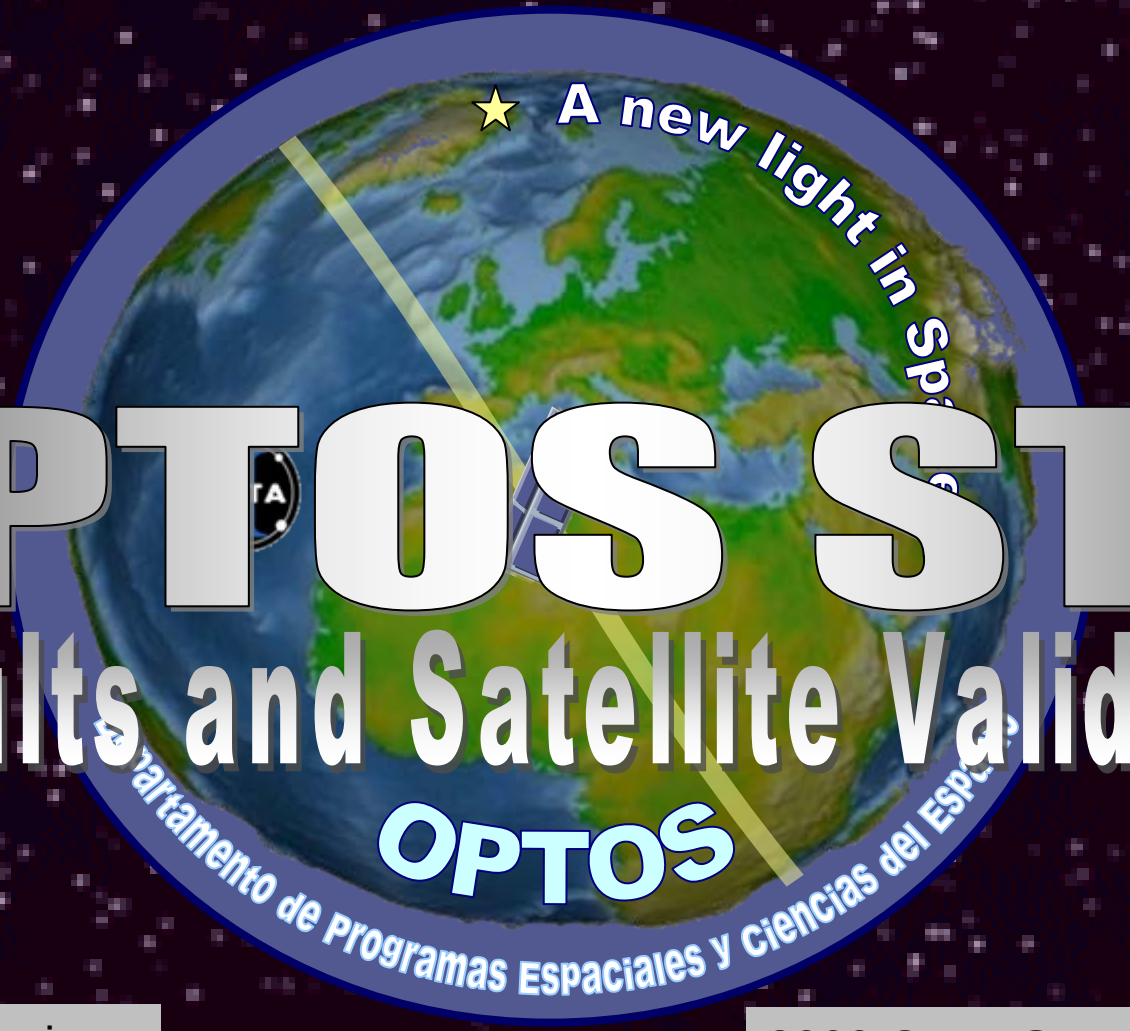

OPTOS STM

Results and Satellite Validation

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INTA

2009 CUBESAT DEVELOPERS WORKSHOP

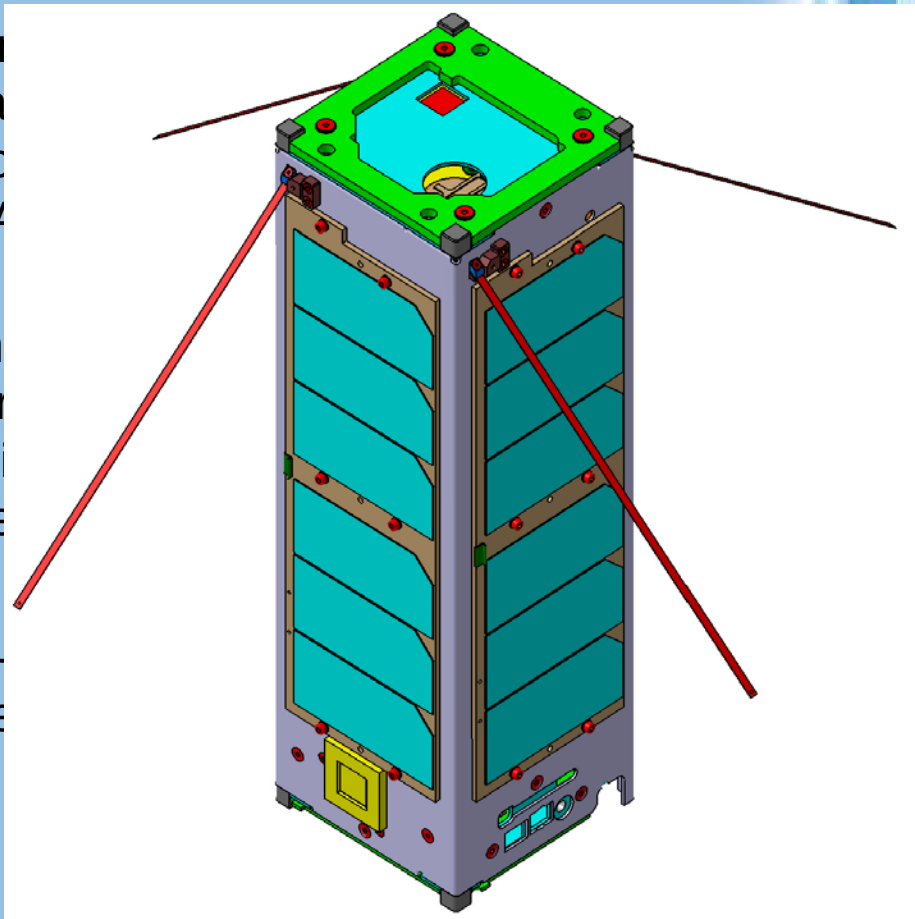
23rd APRIL 2008

CONTENTS

- INTA R+D
- OPTOS
- STM DESCRIPTION
- STM TEST CAMPAIGN
- STM VALIDATION
  - THERMAL
  - MECHANICAL
- PFM TEST CAMPAIGN

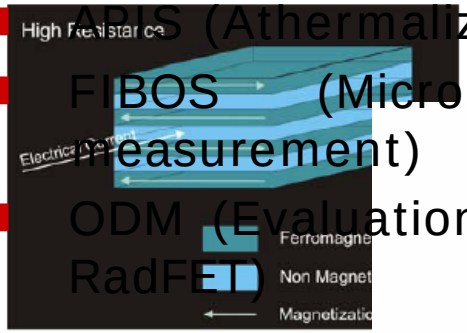
INTA (www.inta.es)

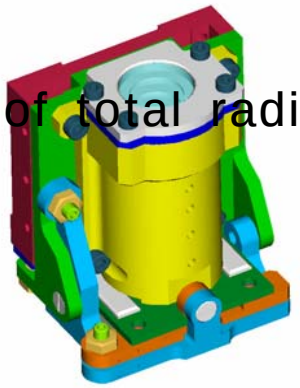
- The Spanish National I
  (INTA) has focused a grea
  in the development o
  technologies (MINISAT, NA
- The latest development
  based on a small platform
  of the art technologies ser
  efficiency low cost multi
  industrial/agency level re
  budgets.
- OPTOS will be the new 3-U
- OPTOS will be used as a te

