

IMAC XXIX Round Robin Experimental Modal Analysis

February 2011
Version 3

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Introduction

This report gives an overview of the EMA test cases that were performed in the framework of the Modal Parameter Estimation Round Robin for IMAC XXIX.

Calibration 1 – Proportionally damped

Introduction

This is an analytical dataset; generated with the model shown in Figure 1. A proportional damping $C = 0.0001K + 0.05M$ was used to generate the test data. The full set of 36 measurements is provided. The data does not contain any modes outside the band provided.

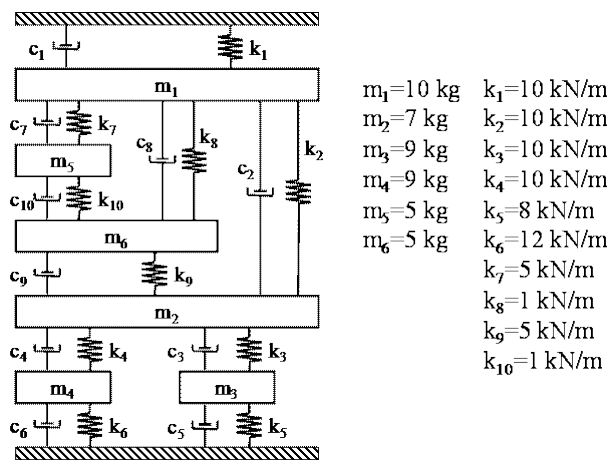


Figure 1: Lumped mass-spring-damper model used to generate the test data.

Settings of the FEMtools MPE toolbox

The following settings were used to identify the modal parameters with the FEMtools MPE.

Parameter	Value
Maximum order	40
Minimum frequency	2
Maximum frequency	15
Minimum damping ratio [%]	0
Maximum damping ratio [%]	40
Maximum frequency deviation [%]	1
Maximum damping deviation [%]	5
Exponential windowing [%]	No
Fast stabilization	No

Table 1: The settings used to identify the modal parameters in FEMtools.

Extracted Modes

The following modal parameters were extracted in FEMtools:

Mode	Frequency [Hz]	Damping [%]	MPC [%]	MPD [°]	Max MAC
1	3.506	0.22	100.00	0.00	3.21
2	5.493	0.25	100.00	0.00	2.70
3	6.427	0.26	100.00	0.00	3.07
4	7.552	0.29	100.00	0.00	0.49
5	8.388	0.31	100.00	0.00	3.21
6	12.641	0.43	100.00	0.00	1.00

Table 2: The modal parameters extracted by the FEMtools MPE.

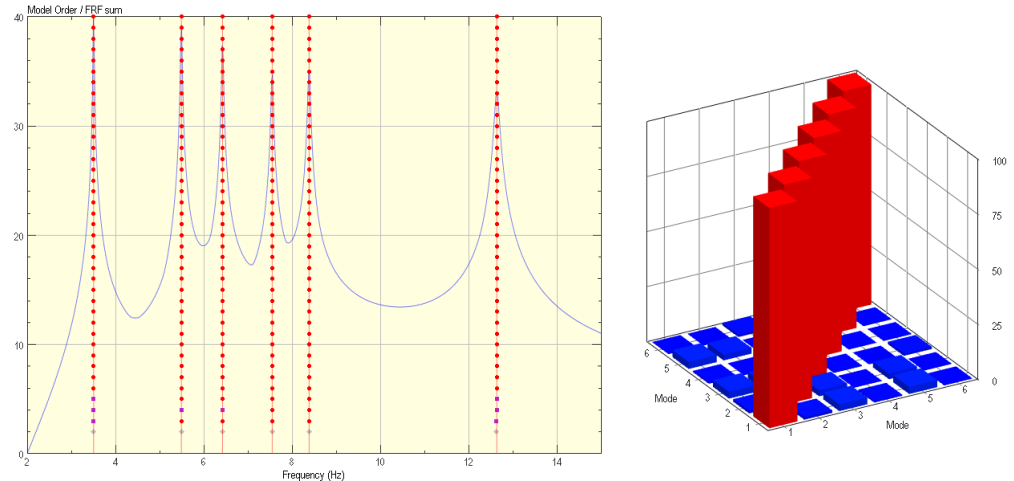


Figure 2: The stabilization chart (left) and the autoMAC of the extracted modes (right).

Calibration 2 – Non-proportionally damped

Introduction

This is an analytical dataset; generated with the model shown in Figure 3. A non-proportional damping $C_1 = 5.1\text{N/m/s}$, $C_2 = 7.5\text{N/m/s}$, $C_3 = 3.9\text{N/m/s}$, $C_4 = 4.3\text{N/m/s}$, $C_5 = 2.96\text{N/m/s}$, $C_6 = 4.32\text{N/m/s}$, $C_7 = 3.65\text{N/m/s}$, $C_8 = 0.58\text{N/m/s}$, $C_9 = 2.85\text{N/m/s}$, $C_{10} = 0.37\text{N/m/s}$ was used to generate the test data. The full set of 36 measurements is provided. The data does not contain any modes outside the band provided.

