MARDiH

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OPERATIONAL MODAL ANALYSIS OF THE LARGE STRUCTURE WORKPIECES

Michał MAZUR, Marek A. Galewski, Krzysztof J. KALIŃSKI

GDAŃSK UNIVERSITY OF TECHNOLOGY
FACULTY OF MECHANICAL ENGINEERING

The National Centre for Research and Development

Machining of large workpieces

Research grant TANGO1/266350/NCBR/2015

„ Application of chosen mechatronic solutions to surveillance of the high-dimensional workpieces cutting process on multi axial machining centres
2015-2018"

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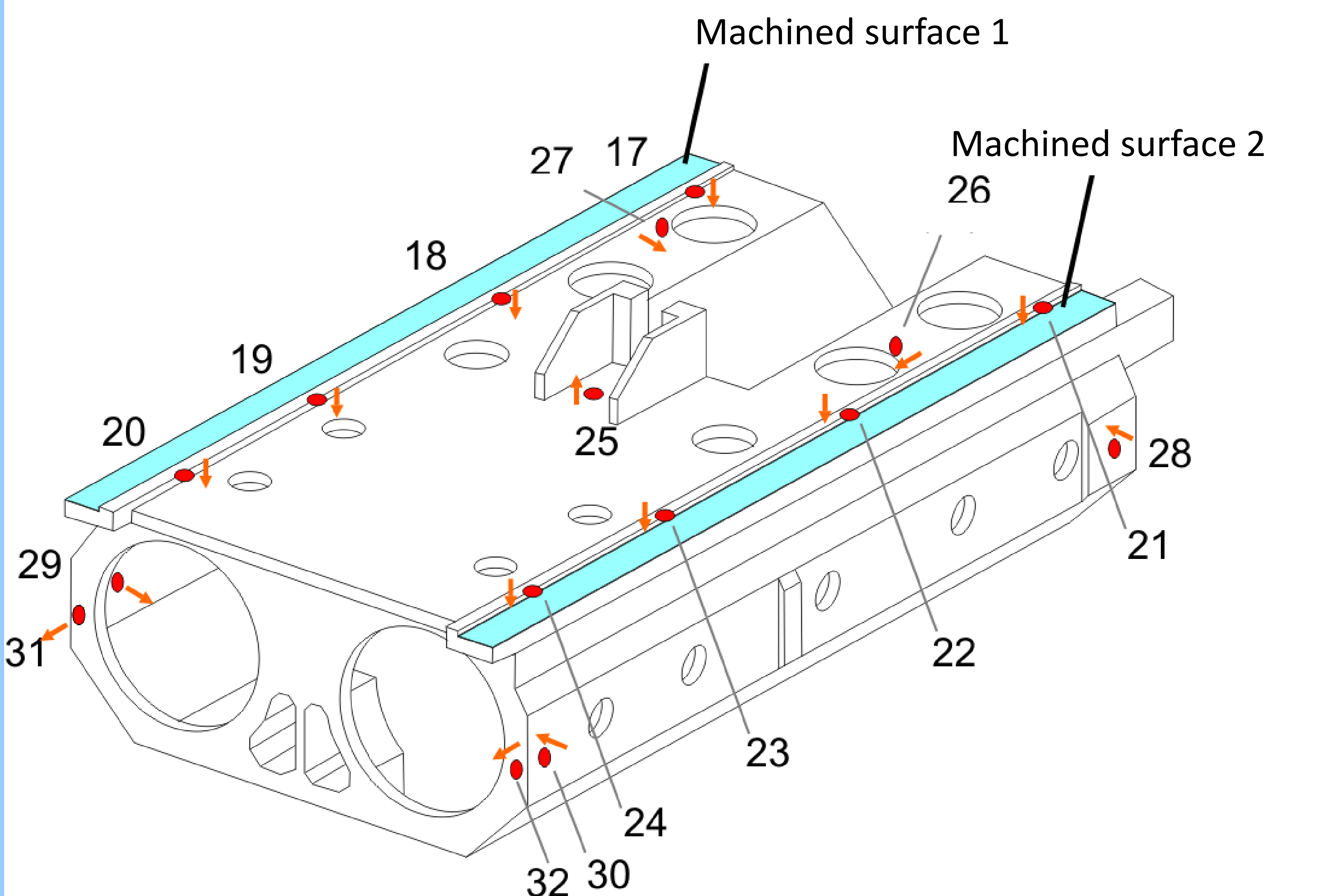
The workpiece