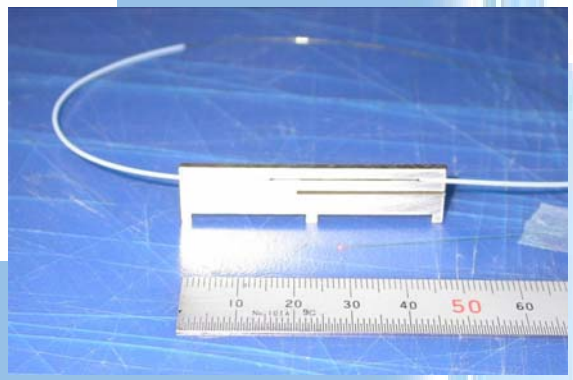


OPTOS (I)

- The payloads on board for the first mission are:
  - GMR (Giant Magneto Resistance sensors for magnetic field measurement)
  - APIS (Athermalized camera using CMOS technology)
  - FIBOS (Micro-photonic devices for temperature measurement)
  - ODM (Evaluation of total radiation dose using commercial RadFET)







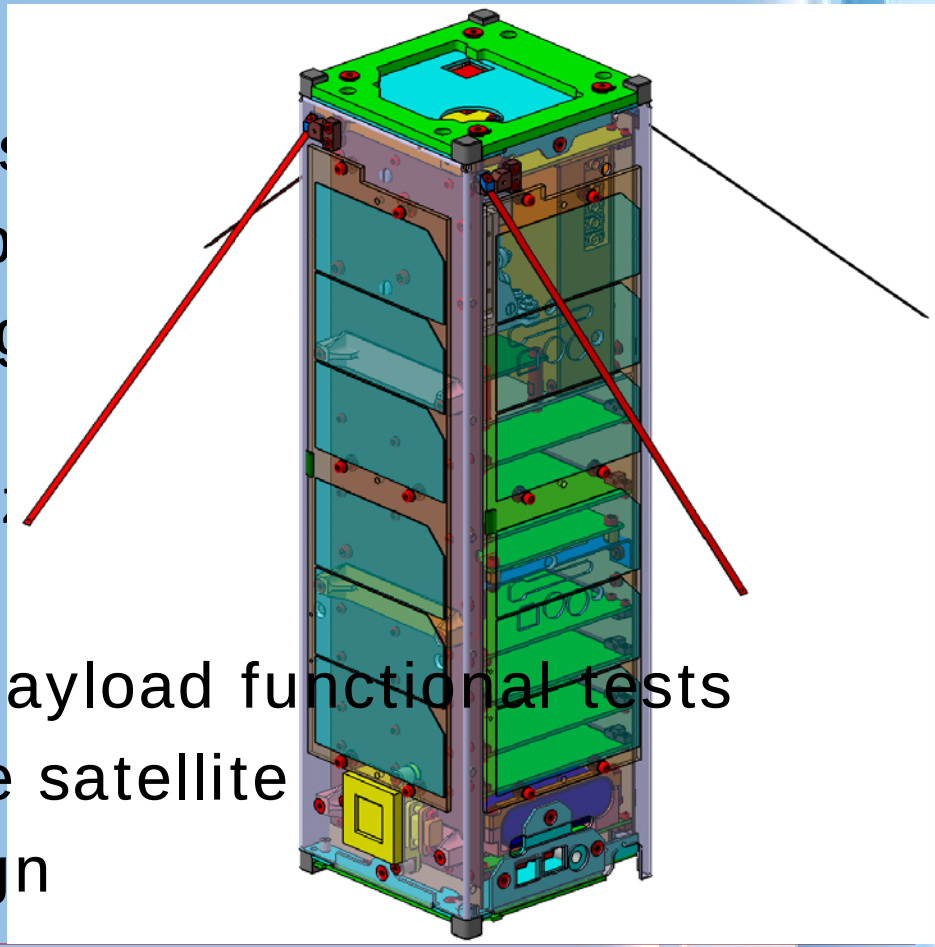
OPTOS (II)

It uses advanced subsystem technologies for satellites of its kind, such as:

- ADCS: Redundant attitude control and determination with three axis control, providing accuracy suitable for Earth observation purposes
- OBCOM: Includes an innovative on board communication system by use of light emitting diodes and sensors which allows communications between boards simultaneously, fast and wireless by means of light, hence optimizing space and integration of the overall system. It also uses a reduced BUS-CAN communication protocol
- OBDH: Distributed data handling CAN based subsystem counting with programmable devices such as CPLDs and FPGAs
- Internal structure: Composite carbon fibber structure

OPTOS (III)

- OPTOS is managed under ESA standards
- CDR has just been p
- STM test campaig successfully
- Design has been fro
- Future actions:
  - Subsystem and payload functional tests
  - Integration of the satellite
  - PFM test campaign

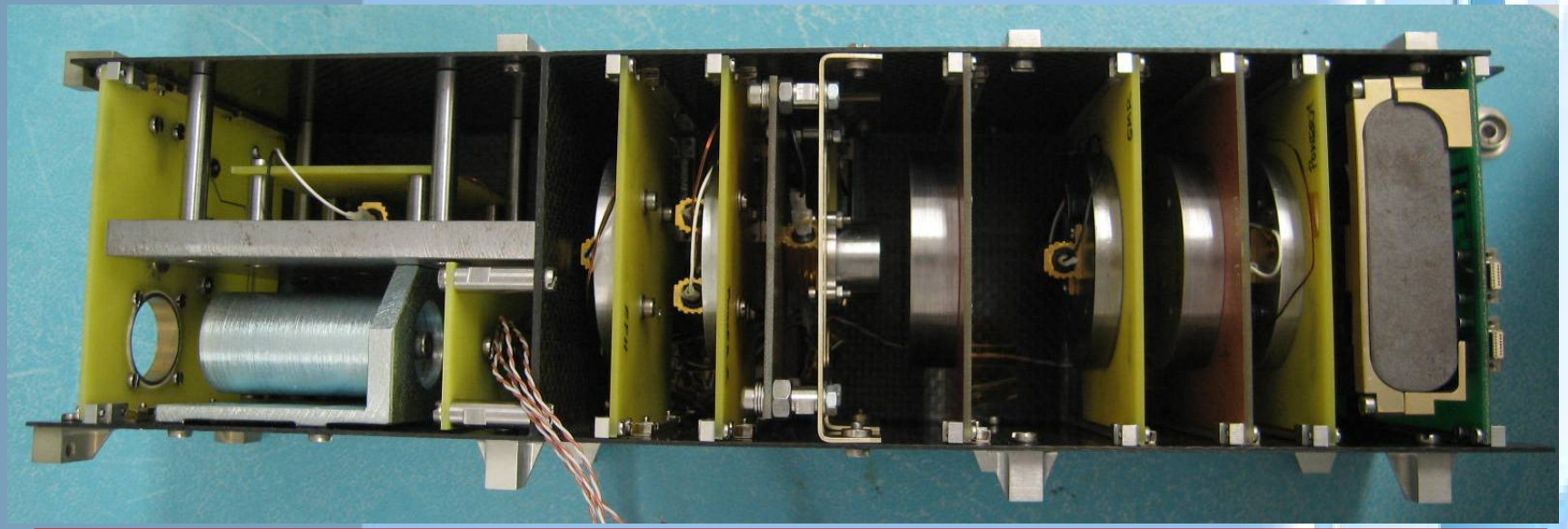


OPTOS STM (I)

- STM model represents OPTOS from structure and thermal points of view
- STM model has been used to validate mechanical and thermal analyses