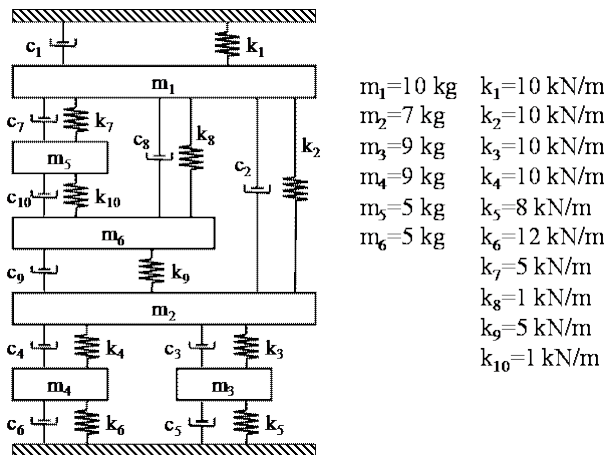


Figure 3: Lumped mass-spring-damper model used to generate the test data.

Settings of the FEMtools MPE toolbox

The following settings were used to identify the modal parameters with the FEMtools MPE.

Parameter	Value
Maximum order	40
Minimum frequency	2
Maximum frequency	15
Minimum damping ratio [%]	0
Maximum damping ratio [%]	40
Maximum frequency deviation [%]	1
Maximum damping deviation [%]	5
Exponential windowing [%]	No
Fast stabilization	No

Table 3: The settings used to identify the modal parameters in FEMtools.

Extracted Modes

The following modal parameters were extracted in FEMtools:

Mode	Frequency [Hz]	Damping [%]	MPC [%]	MPD [°]	Max MAC
1	3.50582	0.55	100.00	0.21	3.21
2	5.49314	0.99	100.00	0.30	2.70
3	6.42685	0.99	100.00	1.06	3.07
4	7.55158	0.94	99.98	1.32	0.49
5	8.38675	1.59	99.98	1.76	3.21
6	12.6376	2.09	99.99	1.04	1.01

Table 4: The modal parameters extracted by the FEMtools MPE.

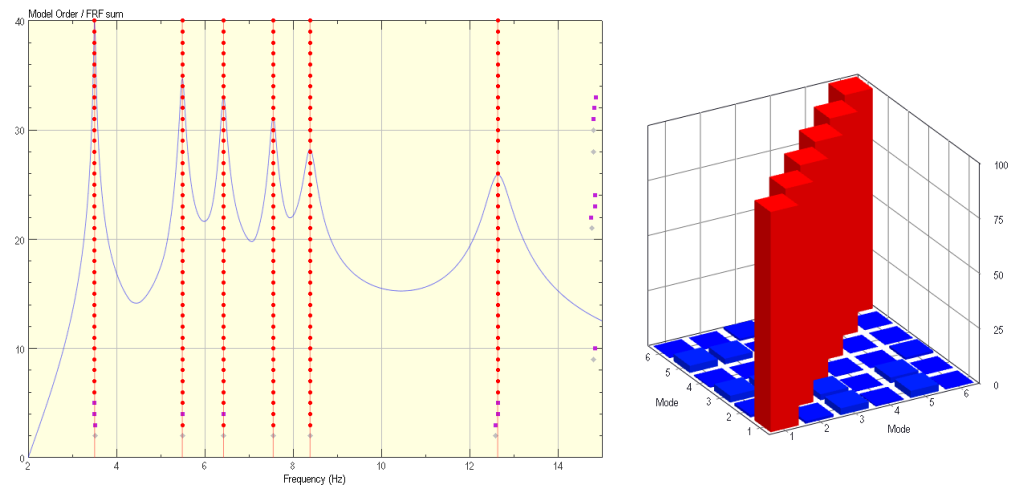


Figure 4: The stabilization chart (left) and the autoMAC of the extracted modes (right).

Calibration 3 – Constant modal damping

Introduction

This is an analytical dataset; generated with the model shown in Figure 5. A constant modal damping of 0.01% was used to generate the test data. The full set of 36 measurements is provided. The data does not contain any modes outside the band provided.