MECHATRONICS

Acceleration sensors placements



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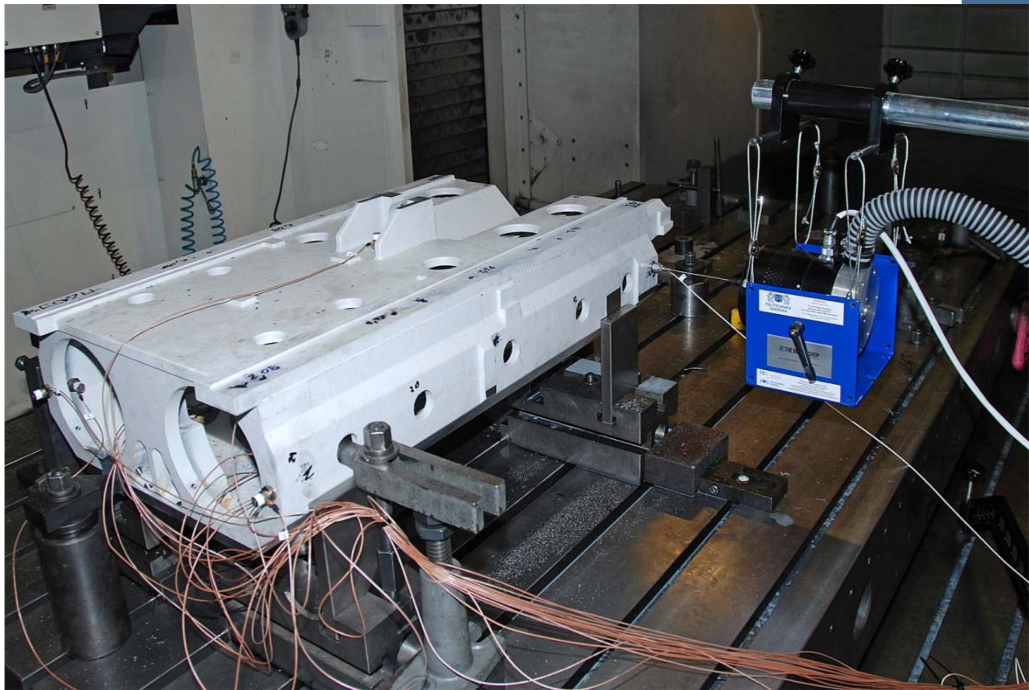
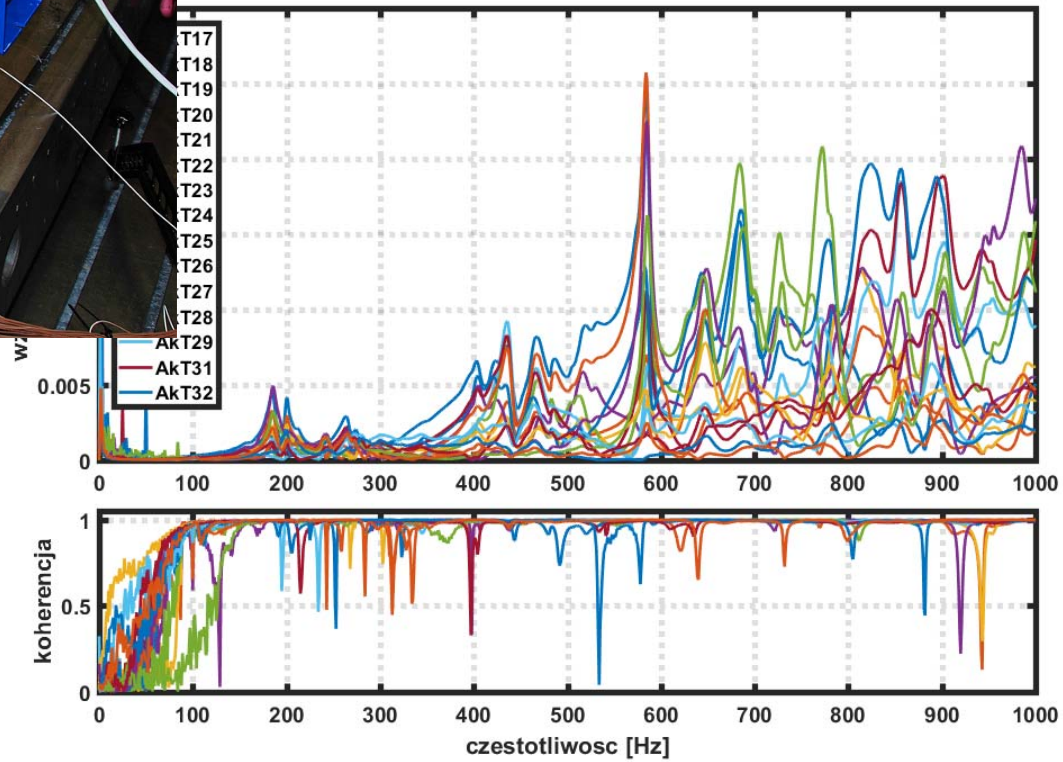
Experimental Modal Analysis

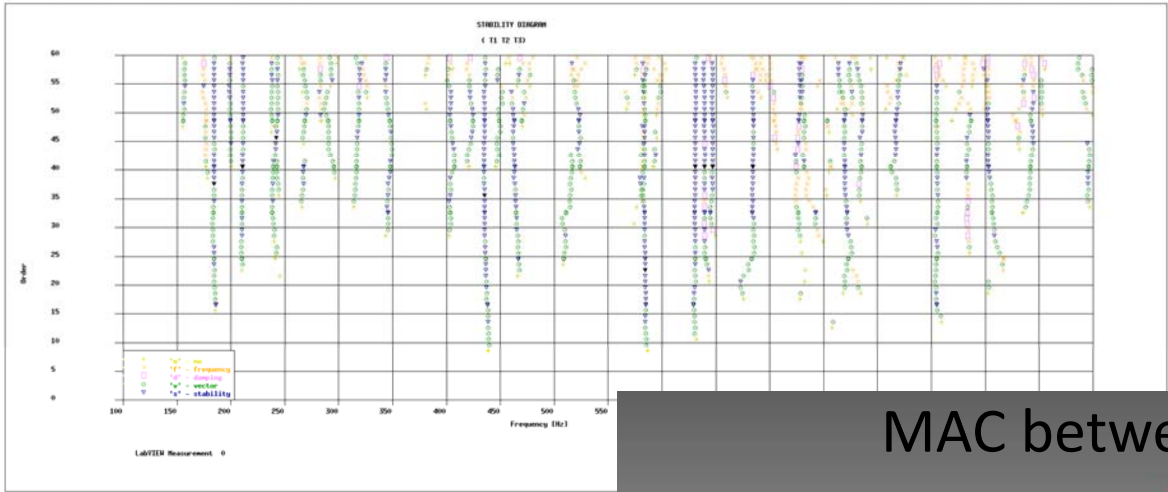


Two methods were used:

ERA – Eigenvalue Realisation Algorithm

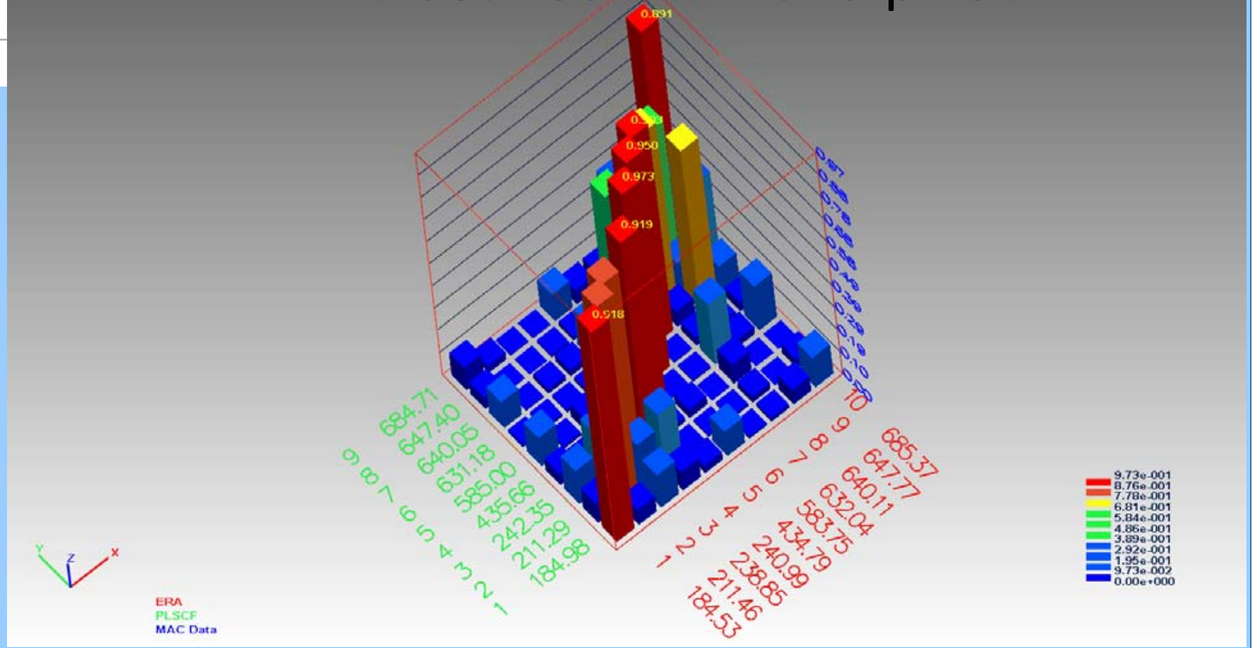
p-LSCFD – polyreference-Least Squares Complex Frequency Domain



