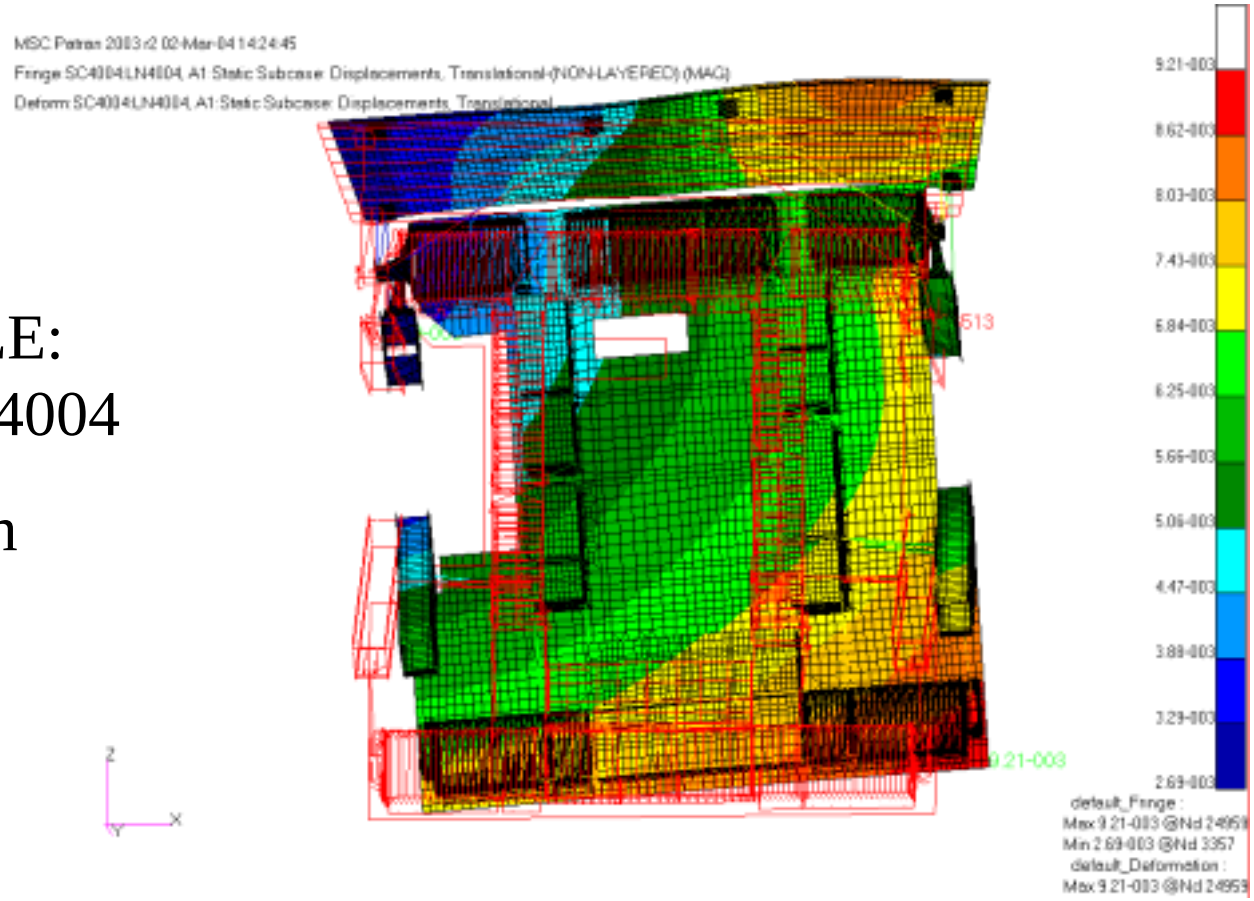
9.85mm



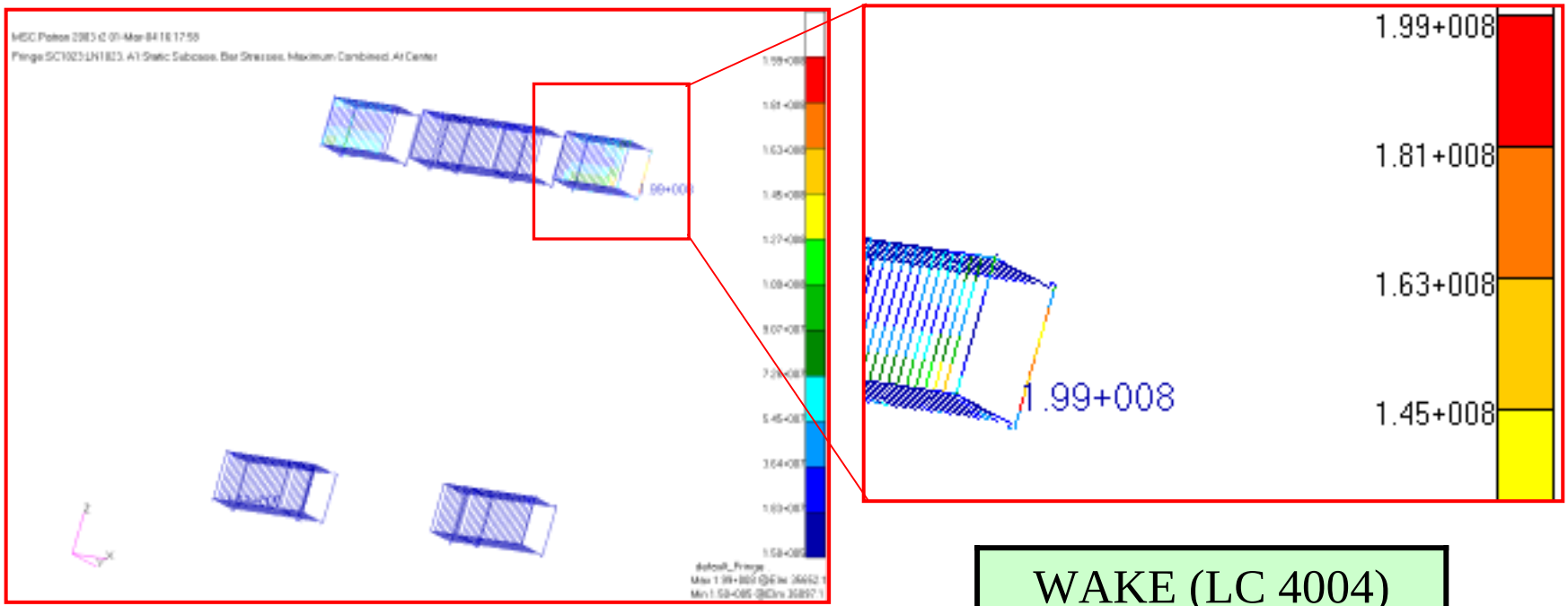
WAKE DISPLACEMENTS

EXAMPLE:
SUBCASE 4004

9. 21mm



CRATE BARS



WAKE (LC 4004)	
Limit stress	200 MPa

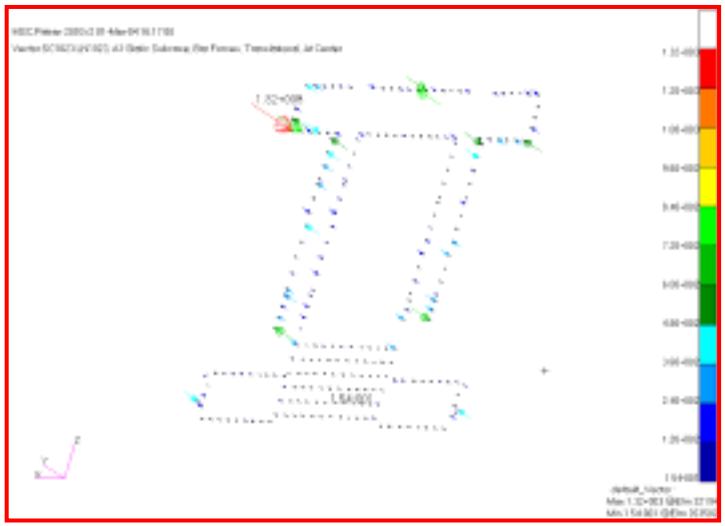
MoS SUMMARY

MARGINS OF SAFETY FOR STRENGHT FAILURE (STRESS)									
ITEM	**MATERIAL**	**F_{ty} [MPa]**	**F_{tu} [MPa]**	**Limit stress [MPa]**	**$S.F._y$**	**$S.F._u$**	**MoS_y**	**MoS_u**	**NOTE**
UPPER BRACKET	AL 7075	369.4	434.3	125	1.25	2	**1.36**	**0.74**	WAKE
MID BRACKET PLATE	AL 7075	369.4	434.3	133	1.25	2	**1.22**	**0.63**	WAKE
