"HENRI COANDA"
AIR FORCE ACADEMY
ROMANIA

GERMANY

"GENERAL M.R. STEFANIK"
ARMED FORCES ACADEMY
SLOVAK REPUBLIC

INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER
AFASES 2011
Brasov, 26-28 May 2011

IAR-99 GROUND VIBRATION TESTS AND DYNAMICS FINITE ELEMENT MODEL

Dorin LOZICI-BRINZEI*, Simion TATARU, Radu BISCA***

*National Institute for Aerospace Research "Elie Carafoli", Bucharest, Romania
**Aerospace Consulting, Bucharest, Romania

Abstract:

In this presentation, we will concentrate on typical Ground Vibration Test (GVT) and Finite Element (FE) comparisons software. It is necessary to note, that standard GVT are obligatory for any new aircraft configuration. We can mention here the investigations of the IAR-99, modern trainer and ground attack aircraft, using PRODERA® GVT equipment. A Finite Element Model (FEM) of the IAR-99 has been developed in PATRAN/NASTRAN®, partly from a previous ANSYS® model. The results obtained with Finite Element Analysis (FEA) are strongly depending on the experience and judgment of the engineers involved in the analysis. Highly representative FEM can be used to investigate potential structural modifications or changes with realistic component corrections. Model validation should be part of every modern engineering analysis and quality assurance procedure.

Key words*: aircraft, ground, vibration, test, model*

1. INTRODUCTION

This paper presents a study performed on the IAR-99, advanced trainer and ground attack aircraft (Fig. 1).

Fig. 1 IAR-99 Advanced trainer

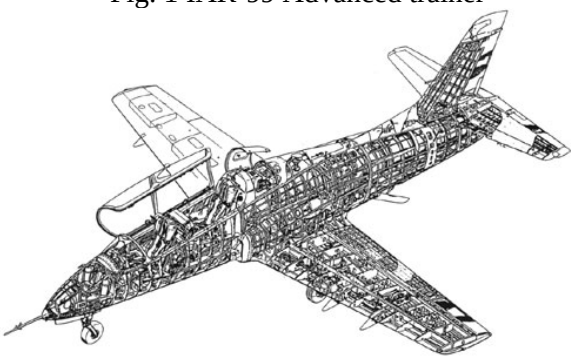

Fig. 2 IAR-99 Advanced trainer

The Romanian Air Force has 17 of the IAR-99 trainer aircraft in service with the 67th Fighter Bomber Group based at Craiova (Fig. 3).

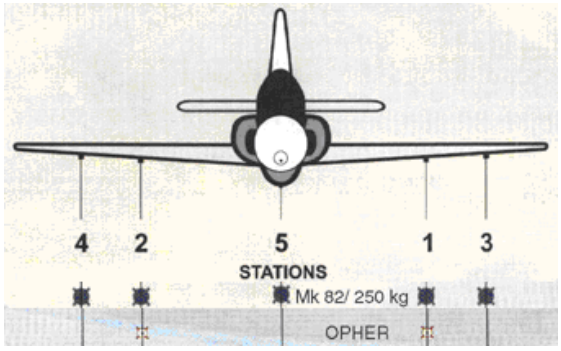

Fig. 3 Armament configuration example

2. LIBRARY OF CAD SUBSYSTEMS

A CATIA® library of CAD models of the IAR-99 and external stores has been developed (Fig. 2).