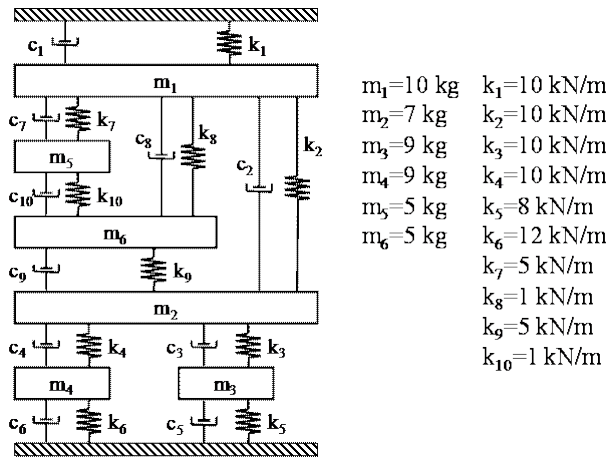


Figure 5: Lumped mass-spring-damper model used to generate the test data.

Settings of the FEMtools MPE toolbox

The following settings were used to identify the modal parameters with the FEMtools MPE.

Parameter	Value
Maximum order	40
Minimum frequency	2
Maximum frequency	15
Minimum damping ratio [%]	0
Maximum damping ratio [%]	40
Maximum frequency deviation [%]	1
Maximum damping deviation [%]	5
Exponential windowing [%]	No
Fast stabilization	No

Table 5: The settings used to identify the modal parameters in FEMtools.

Extracted Modes

The following modal parameters were extracted in FEMtools:

Mode	Frequency [Hz]	Damping [%]	MPC [%]	MPD [°]	Max MAC
1	3.50586	0.01	100.00	0.00	3.21
2	5.49339	0.01	100.00	0.00	2.70
3	6.42713	0.01	100.00	0.00	3.07
4	7.55186	0.01	100.00	0.00	0.49
5	8.38774	0.01	100.00	0.00	3.21
6	12.6407	0.01	100.00	0.00	1.00

Table 6: The modal parameters extracted by the FEMtools MPE.

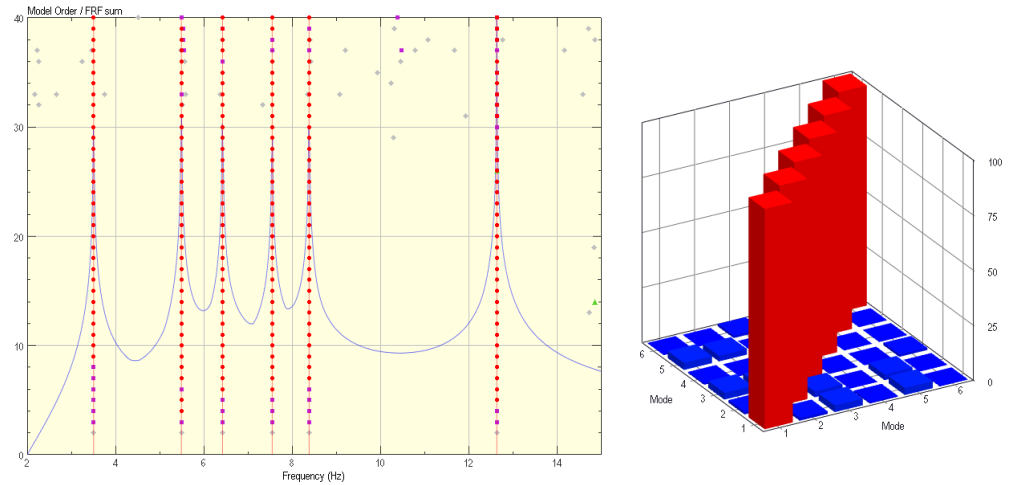


Figure 6: The stabilization chart (left) and the autoMAC of the extracted modes (right).

Plexi Plate

Introduction

The Plexi Plate data set is from a test of a Plexiglas plate that measured 53cm × 32cm × 1.5cm. The plate was tested with free-free boundary conditions. Eight tri-axial accelerometers were mounted using wax and were roved three times to complete the test. Random excitation from three simultaneous sources was used. A hanning window was applied to reduce leakage. The data set contains FRFs from 3 uncorrelated references and 75 response DOFs. FRFs, coherence functions and geometry are provided. The plate is designed to have a double mode at the first resonance peak.

Settings of the FEMtools MPE toolbox

Parameter	Value
Maximum order	60
Minimum frequency	10
Maximum frequency	1600
Minimum damping ratio [%]	0
Maximum damping ratio [%]	40
Maximum frequency deviation [%]	1
Maximum damping deviation [%]	5
Exponential windowing [%]	No
Fast stabilization	No

Table 7: The settings used to identify the modal parameters in FEMtools.

Extracted Modes

The following modal parameters were extracted in FEMtools:

Mode	Frequency [Hz]	Damping [%]	MPC [%]	MPD [°]	Max MAC
1	99.692	5.32	77.96	44.10	73.40
2	100.081	4.86	62.52	46.62	73.40
3	226.429	3.76	94.27	36.04	13.83
4	279.339	3.71	82.28	39.11	13.01
...					