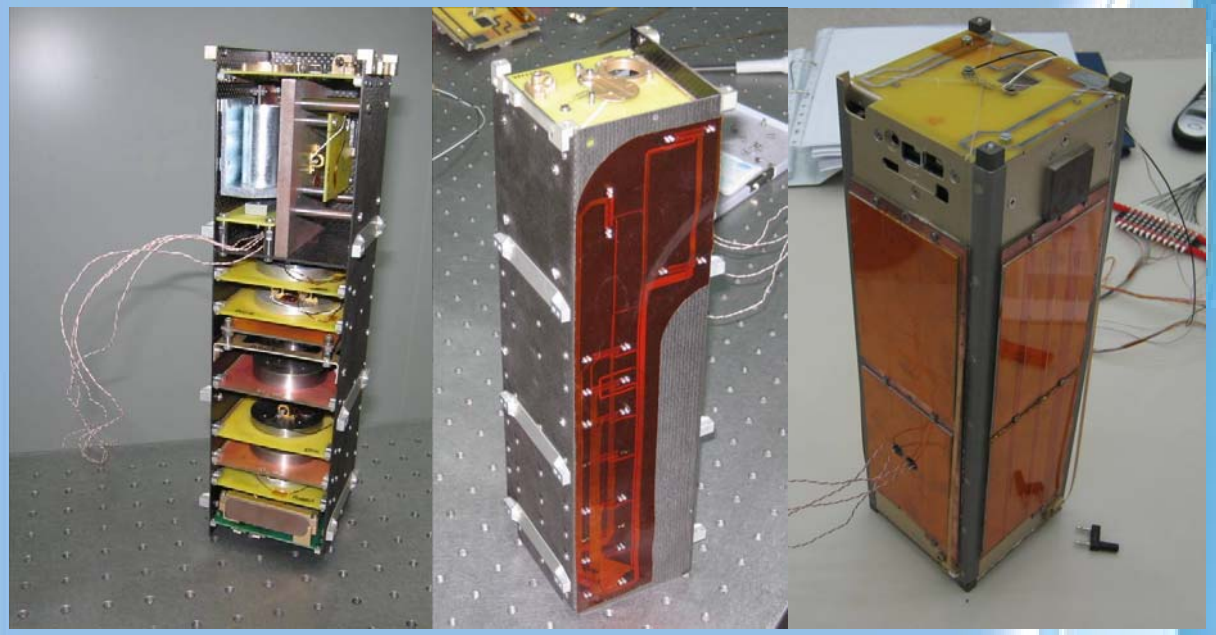
OPTOS STM (II)

- Mechanical:
  - Internal and external structures similar as the ones in the flight model
  - Boards with payloads and subsystem included with mass dummies and flight connectors

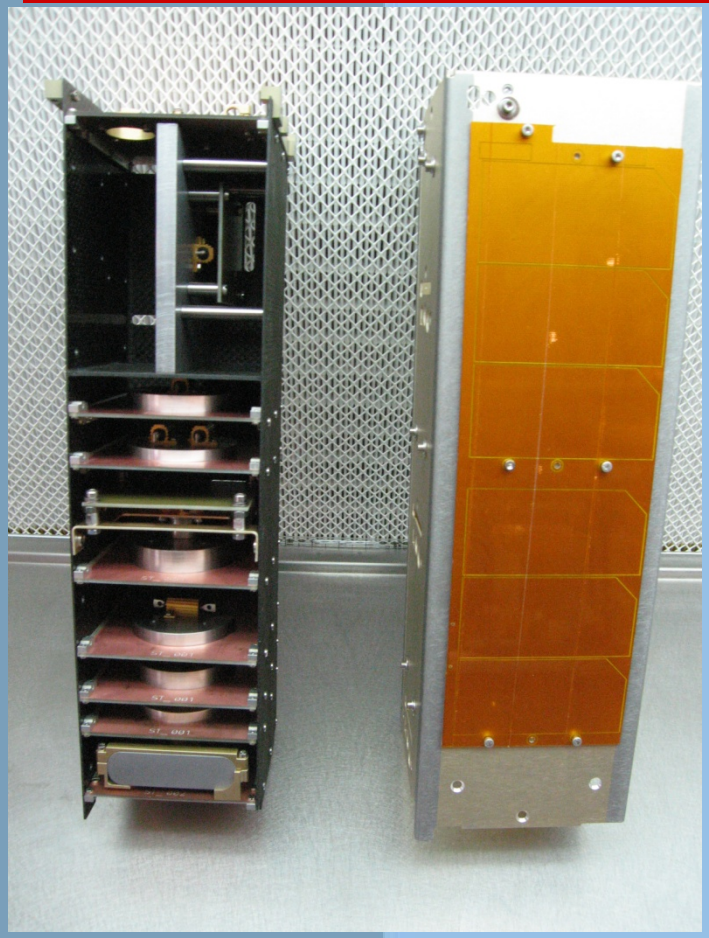


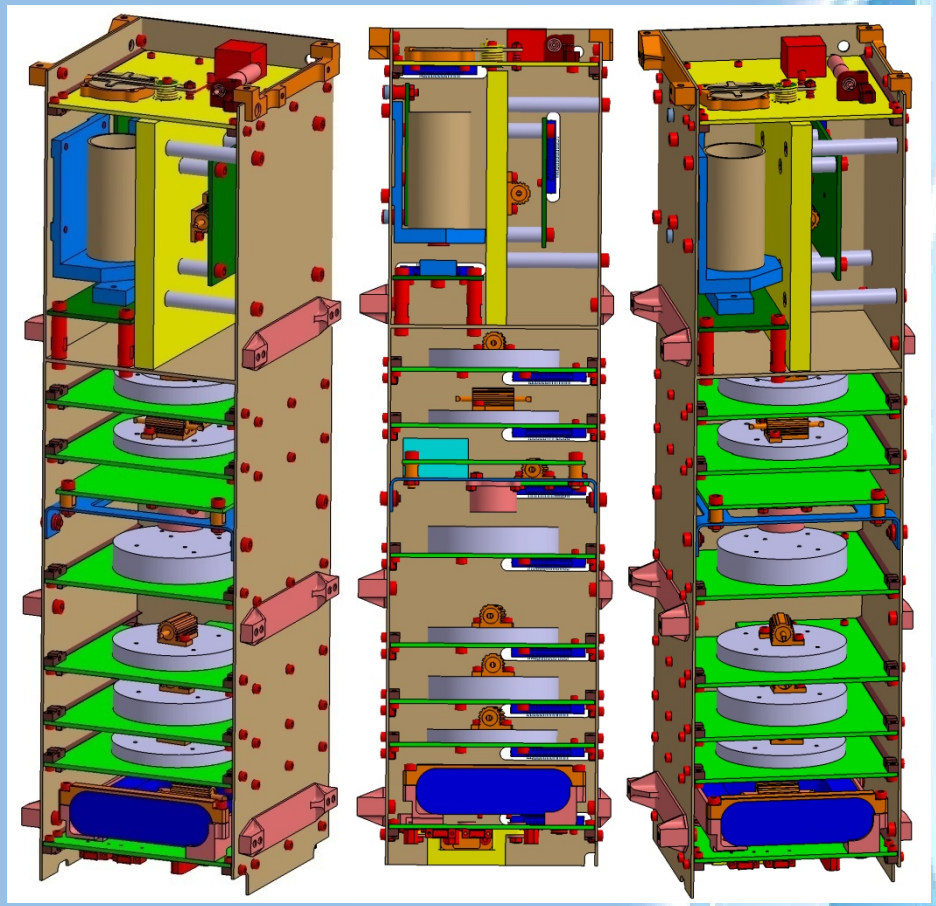
OPTOS STM (III)

- Thermal:
  - Resistances with aluminum box to simulate the dissipation produced in each board
  - Includes thermal sensors TMP-036 that will be used in PFM model

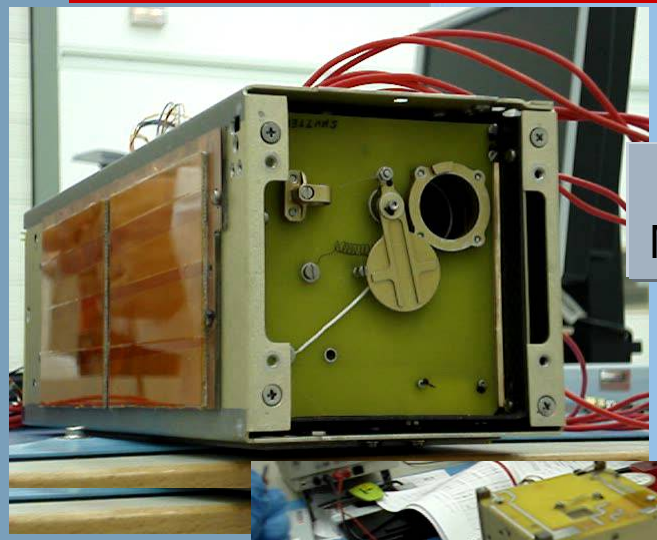


OPTOS STM (IV)