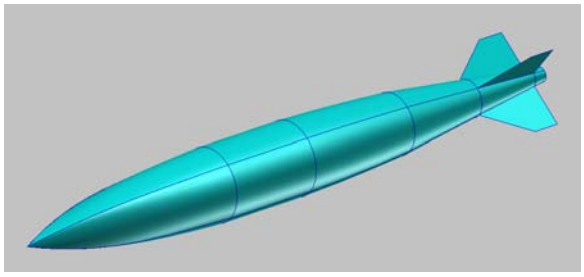

Fig. 4 CAD Library - MK-82

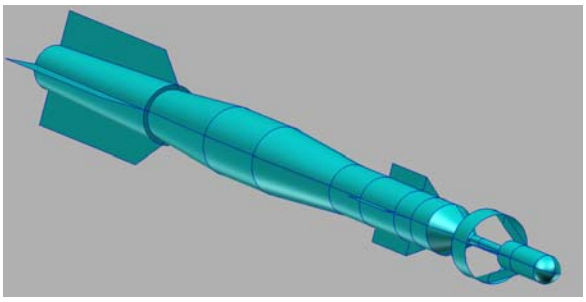

Fig. 5 CAD Library - OPHER

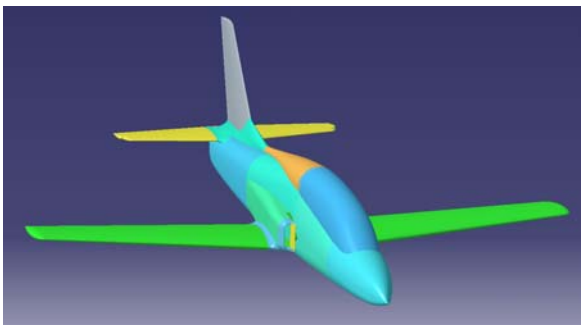

Fig. 6 CAD Library- IAR-99

3. LIBRARY OF FEM SUBSYSTEMS

As an example, the FEM of the IAR-99 without external stores, is represented in Fig. 3

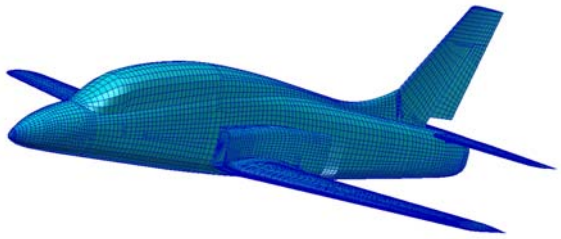

Fig. 7 IAR-99 - FEM

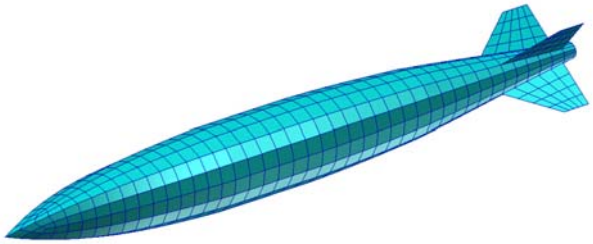

Fig. 8 FEM Library - MK-82

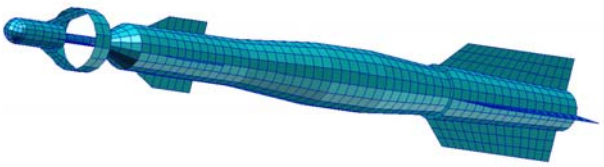

Fig. 9 FEM Library - OPHER

4. AIRCRAFT FEM ASSEMBLY

A finite element model of the IAR-99 has been developed, partly from previous model [3], using PATRAN/NASTRAN software [1].

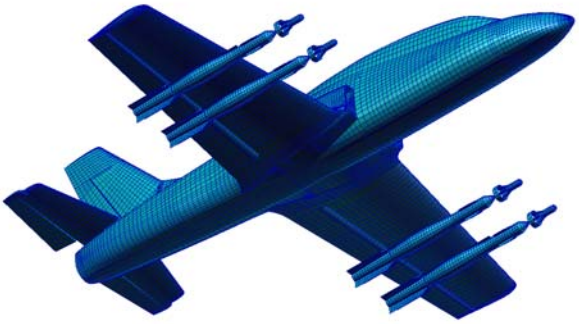

Fig. 10 IAR-99+4xOPHER configuration

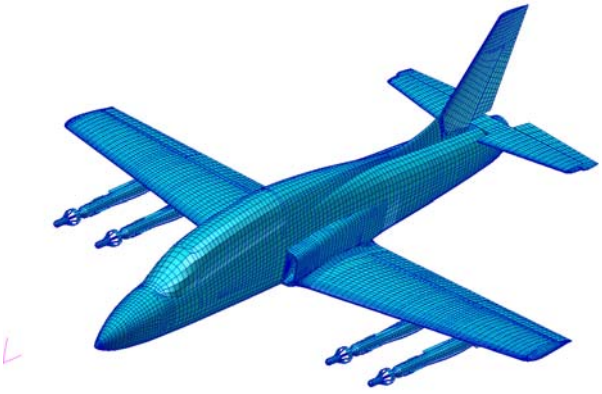

Fig. 11 IAR-99+4xOPHER configuration

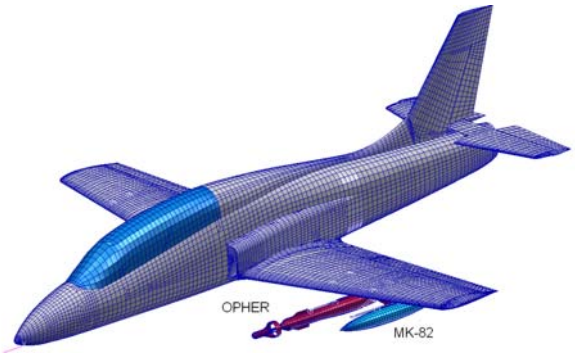

Fig. 12 MK-82 +OPHER configuration

The normal modes obtained from the FE model, represent an accurate enough estimation of the aircraft eigenfrequencies and mode shapes.