...					
5	290.811	3.49	73.22	44.03	13.10
6	355.599	3.42	99.24	26.65	9.76
7	417.331	3.26	99.33	21.96	14.40
8	502.900	3.25	99.06	25.46	7.98
9	568.452	2.94	99.20	21.83	6.00
10	672.699	3.14	98.18	20.64	13.83
11	742.856	2.97	98.26	26.85	15.09
12	831.211	1.42	87.15	38.26	25.06
13	847.190	1.38	76.97	51.11	40.33
14	871.577	1.06	97.85	19.87	40.33
15	887.916	0.89	79.48	47.37	25.37
16	936.383	1.08	90.82	33.48	21.04
17	970.217	2.29	82.06	38.20	16.57
18	1014.886	2.32	93.31	27.26	21.04
19	1041.086	2.85	92.50	34.96	16.67
20	1070.144	2.90	86.79	39.14	17.48

Table 8: The modal parameters extracted by the FEMtools MPE.

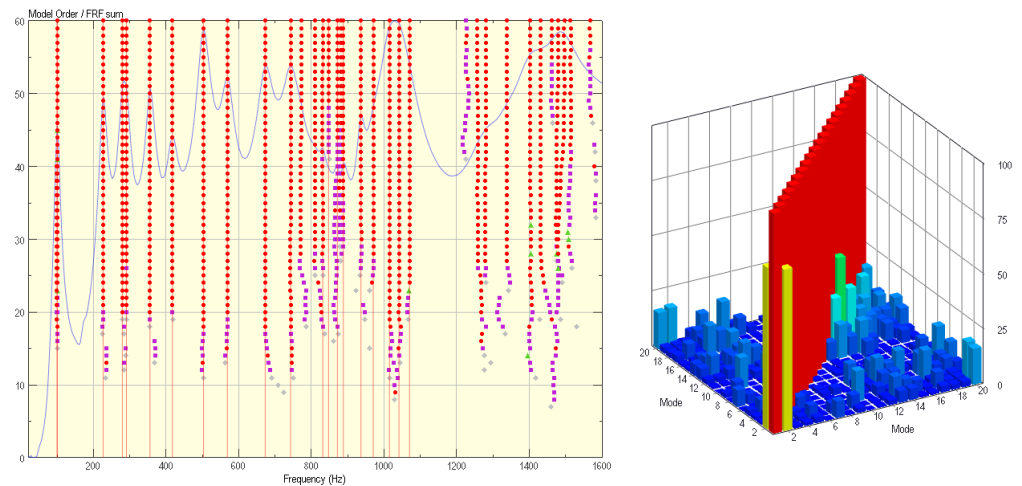


Figure 7: The stabilization chart (left) and the autoMAC of the extracted modes (right).

The plate was designed in such a way that for first two modes have coincident frequencies. The two modes are easily identified, but correctly separating the mode shapes appears to be more challenging. The first mode is most likely the torsional mode, while the second mode appears to be a flexural mode. However, the two identified modes are a combination of those two fundamental modes.

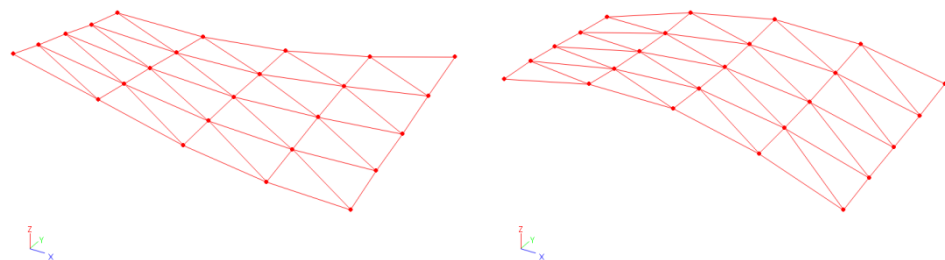


Figure 8: The mode shape of mode 1 (left) and mode 2 (right).

Dryer Cabinet

Introduction

The dryer cabinet dataset is from a test of a residential clothes dryer cabinet. The data set contains FRFs from 4 uncorrelated references and 300 response DOFs. FRFs, coherence functions and geometry are provided. The data set consist of both inertance (acceleration/force) and mobility (velocity/force) FRFs. Four shakers were used to excite the cabinet (burst random) for the MIMO test. The shaker locations were determined such that the cabinet would be excited uniformly. The shakers were placed one on each side (right, left and back) with one shaker on the base. The response of the base was measured with twenty-nine PCB 352B65 accelerometers (simultaneously). The response locations were spread uniformly over the base on a grid size of approximately 9cm. The force and acceleration measurements at the shaker locations were made with PCB 288D01 impedance heads. A Polytec laser was used to measure the response at the locations on the side and back panels of the cabinet. All response measurements were normal to the panel surfaces.