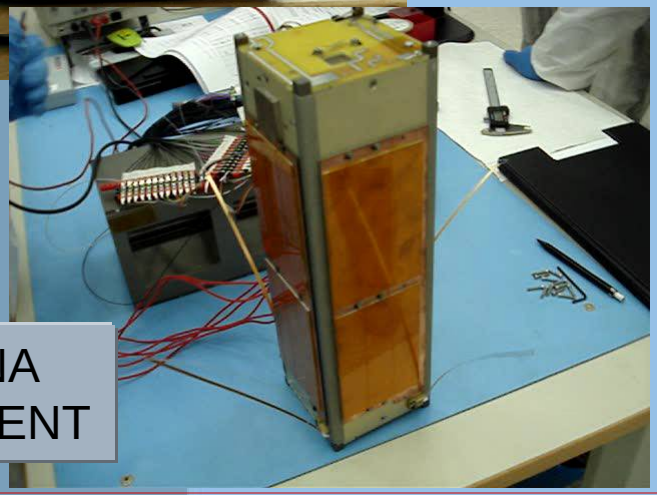




STM TEST CAMPAIGN



SHUTTER MECHANISM



ANTENNA DEPLOYMENT

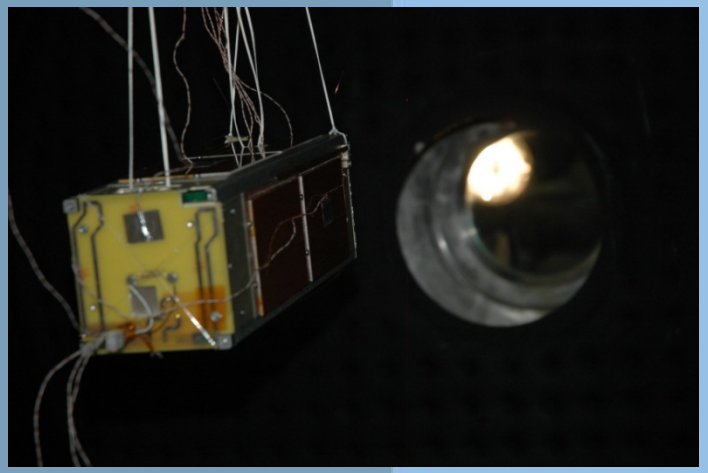
- STM
- Manufacturing
- Initial Inspection
- Thermal Balance
- Visual Inspection and Check
- Vibration tests
- Visual Inspection and Check
- Mass Properties
- Final inspection

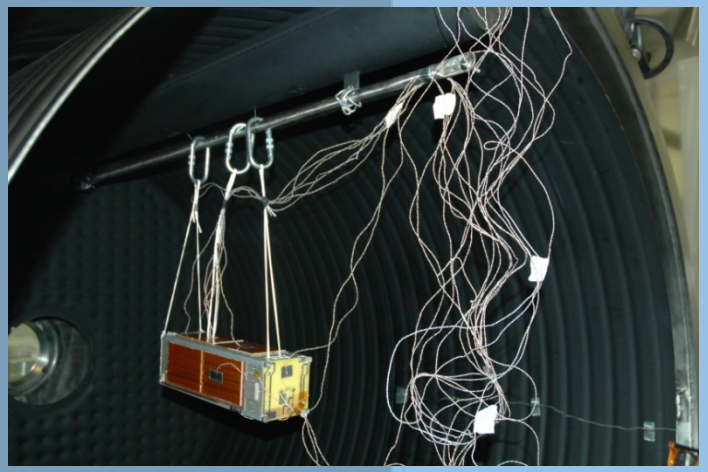
TEST CAMPAIGN

THERMAL ANALYSIS

- Mathematical model using over 250 nodes in a finite element environment
- It has been analyzed and foreseen with tools like ESArad and ESAtan
- The satellite should comfortably operate within ranges between -20ºC / +50ºC, well within operability requirements for every component.
- The temperature estimations are being verified via an STM procedure involving thermal balancing in quasi vacuum conditions at INTA.

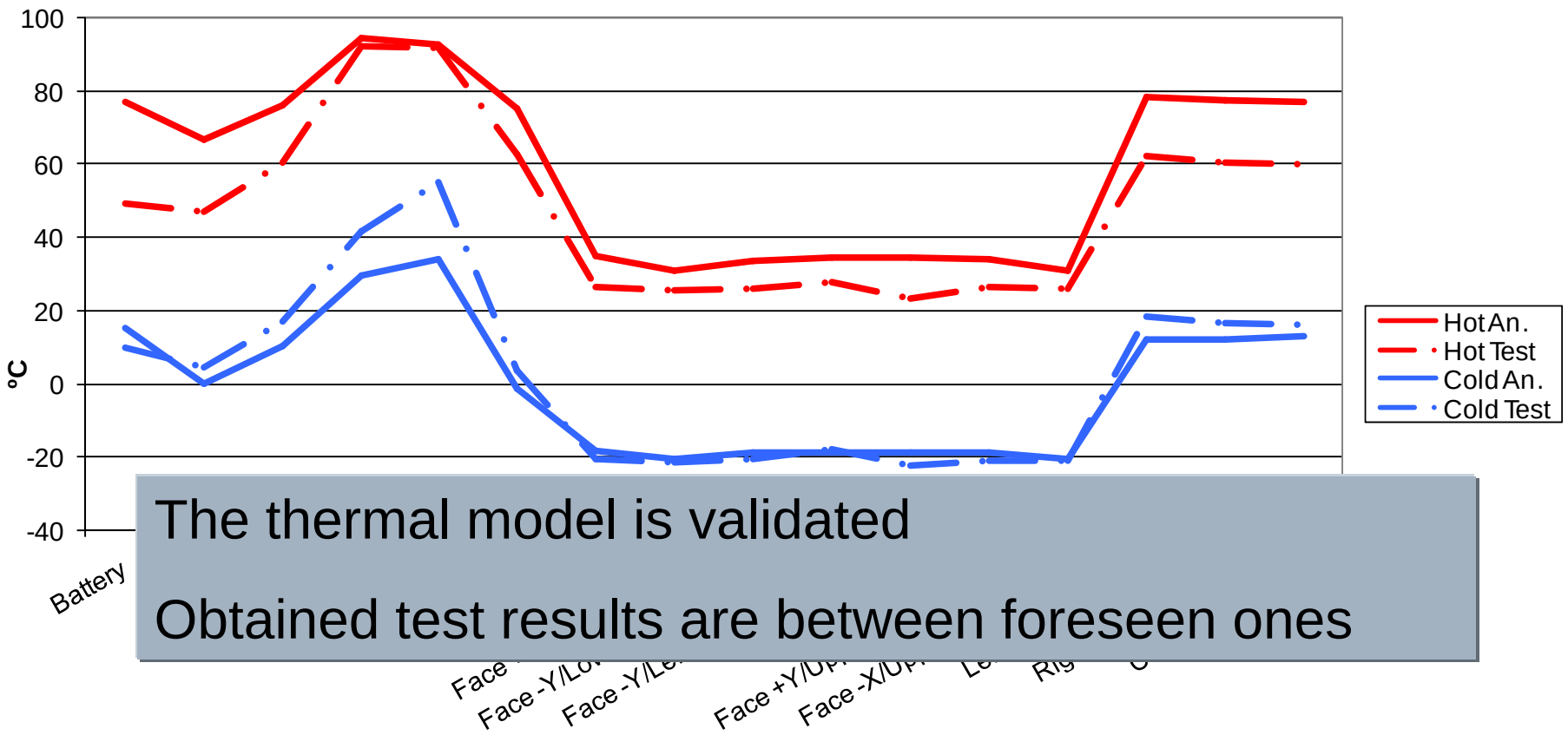
STM THERMAL BALANCE TEST





Board Number	S/S or PL	Resistance Quantity	Resistance value (Ω)	Tension (V)
Board 1	BATTERY BOARD	1 (variable power)	100	4/5/6/7
Board 2	POWER 1 BOARD	1	22	5
Board 3	ODM + MGM BOARD	0	---	
Board 4	GMR BOARD	1	15	5
Board 5	FIBOS BOARD	0	---	
Board 6	INT. ADCS BOARD	1	100	5
Board 7	POWER 2 BOARD	2	50/22	5
Board 8	EPH BOARD	1	22	5
Board 9	TTC BOARD	1	22	5
Board 10	TOP PAYLOAD ASSY.	0	---	
Board 11	SHUTTER BOARD	0	---	