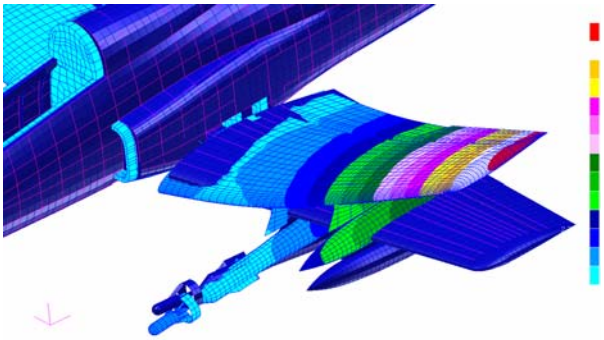

Fig. 13 Wing 1st vertical bending mode

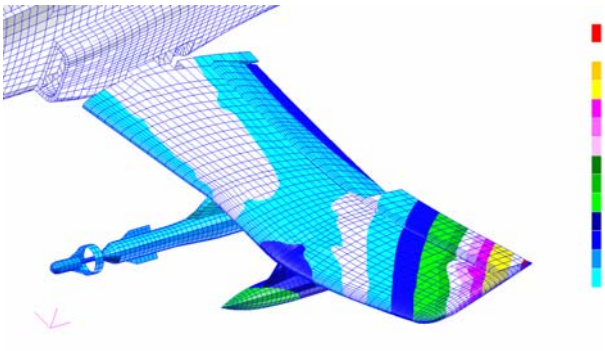

Fig. 14 Wing 2nd vertical bending mode

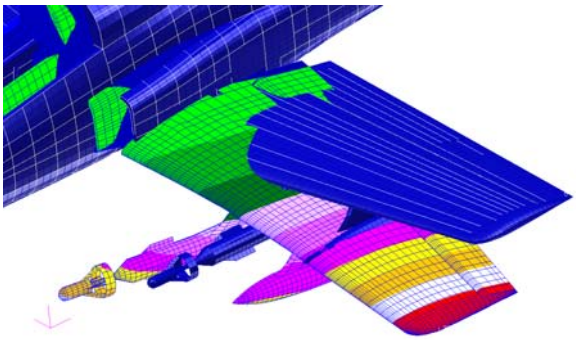

Fig. 15 Wing 1st in plane bending mode

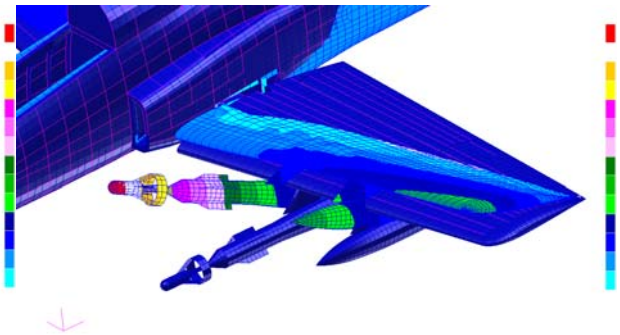

Fig. 19 OPHER 2nd gyration mode

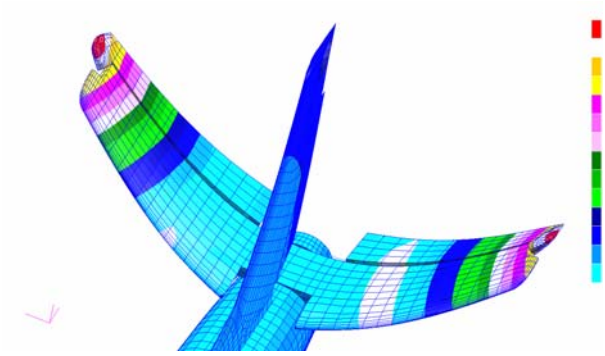

Fig. 16 HT 1st vertical bending mode

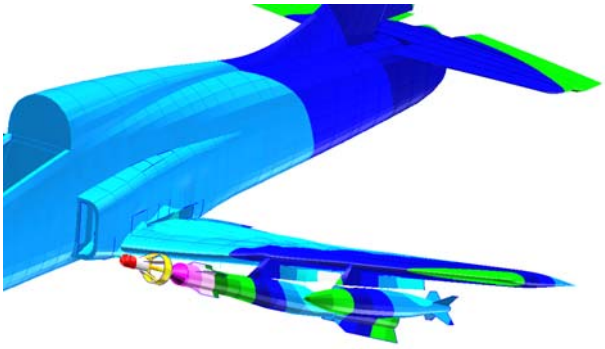

Fig. 20 Fig. 6 Wing 1st torsion mode

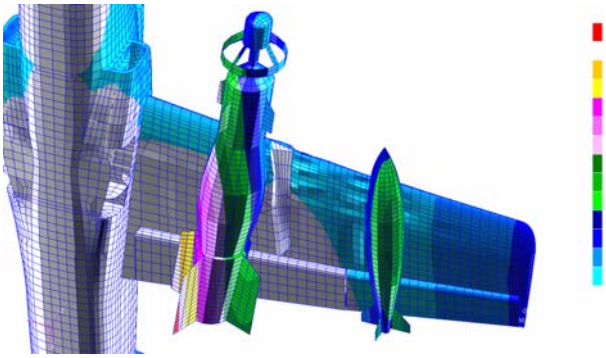

Fig. 17 OPHER 1st gyration mode

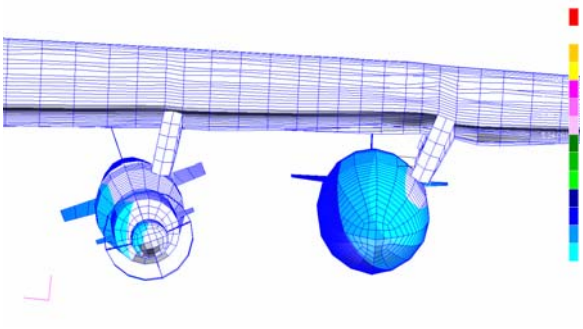

Fig. 21 MK-82 Lateral bending mode

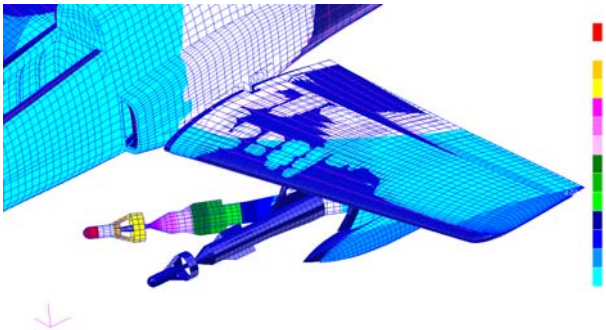

Fig. 18 OPHER 1st gyration mode

5. GROUND VIBRATION TEST

The INCAS/STRAERO stress team completed a successful GVT of the full IAR-99 aircraft, with weapons, in December 1999. During the series of tests, many different weapons configurations were loaded onto the test aircraft. After the first tests, PRODERA equipment was widely used for the GVT of all classes of flying vehicles, military and civil.