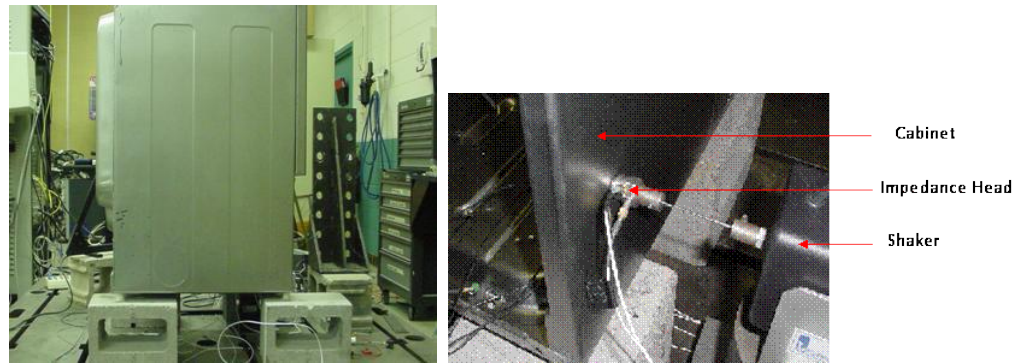


Figure 9: The test set-up of the dryer cabinet data set.

Settings of the FEMtools MPE toolbox

The following settings were used to identify the modal parameters with the FEMtools MPE.

Parameter	Value
Maximum order	80
Minimum frequency	1
Maximum frequency	100
Minimum damping ratio [%]	0
Maximum damping ratio [%]	40
Maximum frequency deviation [%]	1
Maximum damping deviation [%]	5
Exponential windowing [%]	No
Fast stabilization	No

Table 9: The settings used to identify the modal parameters in FEMtools.

Extracted Modes

The following modal parameters were extracted in FEMtools:

Mode	Frequency [Hz]	Damping [%]	MPC [%]	MPC [°]	Max MAC
1	14.010	1.11	76.62	44.07	4.97
2	18.656	0.56	83.36	47.43	5.66
3	21.872	1.01	60.14	51.64	7.59
4	24.628	0.41	96.49	41.98	5.66
5	29.792	0.34	97.24	54.16	5.35
6	32.173	0.86	97.80	59.57	10.69
7	34.073	0.94	98.81	60.95	7.22
8	38.476	1.21	94.51	71.94	21.97
9	41.342	1.07	97.91	73.72	21.97
10	45.215	0.24	96.82	62.07	5.16
11	49.254	0.48	93.81	51.30	23.17
12	50.078	0.59	93.96	53.98	53.86
13	53.235	0.39	90.39	43.93	23.17
14	55.242	0.42	98.97	35.15	17.02
15	57.685	0.47	98.29	77.48	16.82
16	59.607	0.63	97.76	69.52	4.60
17	63.816	0.94	83.53	51.13	42.29
18	65.250	0.77	95.39	70.04	23.36
19	67.546	0.39	97.40	70.90	17.30
20	74.143	0.43	98.38	32.41	25.93
21	75.770	0.73	99.02	53.58	29.13
22	77.891	0.26	99.69	72.06	3.08
23	79.490	0.39	98.98	44.78	17.59
24	82.391	0.42	99.29	77.61	20.28
25	82.399	0.52	99.53	65.70	24.26
26	83.848	0.43	99.54	77.46	8.590
27	86.328	0.31	99.47	75.08	12.97
28	89.131	0.19	93.94	51.31	24.98
29	89.165	0.38	98.02	76.73	12.29
30	91.739	0.83	82.31	62.53	45.05
31	91.780	0.29	81.22	58.03	64.90
32	95.402	0.40	98.46	70.38	27.58
33	96.849	0.58	88.07	68.20	22.46

Table 10: The modal parameters extracted by the FEMtools MPE.

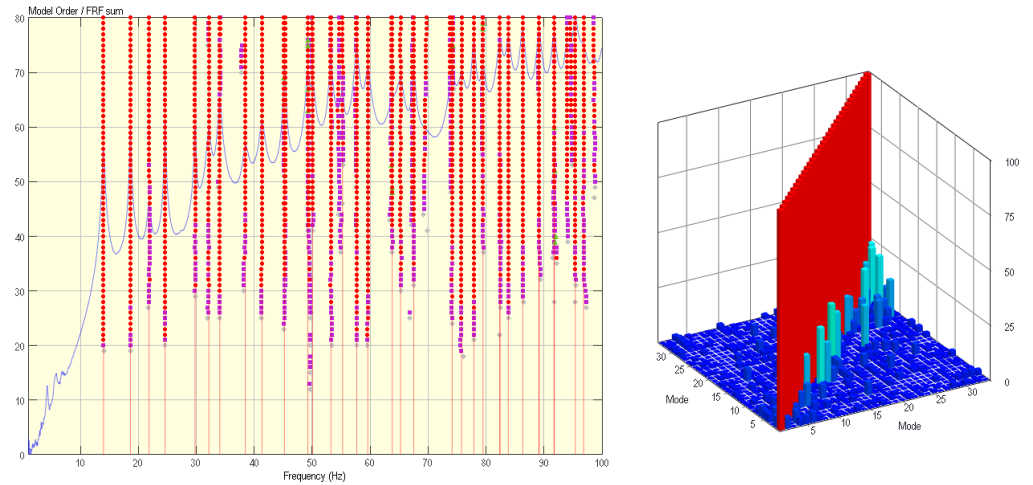


Figure 10: The stabilization chart (left) and the autoMAC of the extracted modes (right).