STM THERMAL BALANCE RESULT



The thermal model is validated

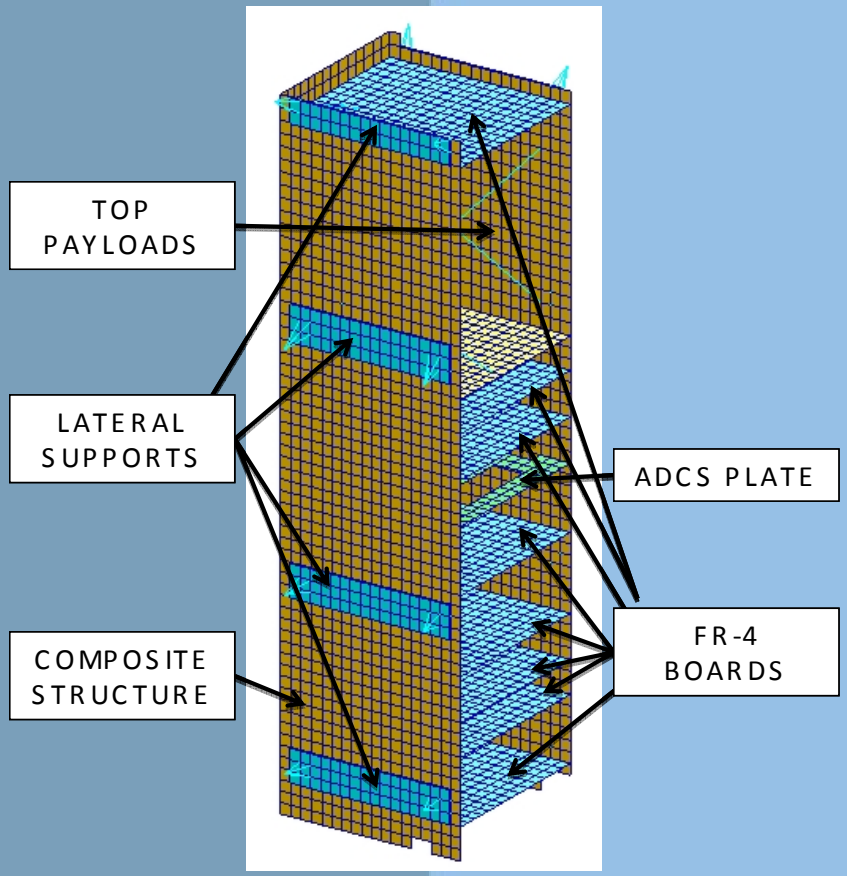
Obtained test results are between foreseen ones

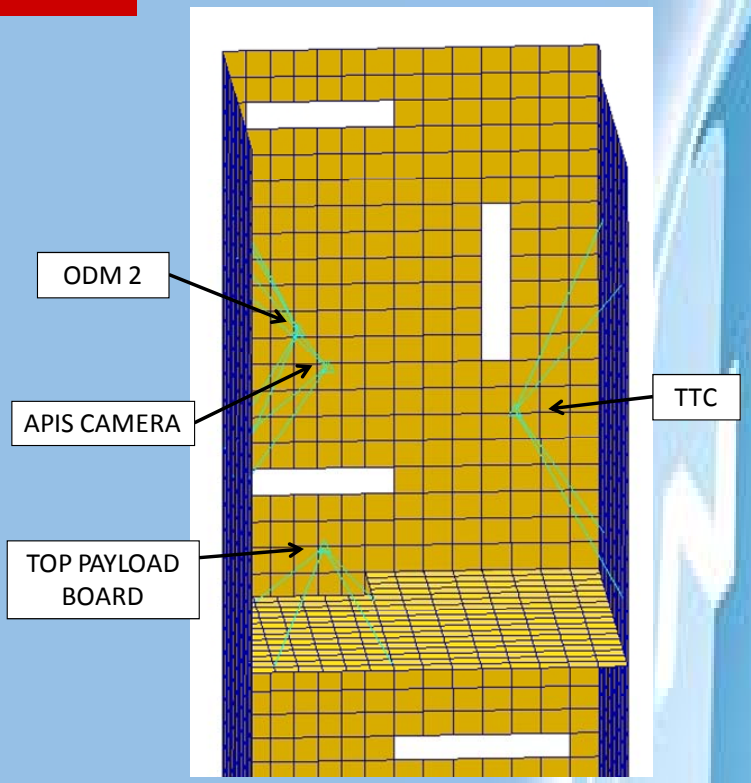
MECHANICAL ANALYSIS
MODELS AND ANALYSES

ON-ORBIT CONFIGURATION	LAUNCH CONFIGURATION
Modal analysis	Modal analysis Static analysis Sine analysis Random analysis

- Linear aproximation used in all analyses

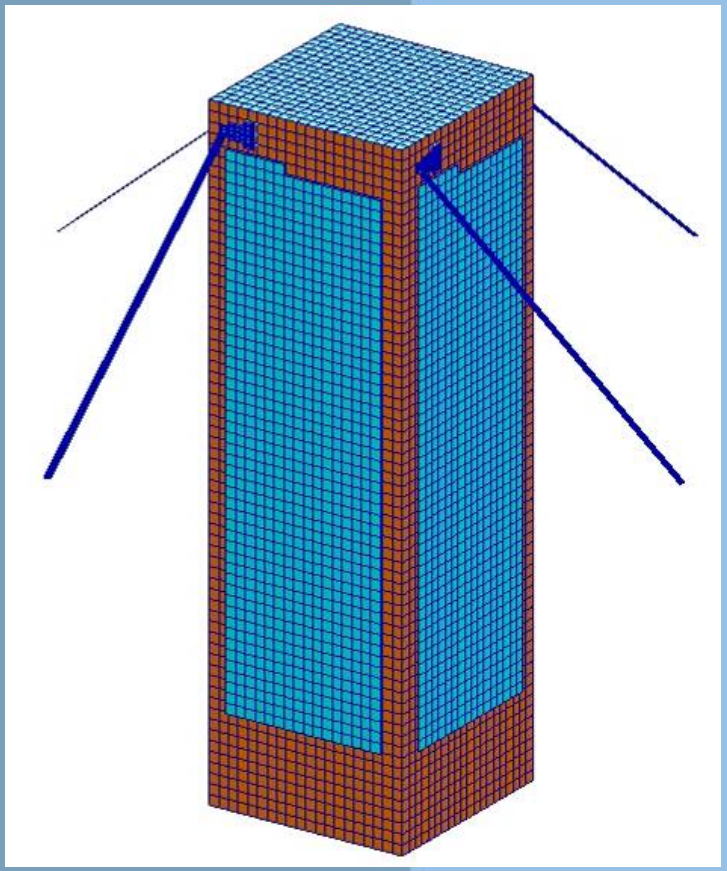
OPTOS FEM (I)
INTERNAL VIEWS





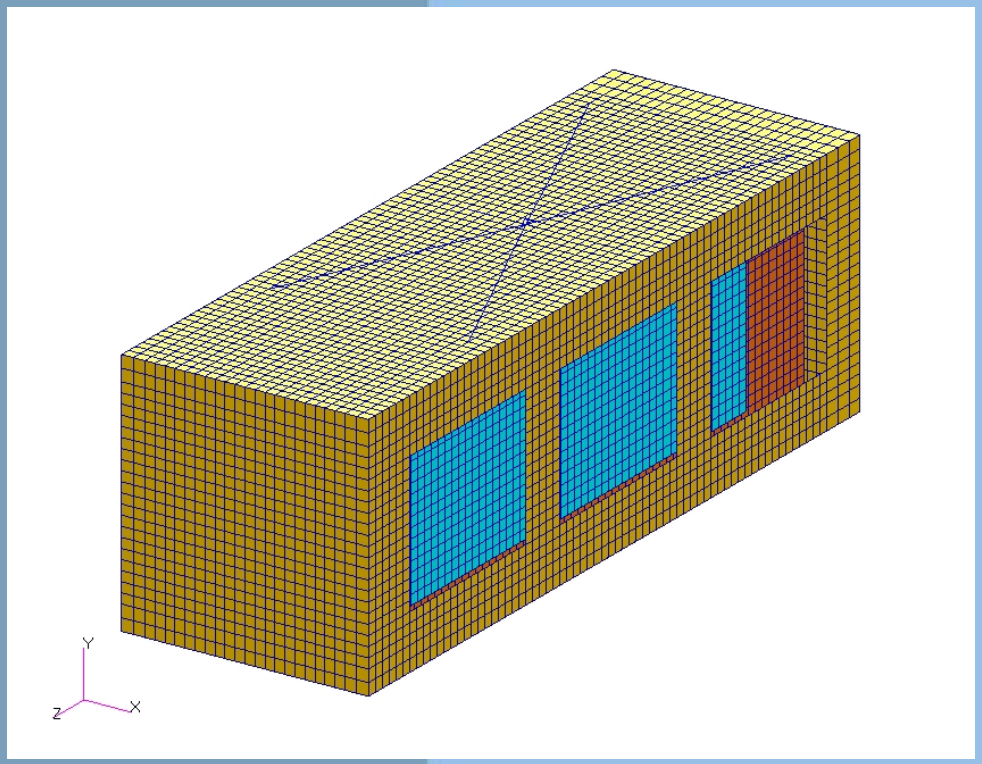
MODEL CONSISTS OF PLATE, MASS AND RIGID ELEMENTS

OPTOS FEM (II)
DEPLOYED CONFIGURATION



- OPTOS OUTSIDE DEPLOYER
- 22659 NODES
- 21144 ELEMENTS
- 1st NATURAL FREQUENCY OF ANTENNAS:
  - 4.2 Hz (BeCu)
  - 5.6 Hz (AISI 316)