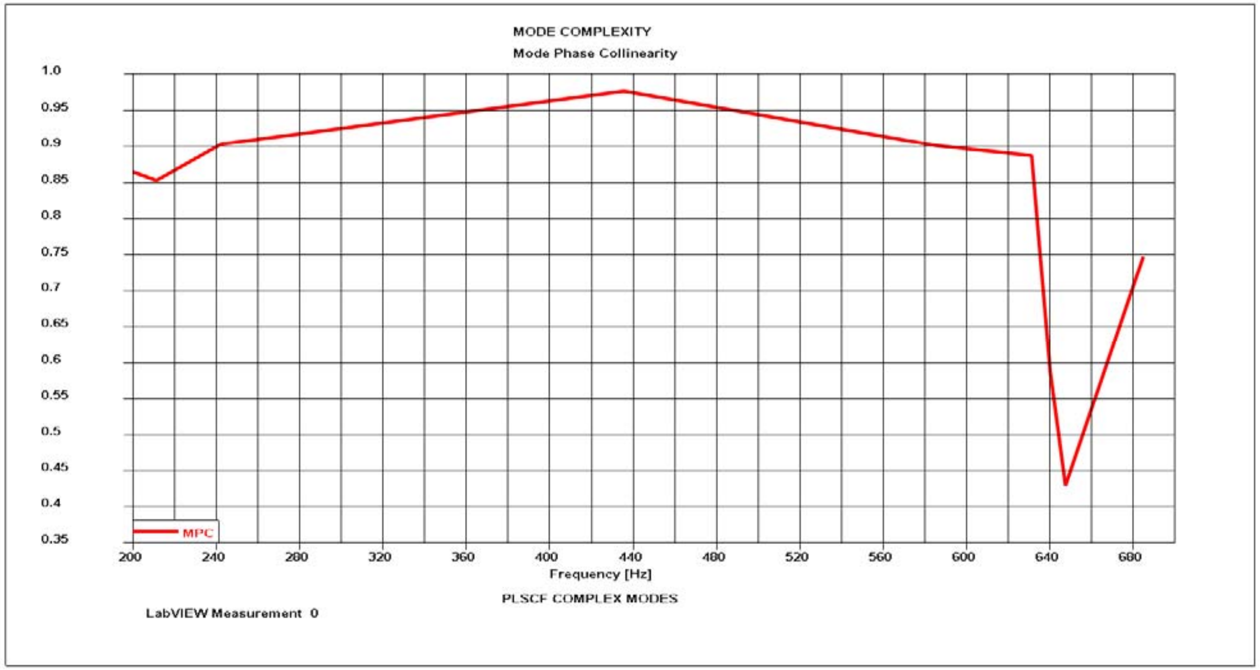


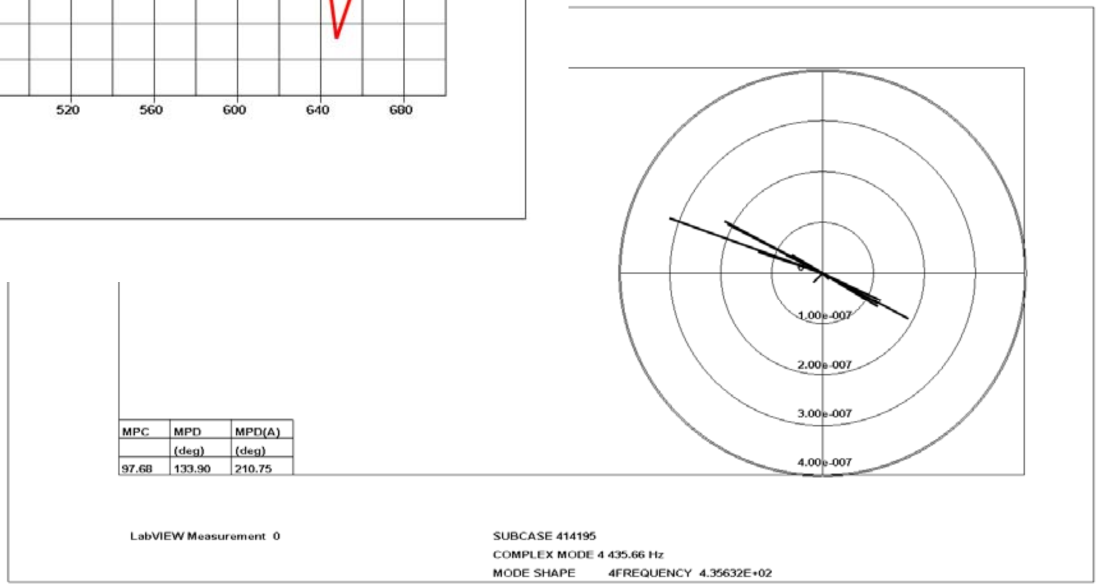
MAC – Modal Assurance Criterion

MAC between ERA and p-LSCFD



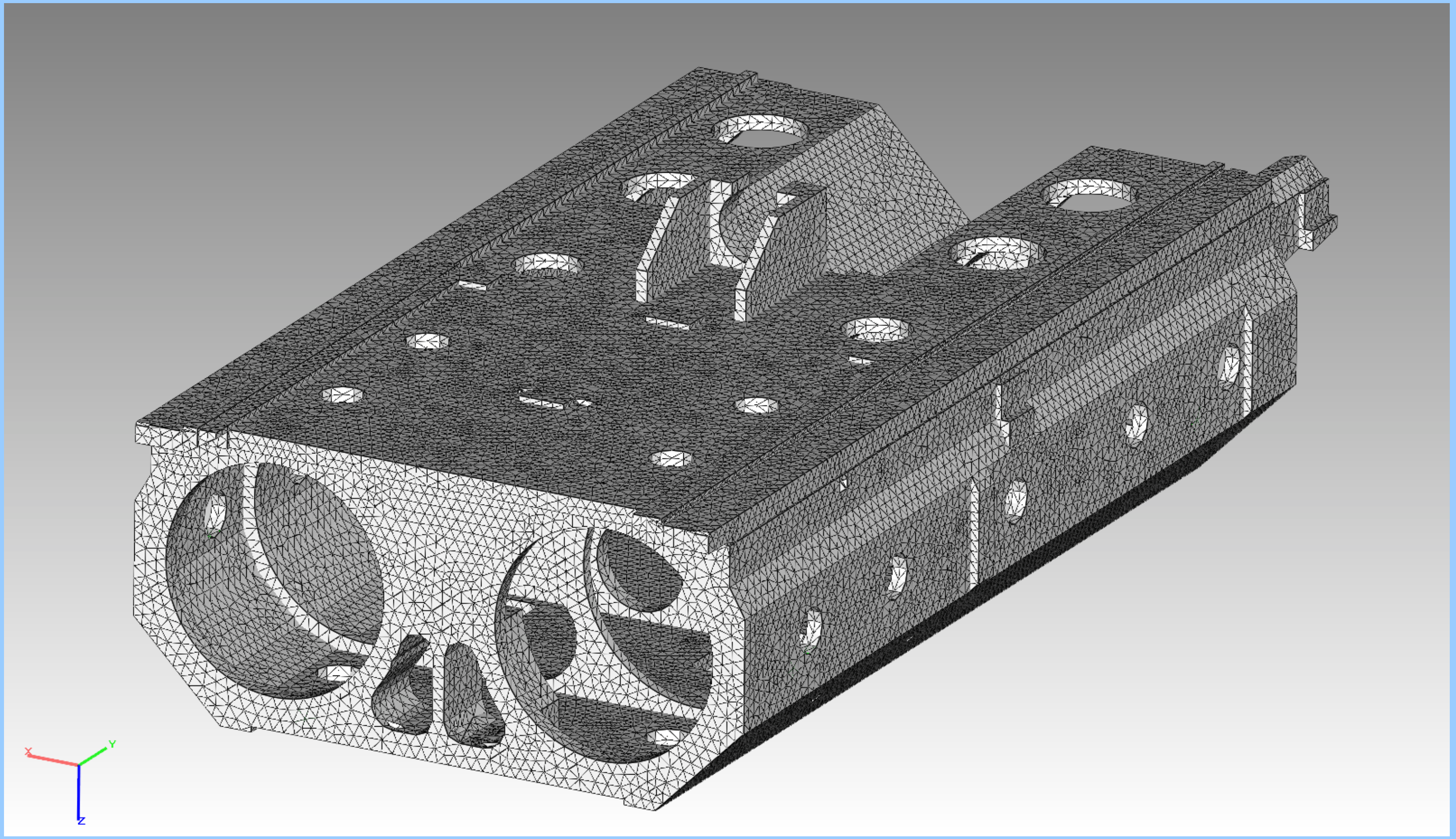
Experimental Modal Analysis - verification