MID BRACKET BAR	AL 7075	369.4	434.3	83	1.25	2	**2.55**	**1.61**	WAKE
LOWER BRACKET PLATE	AL 7075	369.4	434.3	64	1.25	2	**3.65**	**2.42**	WAKE
CRATE WALLS	AL 7075	369.4	434.3	114	1.25	2	**1.59**	**0.90**	WAKE
CRATE BAR	AL 7075	369.4	434.3	200	1.25	2	**0.48**	**0.09**	WAKE
CRATE BOARDS	FR4	NA	188.0	20	1.25	2	**NA**	**3.70**	WAKE
XPD WALLS	AL 7075	369.4	434.3	105	1.25	2	**1.81**	**1.07**	RAM
XPD BAR	AL 7075	369.4	434.3	76	1.25	2	**2.91**	**1.87**	RAM
XPD BOARDS	FR4	NA	188.0	4	1.25	2	**NA**	**21.65**	RAM
LINKS PLATE	AL 7075	369.4	434.3	76	1.25	2	**2.89**	**1.86**	RAM
LINKS BAR	AL 7075	369.4	434.3	58	1.25	2	**4.12**	**2.76**	RAM
PDS PLATE	AL 7076	369.4	434.3	18.70	1.25	2	**14.80**	**10.61**	WAKE
PDS BAR	AL 7077	369.4	434.3	38.50	1.25	2	**6.68**	**4.64**	WAKE

F_{tu} and F_{ty} values have been diminished of 6% to take into account the temperature effects

Possibility to decrease the SF for tested items

RADIATOR to CRATE BOLTS

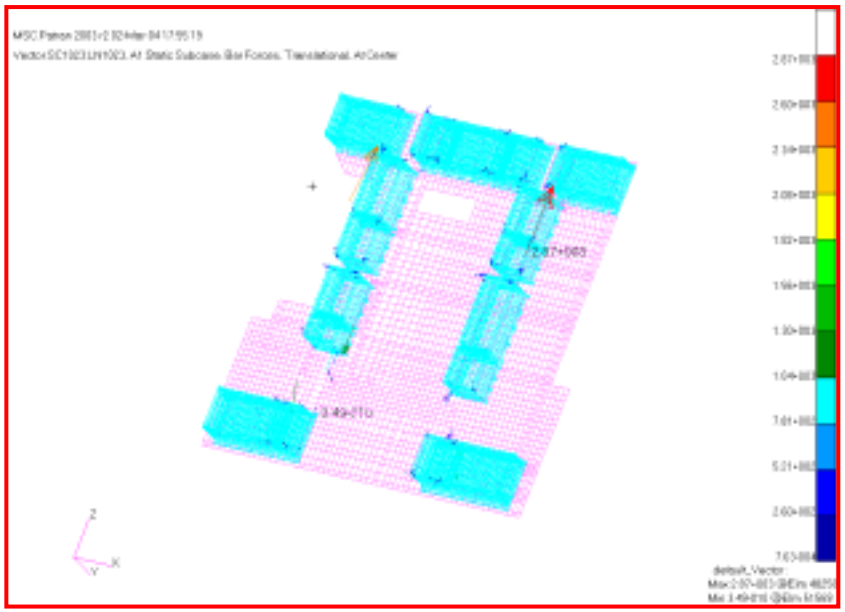


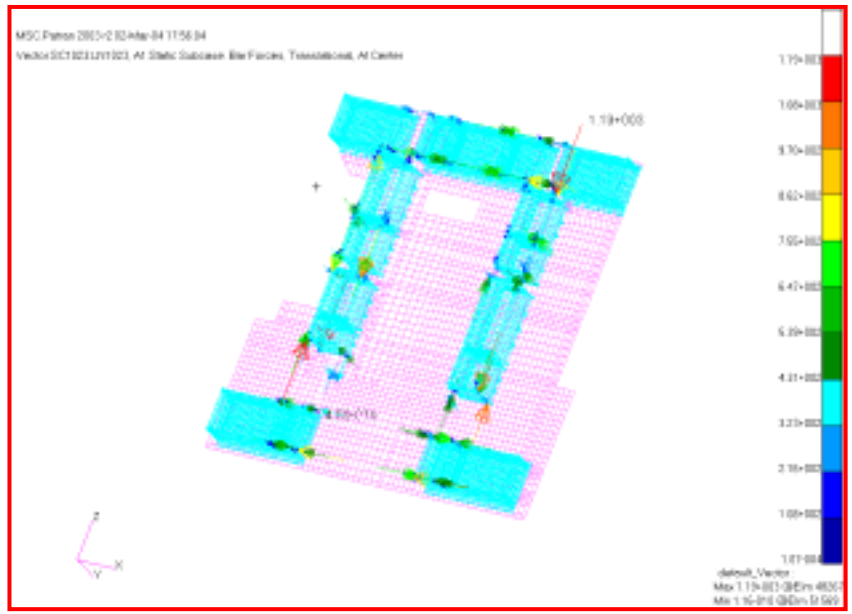
BOLT	NAS 1351-3
MATERIAL	A-286 (u:160ksi-y:119ksi)
AXIAL [N]	1320
SHEAR [N]	3471
MoS	-0.093