Automobile

Introduction

The automobile dataset was collected on a fully assembled sedan. The vehicle was resting on the tires. All accelerometers were mounted and remained in place throughout the test. Burst random excitation with 80% burst was used. The data set contains FRFs from 3 uncorrelated references and 398 response DOFs. FRFs, coherence functions and geometry are provided.

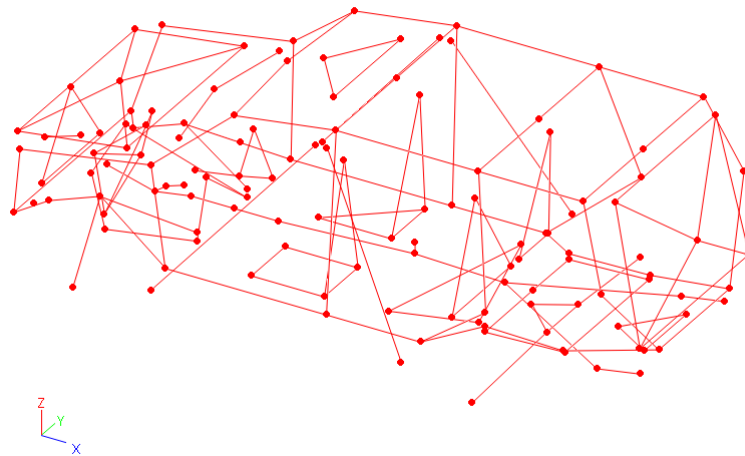


Figure 11: The test mesh of the automobile dataset.

Settings of the FEMtools MPE toolbox

The following settings were used to identify the modal parameters with the FEMtools MPE.

Parameter	Value
Maximum order	80
Minimum frequency	1
Maximum frequency	50
Minimum damping ratio [%]	0
Maximum damping ratio [%]	40
Maximum frequency deviation [%]	1
Maximum damping deviation [%]	5
Exponential windowing [%]	No
Fast stabilization	No

Table 11: The settings used to identify the modal parameters in FEMtools.

Extracted Modes

The following modal parameters were extracted in FEMtools:Extracted Modes

Mode	Frequency [Hz]	Damping [%]	MPC [%]	MPD [°]	Max MAC
1	2.502	13.61	58.08	46.76	13.32
2	3.260	5.23	77.78	42.07	11.62
3	3.558	3.82	89.28	27.76	17.68
4	4.072	5.88	92.85	29.73	17.68
5	5.917	1.81	99.91	15.28	2.71
6	8.640	5.50	95.10	33.31	8.45
7	9.922	10.56	93.13	40.63	17.99
8	10.330	2.49	98.18	39.60	5.18
9	10.514	9.13	86.49	40.56	32.99
10	11.532	5.30	79.21	41.10	32.99
11	12.053	2.58	91.28	53.81	9.29
12	12.789	1.79	69.85	50.78	11.88
13	13.455	2.22	93.85	32.93	1.94
14	14.123	1.10	98.94	44.25	1.96
15	14.691	1.41	95.53	64.78	2.75
16	15.172	4.17	85.91	34.46	14.31
17	15.967	4.18	61.12	53.36	23.42
18	16.110	1.57	83.13	45.83	23.42
19	16.906	2.12	88.31	43.64	9.67
20	17.468	1.33	89.11	47.97	11.65
21	17.834	2.44	80.68	53.51	16.73
22	18.116	2.02	65.29	58.27	16.73
23	19.351	2.62	85.09	56.50	24.09
24	19.903	1.77	92.35	43.61	24.09
25	21.102	2.07	94.20	49.04	27.49
26	22.213	1.58	75.16	51.31	14.42
27	22.605	3.55	63.33	55.97	14.42
...					