OPTOS FEM (III)
LAUNCH CONFIGURATION



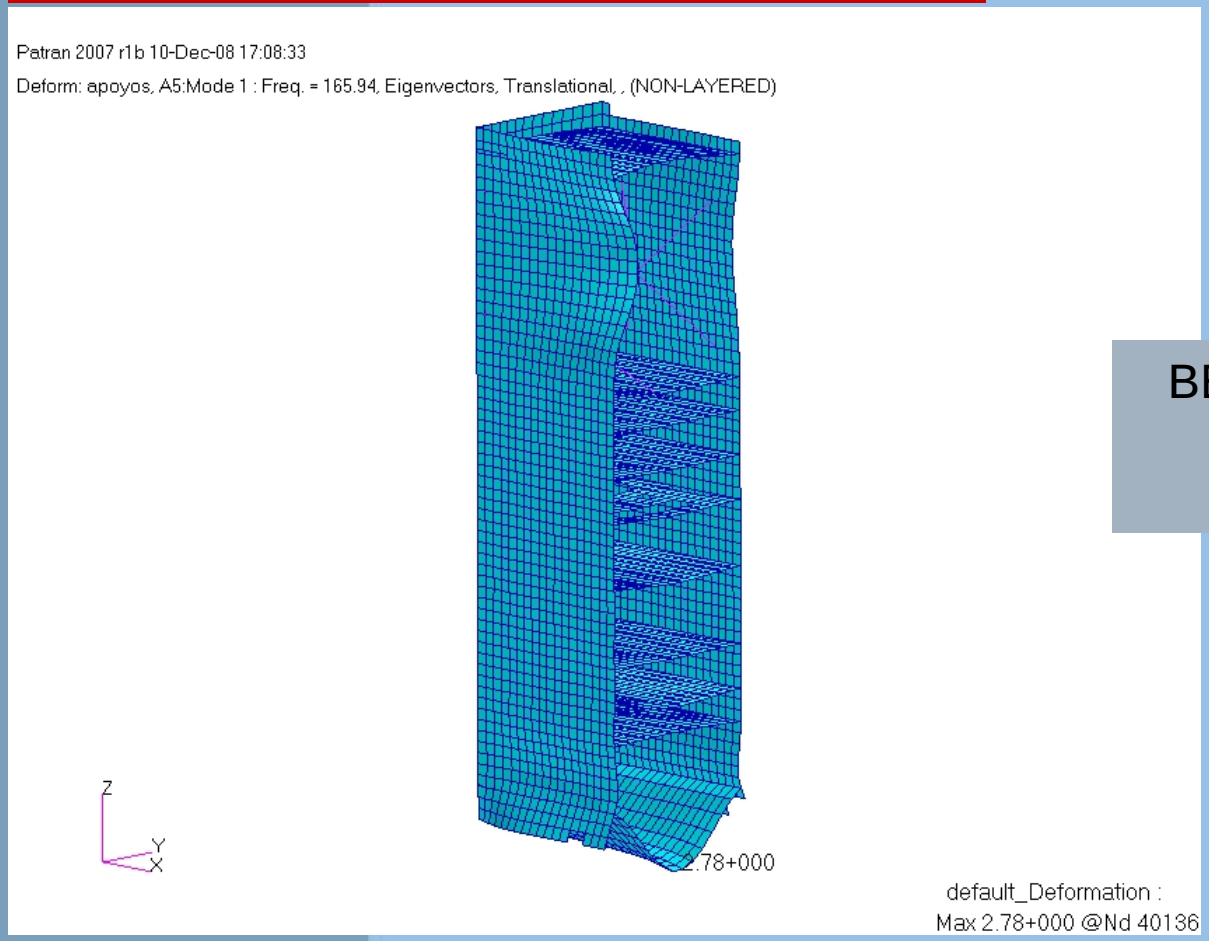
- OPTOS INSIDE DEPLOYER
- 22950 NODES
- 22524 ELEMENTS
- FIRST NATURAL FREQUENCY
  165.95 Hz

MODAL ANALYSIS
NATURAL FREQUENCIES

Number	FREC (Hz)	MODAL EFFECTIVE MASS (Kg)		
		T1	T2	T3
1	165,9	0,005	0	0,849
2	173,3	0,017	0,269	0,033
4	187,6	0,002	0,297	0,136
6	187,9	0,001	0,259	0,077
10	204,6	0,001	0,033	0,282
12	225	0	0,011	0,198
13	234,9	0,325	0,059	0,001
14	248,2	0,002	0,103	0,564
17	258,7	0,057	0,282	0,002
19	274,1	0,001	0,005	0,195
21	295,3	0,011	0,698	0,044
22	306,6	0,002	0,043	0,434
23	316,3	0,163	0	0
24	329,1	0,003	0,003	0,349
28	372,3	0,714	0,008	0,001
33	391,2	0,351	0,002	0,042
34	396,2	0,795	0,012	0,008
35	399,4	0,26	0,003	0
38	402,8	0,62	0,005	0,002
46	467,9	0,218	0,012	0,001

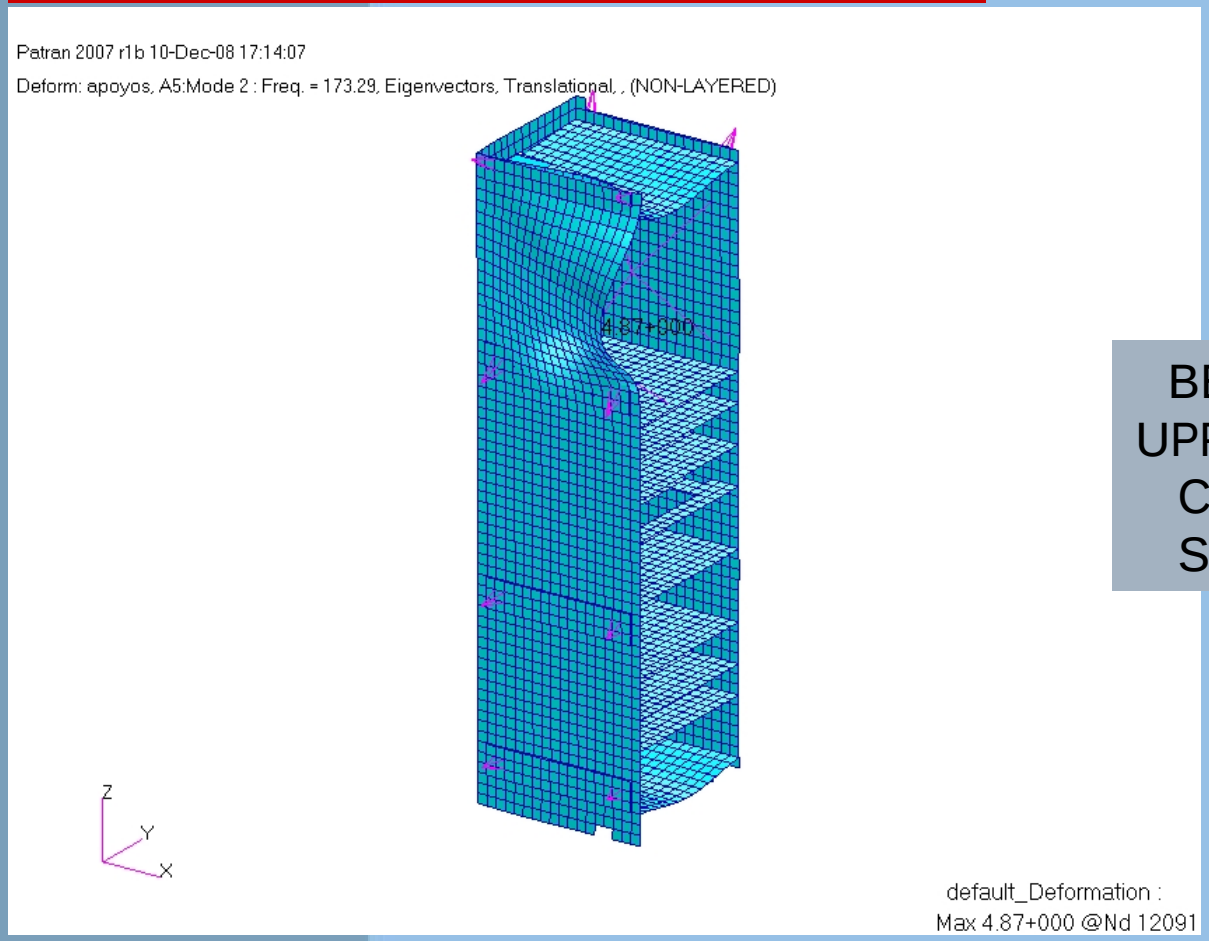
- Most representative normal modes.
- All of them are related with carbon fibber structure, boards and solar arrays