Fig. 22 GVT configuration example, [2]

During the test, the airplane was standing on under-inflated tyres of the main landing gear.

Fig. 23 GVT configuration example (detail)

For each test condition, external shakers induced vibration of the aircraft's wings, stabilizer and stores to verify the stores' effect. The aircraft's response was measured with more than 50 accelerometers and other external devices.

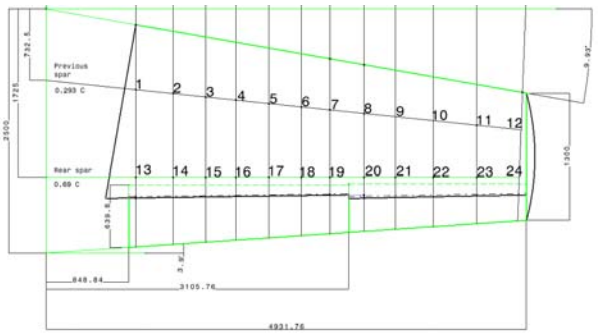

Fig. 24 Wing measuring point example

Table 1 Measuring points coordinates

Sec. No.	CURVE NO.1			CURVE NO.2		
	It. No.	X (mm)	Y (mm)	Itm No	X (mm)	Y (mm)
1	1	827	920	13	1731	920
2	2	867	1305	14	1734	1305
3	3	902	1635	15	1736	1635
4	4	934	1950	16	1718	1950
5	5	969	2286	17	1741	2286
6	6	1004	2622	18	1743	2622
7	7	1034	2912	19	1745	2912
8	8	1071	3265	20	1748	3265
9	9	1104	3585	21	1750	3585
10	10	1145	3975	22	1753	3975
11	11	1191	4420	23	1756	4420
12	12	1240	4891	24	1760	4891