...					
28	23.280	1.49	70.35	50.77	27.49
29	23.927	3.93	62.45	47.94	18.93
30	27.213	1.46	71.88	53.32	28.28
31	27.498	1.46	77.86	42.79	28.28
32	28.020	1.32	63.84	57.23	16.74
33	28.353	0.71	98.72	66.60	4.54
34	29.912	2.55	88.37	36.44	5.87
35	31.663	1.51	58.68	56.94	24.12
36	31.885	2.27	98.40	34.24	12.14
37	32.740	1.81	65.66	51.13	32.19
38	34.246	1.34	60.87	49.27	32.19
39	34.583	2.46	65.08	55.64	40.33
40	35.235	1.57	93.66	50.73	31.52
41	35.990	2.70	71.71	56.11	18.32
42	37.251	2.24	75.16	45.52	40.33
43	37.709	1.31	75.62	51.75	32.00
44	38.029	1.27	72.80	46.00	32.00
45	38.657	1.85	65.70	52.13	20.55
46	40.414	2.12	68.29	51.94	11.17
47	42.411	2.44	72.99	41.17	15.61
48	42.974	1.16	98.57	46.64	10.63
49	43.137	2.23	69.39	45.38	15.61
50	44.703	1.49	66.39	48.11	30.22
51	46.787	2.07	72.62	50.27	30.22
52	47.641	1.57	63.58	46.07	16.48

Table 12: The modal parameters extracted by the FEMtools MPE.

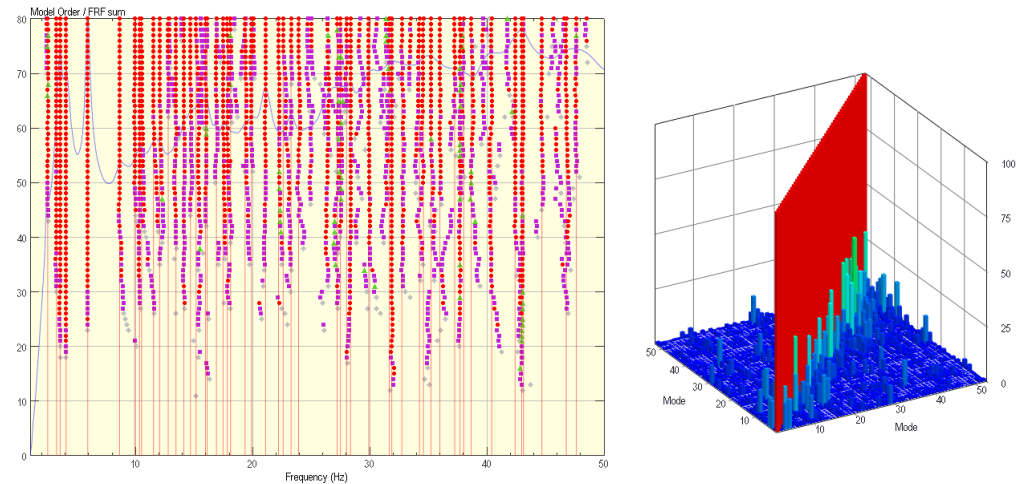


Figure 12: The stabilization chart (left) and the autoMAC of the extracted modes (right).

Introduction

The Aerospace dataset is collected on the RADARSAT-I satellite. The base of the structure was rigidly mounted to a 260 pound anchor. All accelerometers were mounted and remained in place throughout the test. Burst random excitation with 80% burst was used. The data set contains FRFs from 5 uncorrelated references and 240 response DOFs. The test object had several panels with local modes. The coherence functions are not available for these data. Only FRFs and geometry are provided.

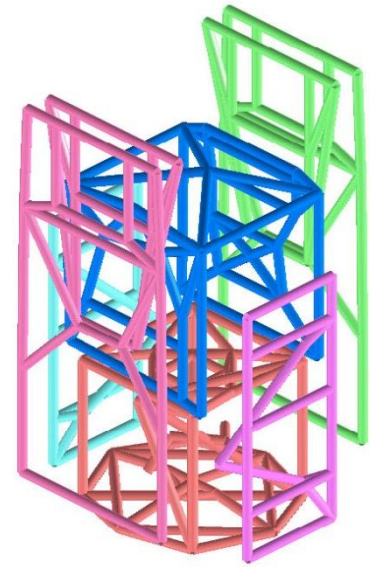


Figure 13: The test set-up (left) and the measurement grid (right) of the RADARSAT-I.

Settings of the FEMtools MPE toolbox

The following settings were used to identify the modal parameters with the FEMtools MPE.

Parameter	Value
Maximum order	80
Minimum frequency	0.1
Maximum frequency	90
Minimum damping ratio [%]	0
Maximum damping ratio [%]	40
Maximum frequency deviation [%]	1
Maximum damping deviation [%]	5
Exponential windowing [%]	No
Fast stabilization	No

Table 13: The settings used to identify the modal parameters in FEMtools.