MODAL ANALYSIS
Mode 1: 165.94 Hz



BENDING OF BATTERY BOARD

MODAL ANALYSIS
Mode 2: 173.29 Hz



BENDING OF UPPER SIDE OF COMPOSITE STRUCTURE

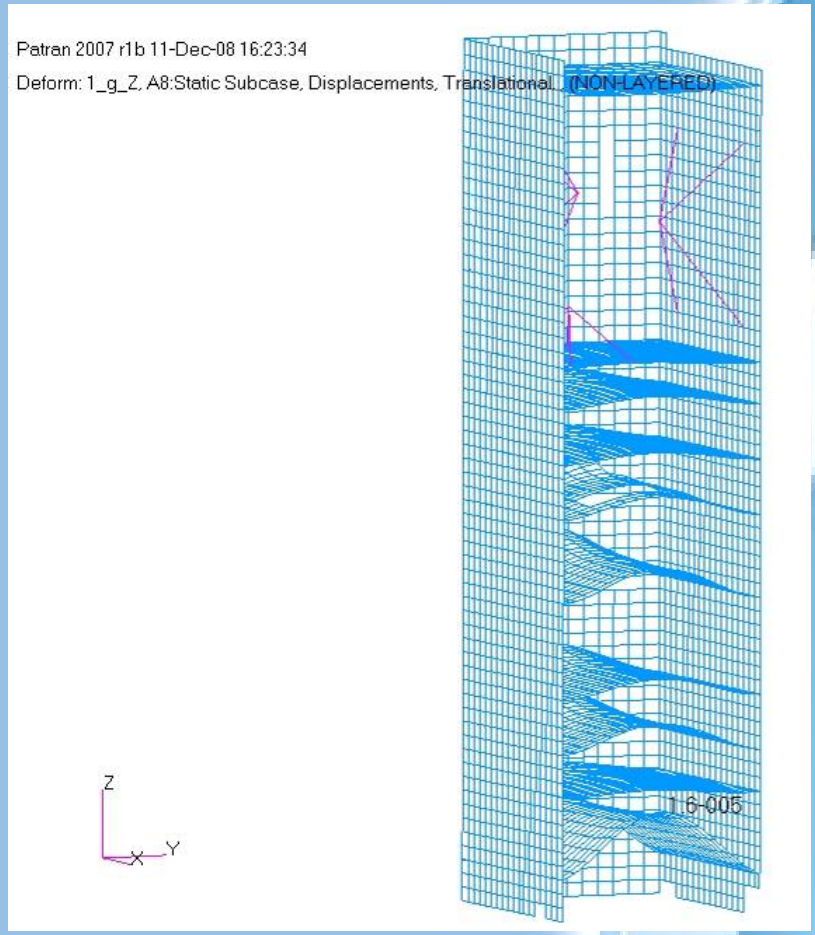
RANDOM ANALYSIS
MAXIMUM STRESSES. MARGINS OF SAFETY

OPTOS COMPONENT	MAX STRESS (MPa)	Msy	Msu
COMPOSITE STRUCTURE	48,64	-	10,45
LATERAL SUPPORTS	12,39	19,77	17,64
CENTRAL BODY OF CubeSAT	64,35	0,56	0,66
COVERS OF CubeSAT	104,22	0,00	0,02
P-POD	24,38	2,01	3,23
BATTERY BOARD	17,46	0,79	0,38
EPS 1 BOARD	4,14	6,56	4,84
ODM + MGM BOARD	8,12	2,85	1,97
GMR BOARD	6,15	4,09	2,93
FIBOS BOARD	11,84	1,64	1,04
ADCS PLATE	17,52	8,90	7,85
EPS 2 BOARD	5,17	5,05	3,67
EPH BOARD	3,25	8,61	6,42
SHUTTER BOARD	10,69	1,92	1,26
SOLAR ARRAYS	5,07	5,17	3,77

- Dimensioning loads are derived by using a quadratic combination of low frequency loads, and the random environment
- Safety factors:
  - Yield: 1.5
  - Ultimate: 2.0
- All margins positive

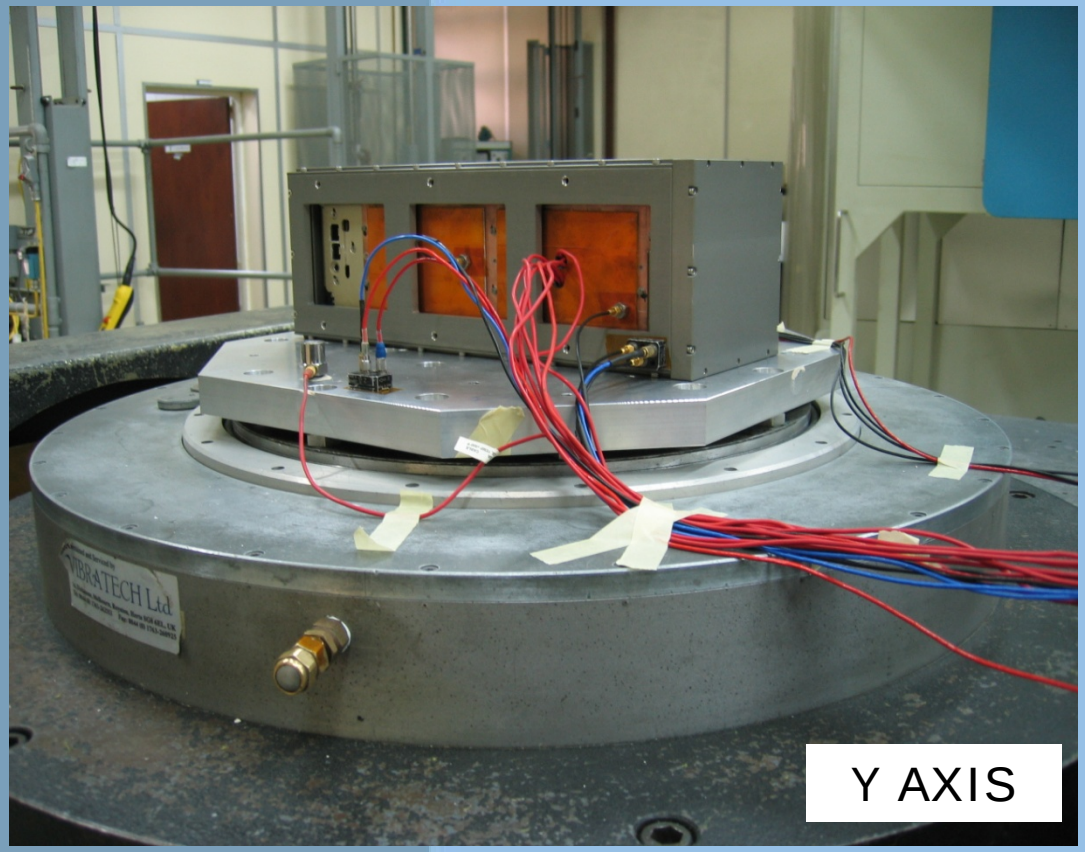
RANDOM ANALYSIS
DISPLACEMENTS

OPTOS COMPONENT	MAX DISPLACEMENT (mm)
COMPOSITE STRUCTURE	0,096
BATTERY BOARD	0,319
EPS 1 BOARD	0,128
ODM + MGM BOARD	0,259
GMR BOARD	0,219
FIBOS BOARD	0,299
ADCS PLATE	0,319
EPS 2 BOARD	0,146
EPH BOARD	0,153
SHUTTER BOARD	0,086
TTC	0,108