- **Mean Phase Collinearity**
- **MAC**
- **Frequency**

FEM model



249078 finite elements of the **Tet10** type

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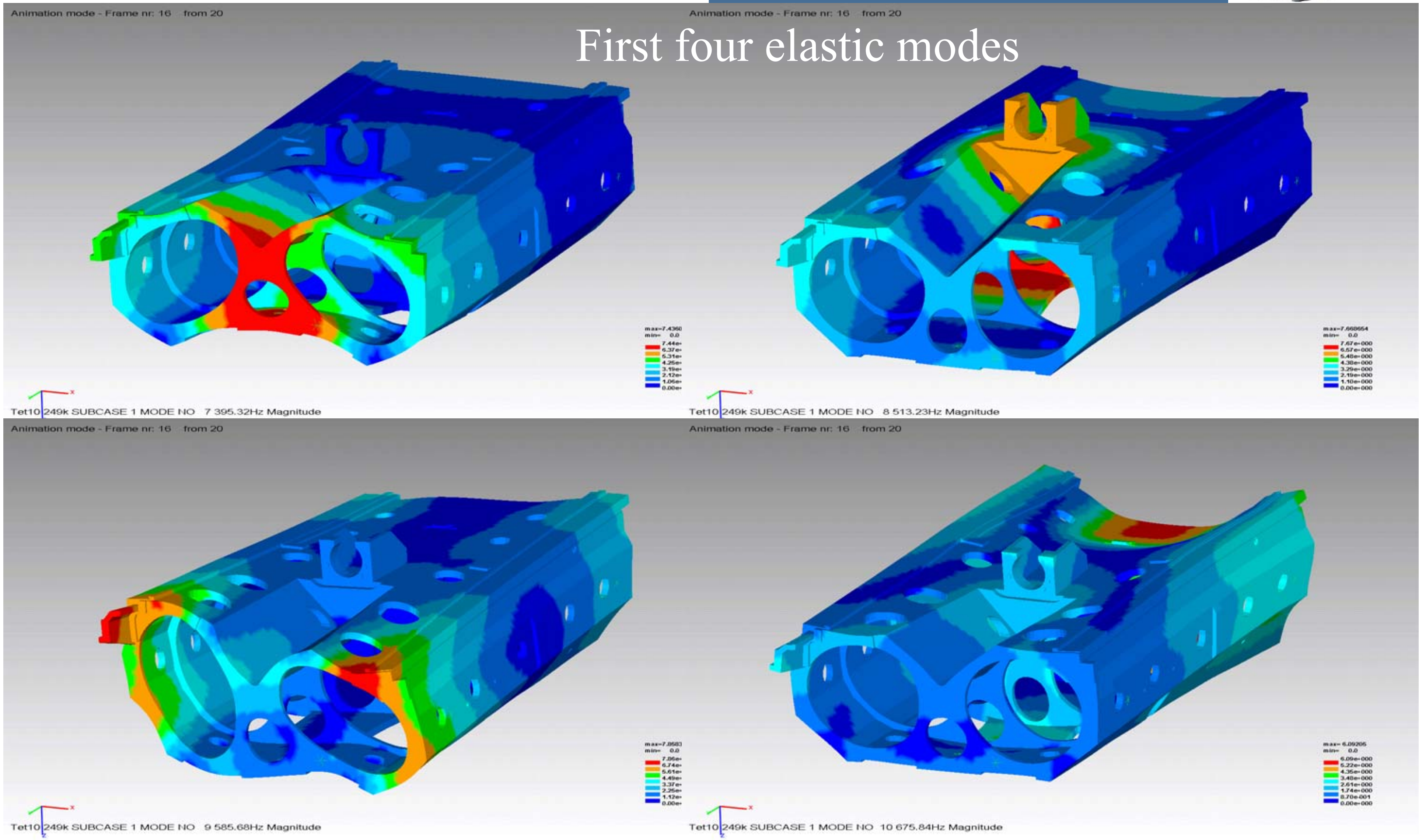
Free-free normal modes

MECHATRONICS

First four elastic modes



Supports components

Modified PSO algorithm was used to estimate supports stiffness factors

Correlation results day 1

MAC

0,97	0,02	0,04	0,02	0,09	0	0,11
0,04	**0,95**	0,11	0	0	0,01	0,03
0,07	0,07	**0,95**	0,02	0,02	0	0,01
0,25	0,01	0	0,04	0,04	0	0,02
0,03	0,05	0,06	**0,89**	0,04	0,07	0,12
0,16	0,06	0,03	0,01	0,18	0,03	0
0,07	0,04	0	0,07	**0,89**	0,03	0,11
0,01	0,02	0	0,01	0,04	**0,93**	0,2
0,13	0,01	0	0,16	0,03	0,1	0,22
0,01	0,08	0	0,19	0,02	0,3	**0,93**

Natural frequency

Identification from measurement	178,2	207,9	238,2	-	430,1	-	575,7	618,6	-	721,3
Computation	179,2	207,5	237,8	271,7	429,5	430,6	567,9	616,0	705,0	723,5

Correlation results day 2

MAC

0,96	0,05	0,08	0,01	0,09	0
0,01	**0,98**	0,24	0	0,01	0,03
0,08	0,18	**0,95**	0,03	0,05	0,01
0,2	0	0	0	0,03	0
0,13	0,08	0,03	0,01	0,18	0
0,08	0	0	**0,94**	0,06	0,01
0,05	0,03	0,03	0,05	**0,87**	0,01
0	0,03	0	0,01	0,01	**0,94**

Natural frequency

Identification from measurement	185,0	211,3	242,4	-	-	435,7	585,0	631,2	-	-
Computation	184,6	211,4	242,2	295,5	434,3	434,4	571,5	630,2	710,5	729,5

Model may be subject to change due to pretension.