Fig. 25 GVT configuration

The frequency and shapes of all four modes was used to modify the model, and the results of the updating has errors of less than 5% on each of the first three modes; and less than 10% for the fourth mode

Table 2 Test-FEA comparison

Mode description	FEM	GVT	FEM/GVT
1st Wing Bending	7.301	7.29	0.15%
2nd Wing Bending	36.05	34.32	5.04%
OPHER Gyration	12.388	12.34	0.39%
MK-82 Lateral	15.88	15.18	4.61%
HT Sym. Bending	24.83	27.58	-9.97%

At the conclusion, the ultimate goal of the IAR-99 finite element analysis effort is to have a highly representative model, which has been validated by measured ground and flight test data.

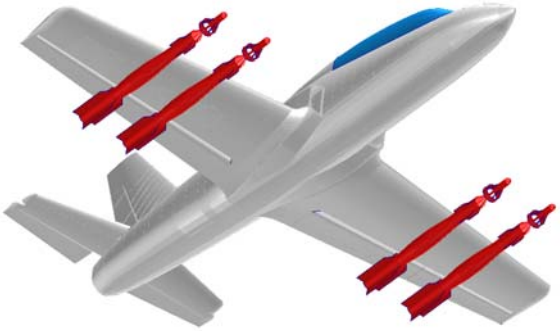

Fig. 26 IAR-99 External Stores Dynamics FEM

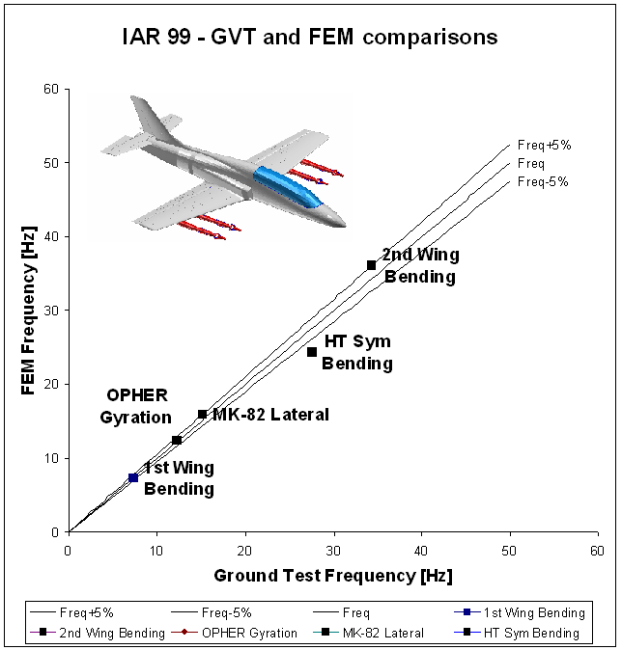

Fig. 27 GVT-FEA comparison

Highly representative FEM can be used to explore future structural modifications or changes with realistic component modifications.

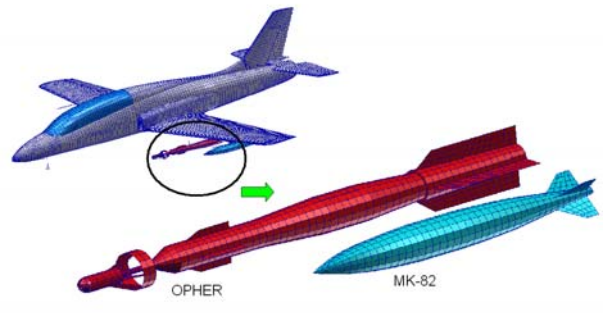

Fig. 28 IAR-99 External Stores Dynamics FEM

REFERENCES

1. MSC - *PATRAN, NASTRAN*, 2010.
2. A.Ionita, D. Lozici-Brinzei, s.a., *Ground vibration experiments, IAR-99* STRAERO/ INCAS internal report N-9913/C-2340, Nov. 1999.
3. P. Rosu, *Teza de doctorat*, Academia Tehnica Militara, 2010.
4. MIL-A-8591H, *Airborne stores suspension equipment and aircraft-stores interface*, March 1990