Extracted Modes

The following modal parameters were extracted in FEMtools:Extracted Modes

Mode	Frequency [Hz]	Damping [%]	MPC [%]	MPD [°]	Max MAC
1	15.618	0.16	99.54	6.88	47.24
2	16.852	0.13	99.75	36.75	12.05
3	29.017	0.15	99.81	15.64	8.60
4	32.386	0.12	98.32	53.14	33.99
5	33.001	0.17	99.42	37.81	35.42
6	33.115	0.07	96.87	46.42	39.08
7	33.826	0.13	99.90	3.85	52.21
8	37.350	0.10	99.76	30.89	50.88
9	38.041	0.12	99.88	21.26	36.76
10	39.960	0.16	99.96	10.49	20.32
11	44.757	0.19	99.96	14.71	11.27
12	46.029	0.21	99.92	21.51	11.99
13	46.911	0.11	99.96	18.81	1.89
14	47.619	0.13	99.88	12.43	10.12
15	49.061	0.16	99.45	12.48	52.21
16	49.298	0.25	99.87	28.94	12.74
17	49.795	0.20	99.85	28.36	29.52
18	50.020	0.13	99.61	34.73	39.08
19	50.449	0.14	99.82	18.20	36.76
20	50.720	0.11	99.63	23.03	50.88
21	51.063	0.25	99.75	19.11	29.52
22	51.401	0.23	99.66	25.26	36.83
23	51.884	0.28	99.74	15.69	23.76
24	52.146	0.23	99.90	14.18	36.83
25	53.797	0.25	99.83	10.80	15.96
26	54.274	0.23	99.88	11.13	30.04
27	55.963	0.22	99.97	13.90	40.24
28	57.013	0.31	99.81	17.71	30.04
29	57.217	0.28	99.85	15.42	40.24
30	57.805	0.20	99.97	14.23	28.97
31	59.804	0.31	99.69	20.33	11.12
32	61.090	0.25	99.95	6.89	12.45
33	66.475	0.29	99.90	12.79	31.28
34	67.261	0.23	99.95	13.71	7.51
35	68.128	0.31	99.57	13.36	70.08
36	68.684	0.36	99.04	17.78	70.08
37	69.889	0.35	99.24	13.34	28.57
38	70.331	0.38	99.44	19.45	23.42
39	72.627	0.35	95.57	33.20	25.82
40	72.830	0.36	97.01	26.38	24.39
41	73.720	0.33	98.44	26.57	29.67
42	75.391	0.36	99.28	19.20	29.67
43	76.297	0.85	92.82	36.07	44.32
...					

...					
44	77.551	0.31	99.17	24.90	39.77
45	77.582	0.64	98.49	26.15	20.47
46	78.405	0.28	97.76	20.45	17.42
47	79.397	0.17	97.57	23.38	21.30
48	79.424	0.22	97.81	38.15	44.32
49	80.451	0.28	91.43	24.69	27.29
50	80.589	0.52	96.15	40.17	23.42
51	80.835	0.34	97.23	26.78	27.29
52	81.369	0.35	98.56	21.39	28.57
53	82.664	0.18	96.13	31.77	38.97
54	82.738	0.32	95.66	36.54	19.44
55	84.136	0.21	97.63	29.82	24.39
56	84.445	0.16	98.20	28.09	22.12
57	86.077	0.35	96.29	26.98	28.39
58	86.572	0.19	91.21	61.72	8.37

Table 14: The modal parameters extracted by the FEMtools MPE.

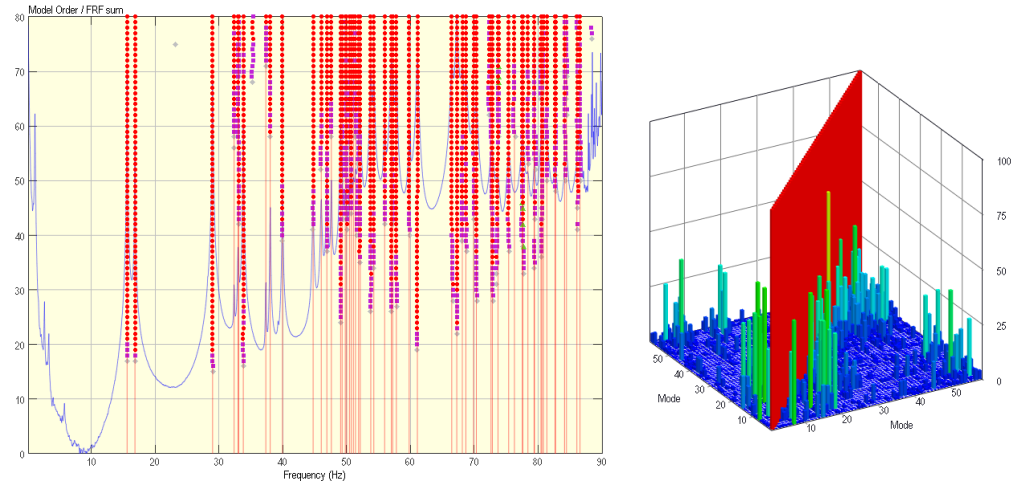


Figure 14: The stabilization chart (left) and the autoMAC of the extracted modes (right).