- Maximum displacements are under the allowed gap

STM VIBRATION TEST
TEST SET-UP



Accelerometers
(monoaxial and triaxial**)**

- Five internal
- Three external
- One in P-POD
- One in base plate
- Two for control

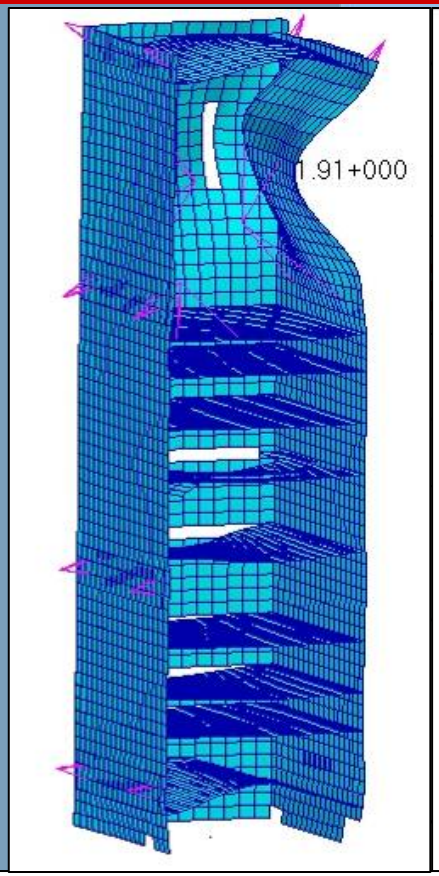
20 channels used

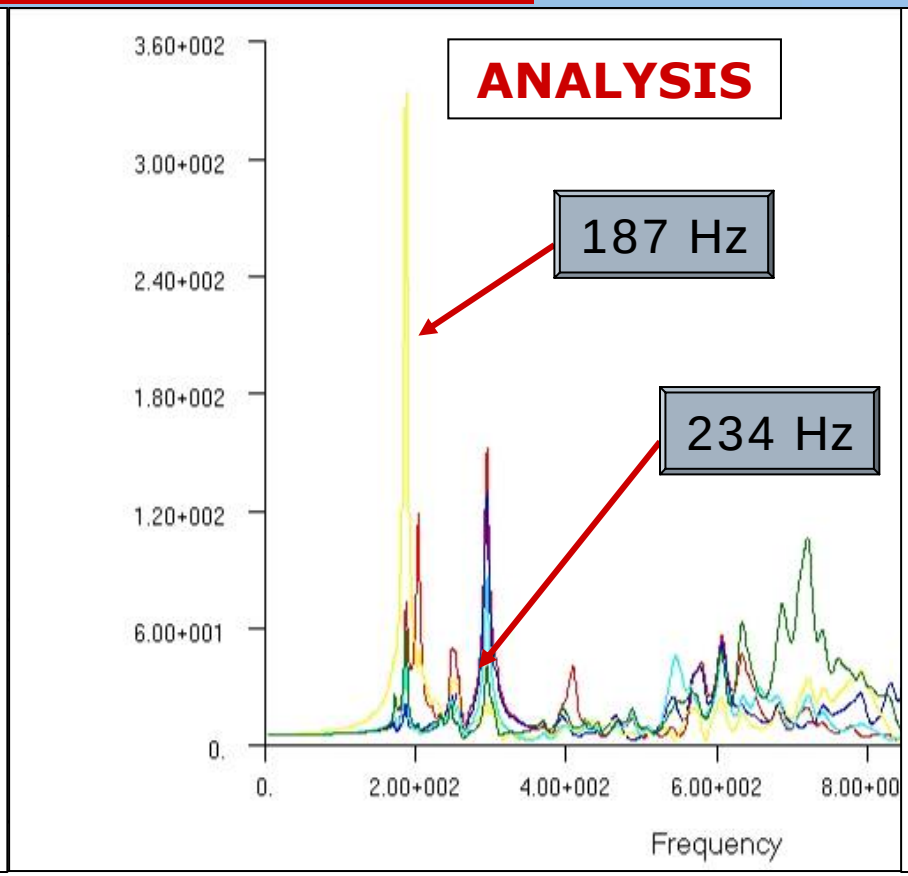
STM VIBRATION TEST
TEST SEQUENCE

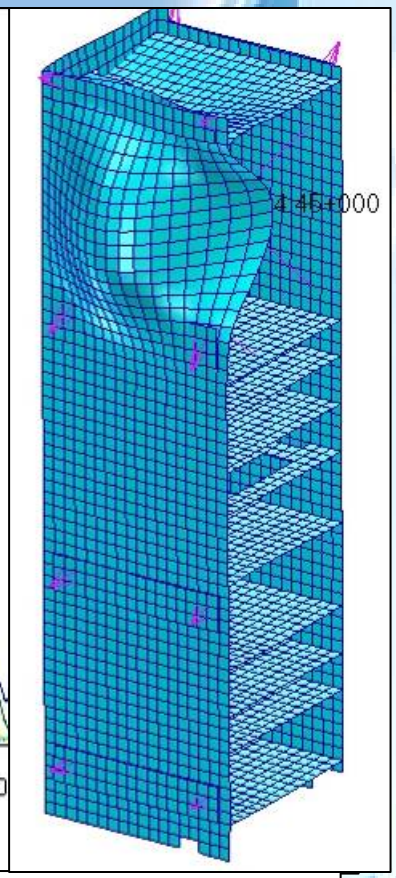
- Initial inspection
- Integration of STM/P-POD in vibration plate
- Mount on vibrator
- X TEST
- Visual inspection
- Z TEST
- Visual inspection
- Y TEST
- Visual inspection
- Unmount from vibrator
- Extraction of STM
- Final inspection

- Low level sine
- Sine PSLV
- Low level sine
- Random DNEPR
- Low level sine

STM VIBRATION TEST
TEST RESULTS







Y axis accelerometer located in the +Y wall of composite structure beside TTC

STM VIBRATION TEST CONCLUSIONS

The test is considered successfully performed and the specimen verified for dynamic environment because:

- Excitation levels measured and recorded by pilot accelerometers are in agreement with the specified ones according to defined control strategy
- Response signals have been properly acquired and recorded allowing later treatment
- No structural anomaly occurs during testing
- After fully visual and electrical inspection, no damage is observed
- No significant drift in frequencies is detected between low level results

Test results have been compared with mechanical analysis anticipated results. **So the STM FEM model analysis is validated**.

PFM TEST CAMPAIGN

INITIAL INSPECTION

MASS PROPERTIES

CONTROL FUNCTIONAL & ELECTRICAL SYSTEM TEST

RF INITIAL TEST

SINE & RANDOM VIBRATION

VISUAL INSPECTION & FUNCTIONAL – ELECTRICAL & RF CHECK

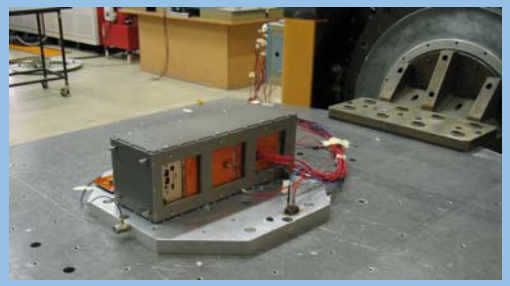
THERMAL VACUUM CYCLING

VISUAL INSPECTION & FUNCTIONAL – ELECTRICAL & RF CHECK

EMC TEST

RF FINAL TEST

FINAL INSPECTION



THANKS FOR YOUR ATTENDANCE

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2009 CUBESAT DEVELOPERS WORKSHOP

23rd APRIL 2008