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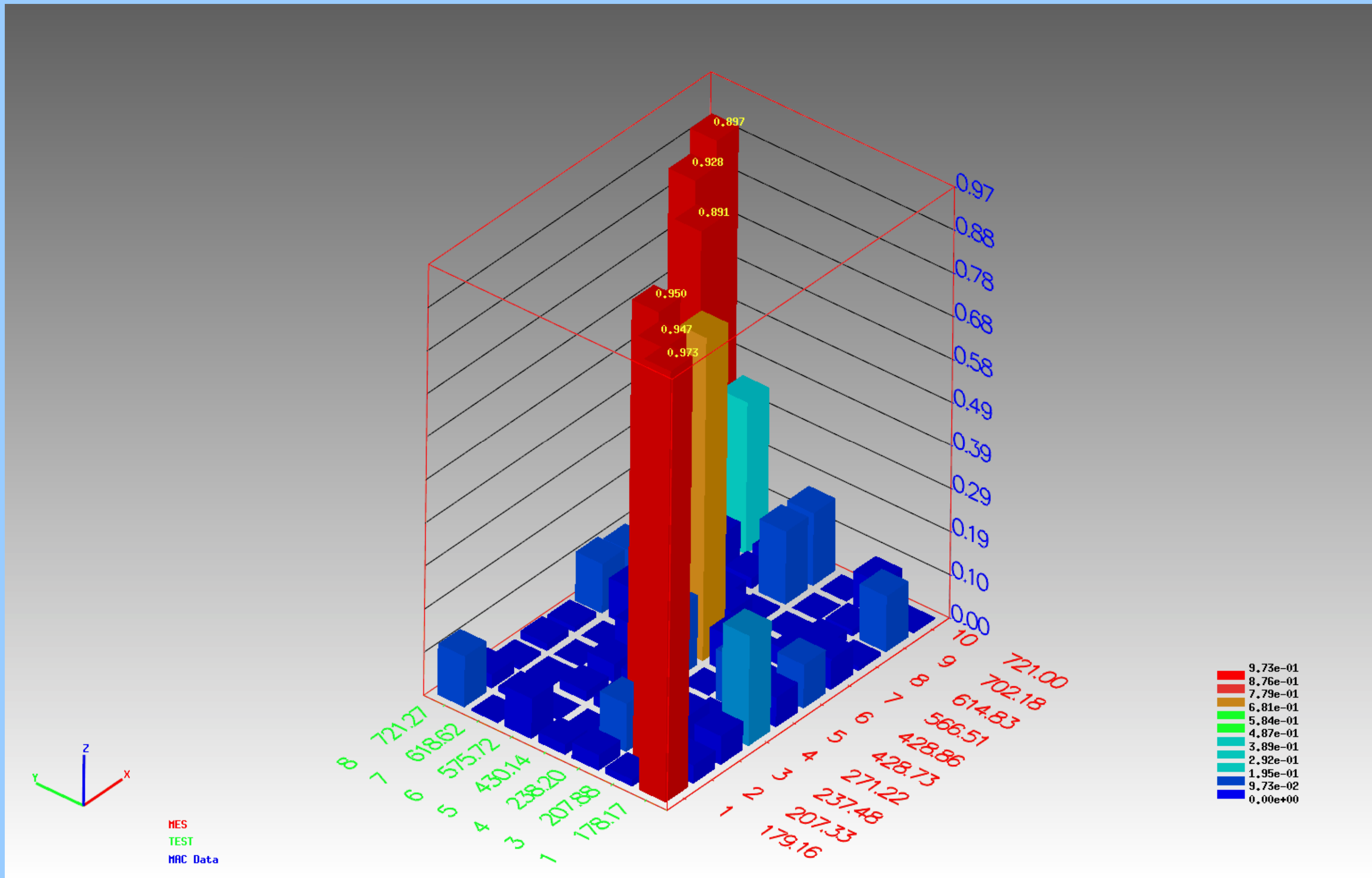
Correlation results day 2

MAC: measurements and FEM computation



Assumption:

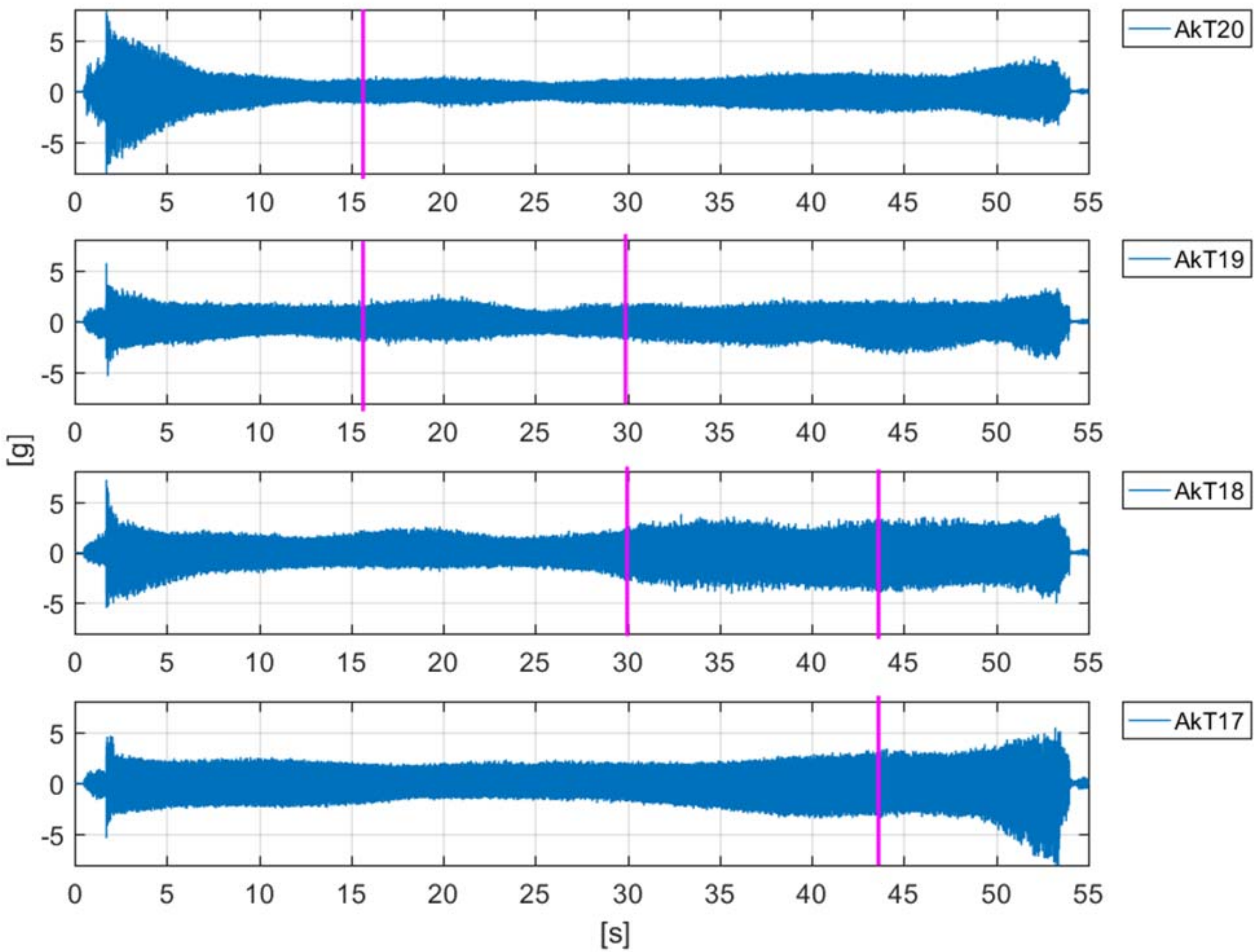
The only one dominant pole exists
in spectrum of the milled workpiece.