BOLT	NAS 1351-4
MATERIAL	A-286 (u:160ksi-y:119ksi)
AXIAL [N]	1320
SHEAR [N]	3471
MoS	**0.308**

BOLT	NAS 1351-3
MATERIAL	A-286 (u:200ksi-y:150ksi)
AXIAL [N]	1320
SHEAR [N]	3471
MoS	**0.062**

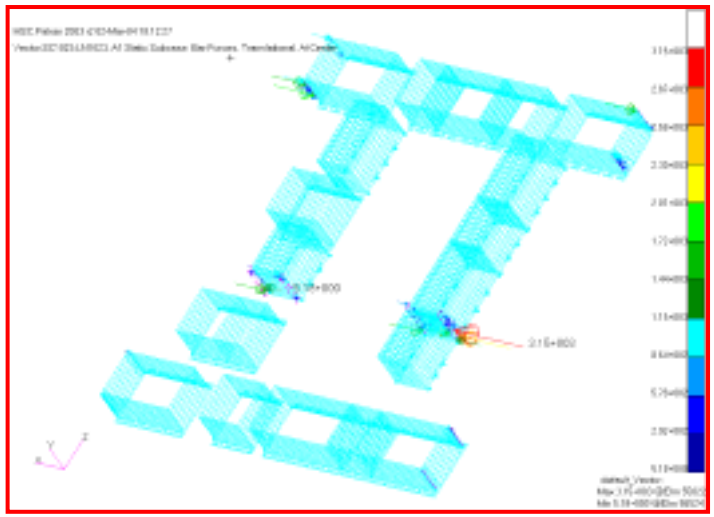
LINKS BOLTS

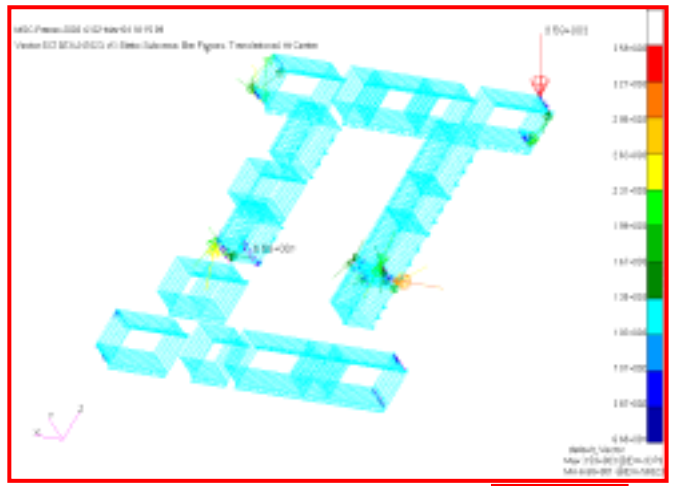




BOLT	NAS 1351-3
MATERIAL	A-286 (u:160ksi-y:119ksi)
AXIAL [N]	2865
SHEAR [N]	1194
MoS	**0.383**

BRACKET to CRATE BOLTS



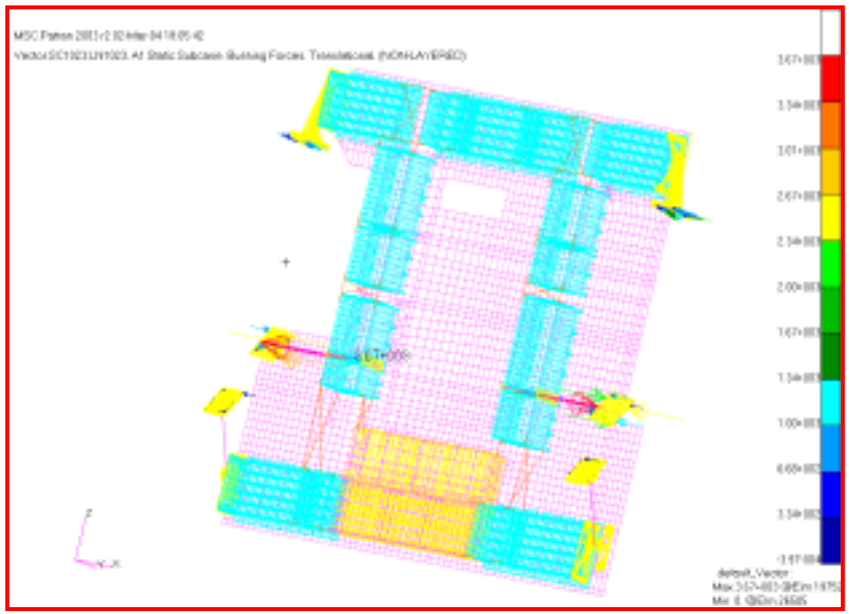


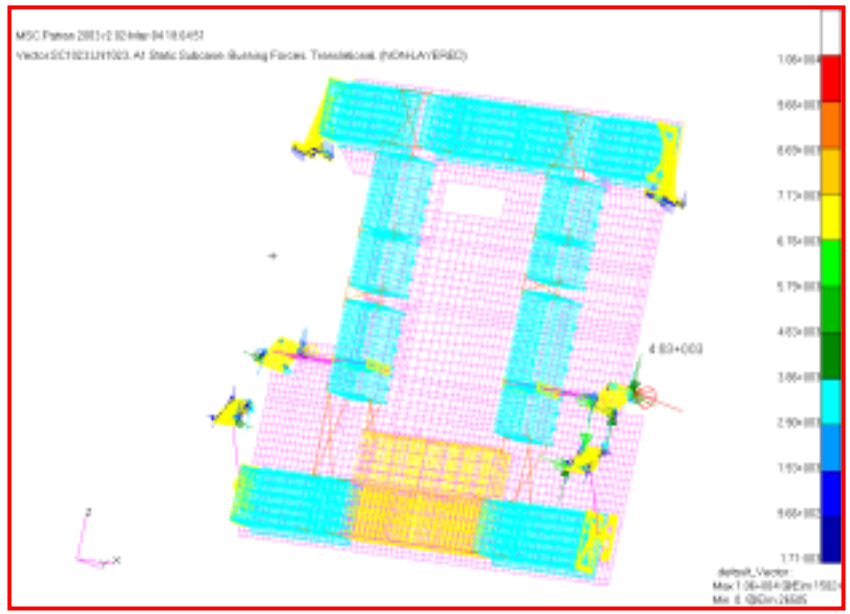
BOLT	NAS 1351-3
MATERIAL	A-286 (u:160ksi-y:119ksi)
AXIAL [N]	3157
SHEAR [N]	3247
MoS	**-0.131**

BOLT	NAS 1351-4
MATERIAL	A-286 (u:160ksi-y:119ksi)
AXIAL [N]	3157
SHEAR [N]	3247
MoS	**0.262**

BOLT	NAS 1351-3
MATERIAL	A-286 (u:200ksi-y:150ksi)
AXIAL [N]	1320
SHEAR [N]	3471
MoS	**0.019**

USS BOLTS





BOLT	NAS 1351-4
MATERIAL	A-286 (u:160ksi-y:119ksi)
AXIAL [N]	3676
SHEAR [N]	11586
MoS	**-0.446**

CONCLUSIONS & COMMENTS

FOR BOTH MAIN RADIATORS

- MINIMUM FREQUENCY: 27.1 Hz > **25 Hz**
- MoS for STRESS (V.M. & MC) > **0** for all the items analyzed
- MoS for BOLT FORCES:
  - EBOXES/RPANEL < **0**
  - LINKS/CRATEs &XPDs > **0**
  - BKT/EBOXES < **0**
  - USS/BRAKETS < **0**

POSSIBILITY TO MODIFY THE BOLT SIZE OR MATERIAL

CONCLUSIONS & COMMENTS

NOTE:

THESE RESULTS COME FROM THE ANALYSIS OF ONLY 9 LOAD CASES, THE FINAL ANALYSIS SHALL BE UPDATED:

- 192 LOAD CASES (from LMSO)
- **SVP** LOADS (ACOUSTIC, THERMAL & EVA)
- BUCKLING VERIFICATION (PLATES & RODS)