Liao-Young 1996 condition:

$$\frac{zn_o}{60} = \frac{f_\alpha}{0,25 + k}, \quad k = 0,1,2,\ldots$$

f_α – natural frequency of the workpiece [Hz],
n_o – sought spindle angular velocity [rev/min],
z – numer of edges of the tool

Vibration during the milling process



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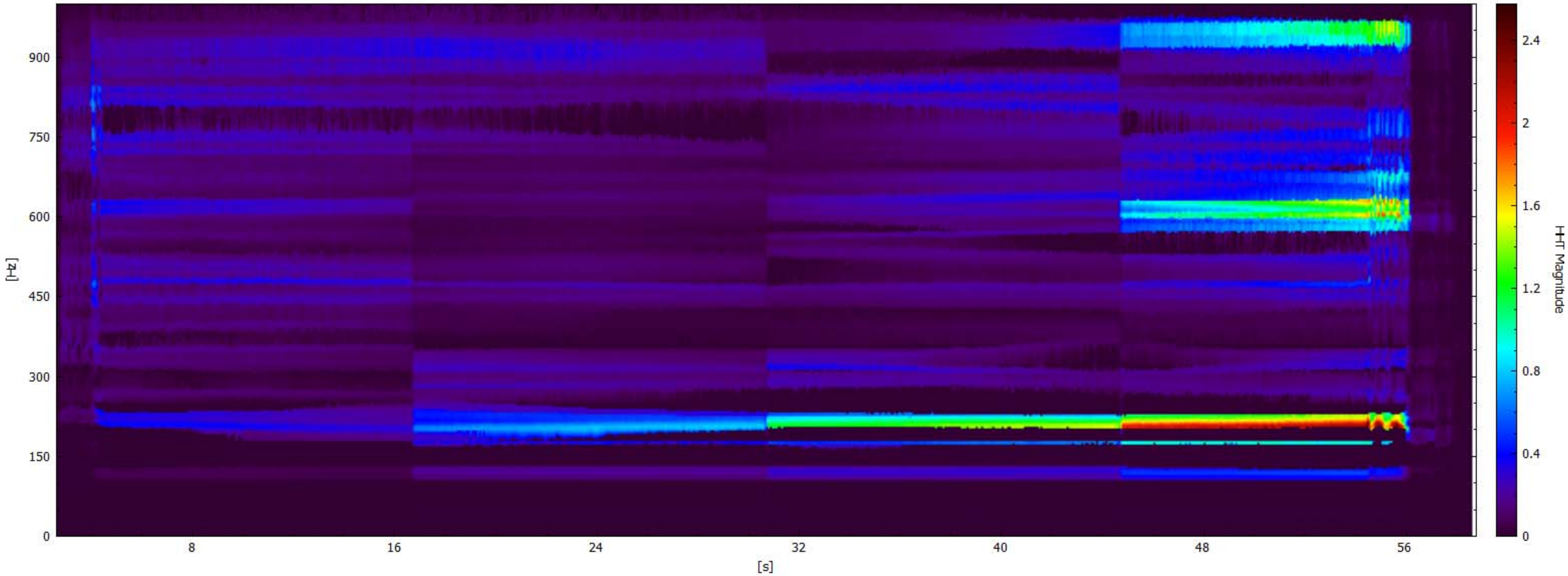
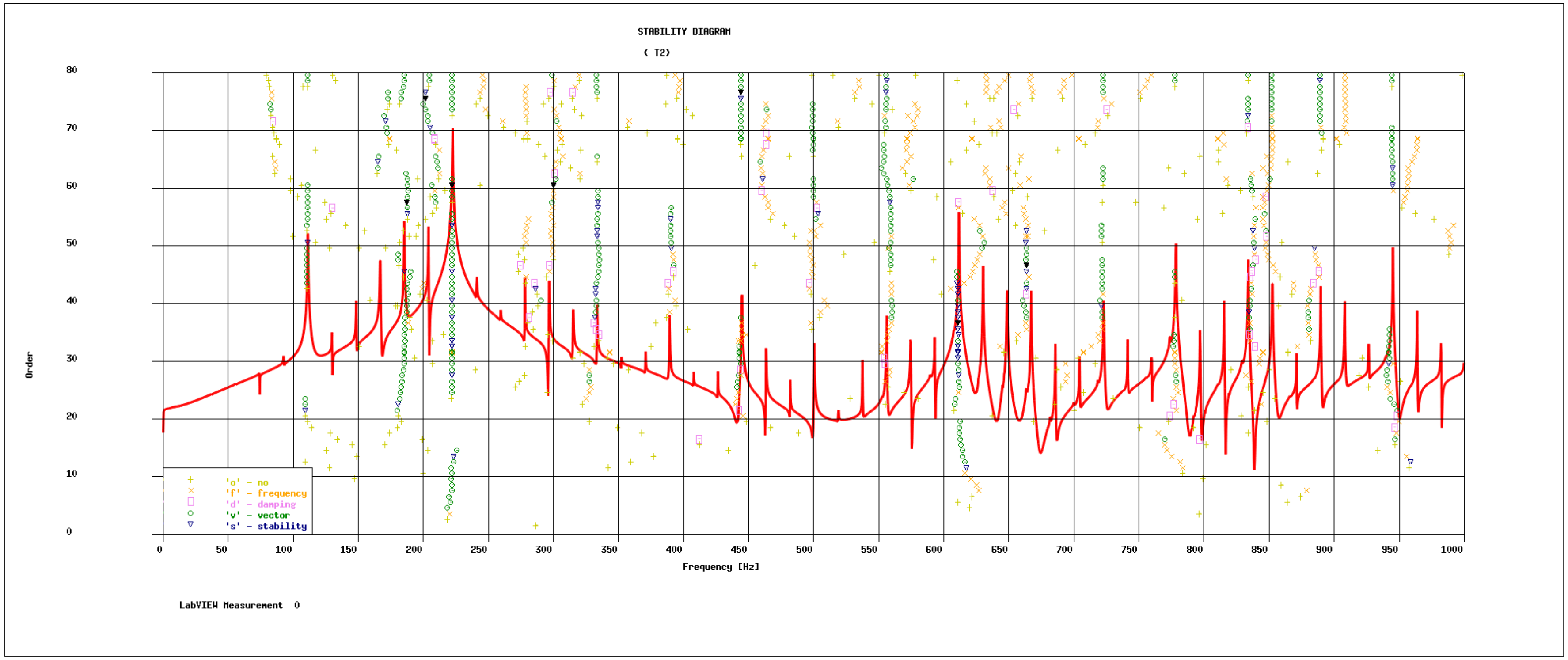
Hilbert-Huang Transform (HHT)



The very well refined face milling process

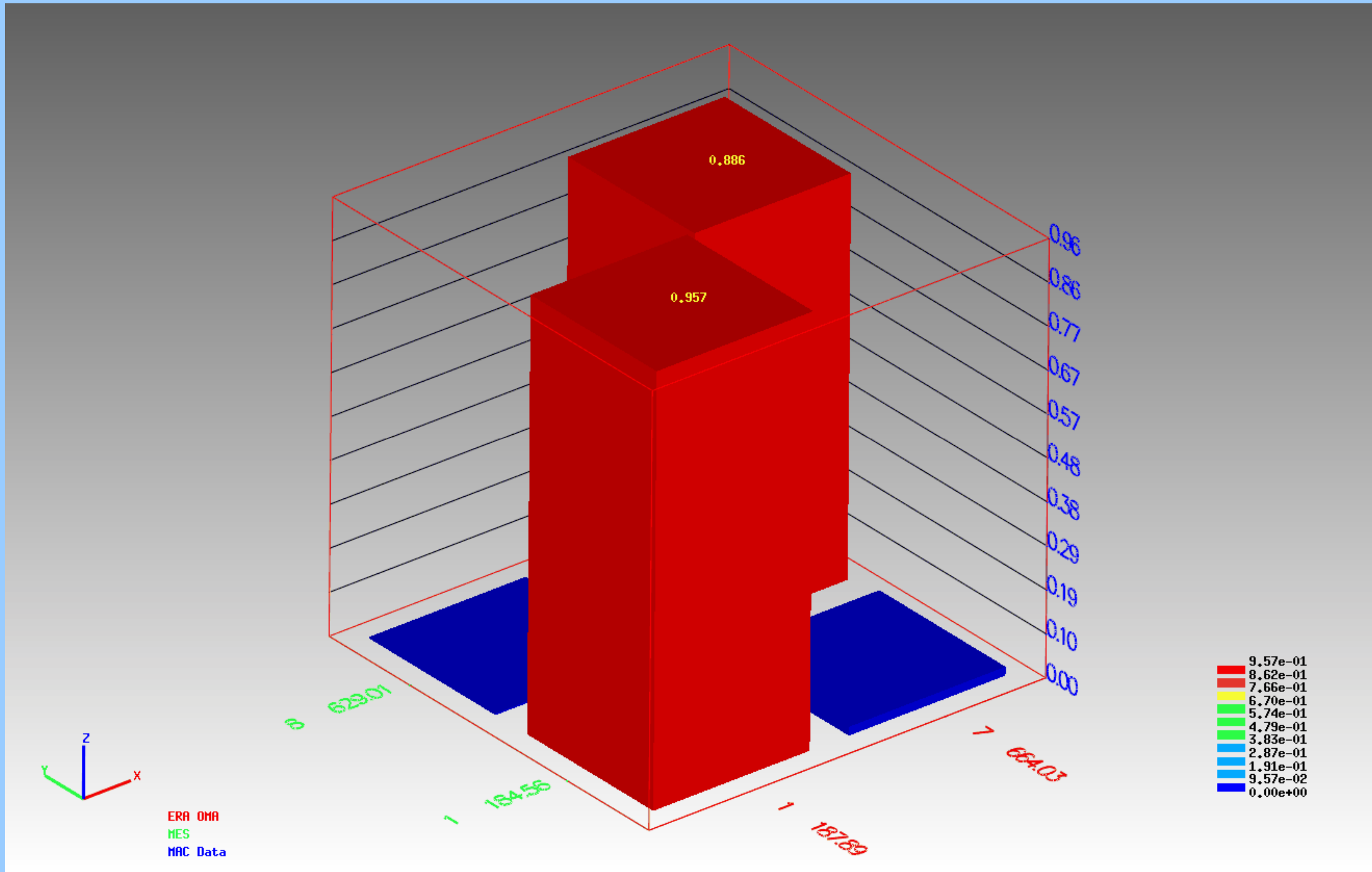
– nearly nothing happens here ☹

Power Spectral Density function was computed with the Welch method



Modified ERA – harmonics appear at poles with very small damping

Correlation



Only two modes very identified correctly

Conclusion

- For well refined machining technology OMA may not be suitable as a main method of identification
- Results from the OMA could be used to track model changes during the process of machining

Thank you for your attention!

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