



COLABORACIÓN DEL INTA EN LA CONSTRUCCIÓN DEL MOCK-UP DEL FTD

Malte Frövel, María Antonia de la Torre

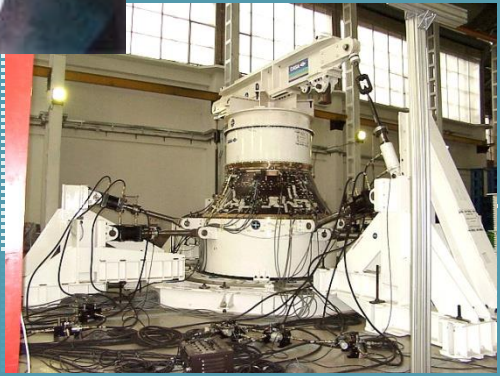
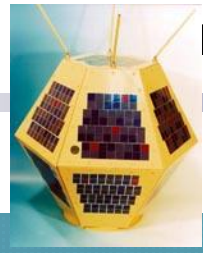
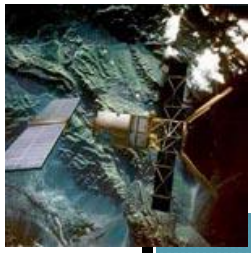
**XII Meeting of the Spanish Network for future
linear colliders**

CIEMAT: 26.1.2016

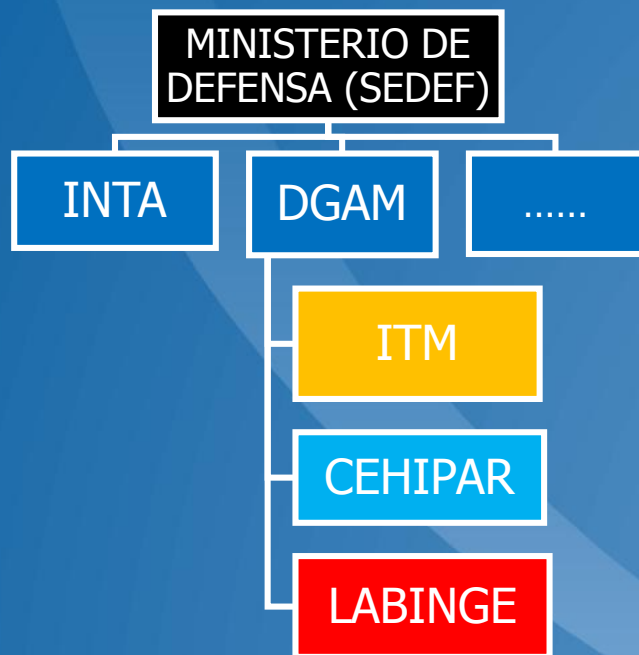




Brief Presentation of INTA

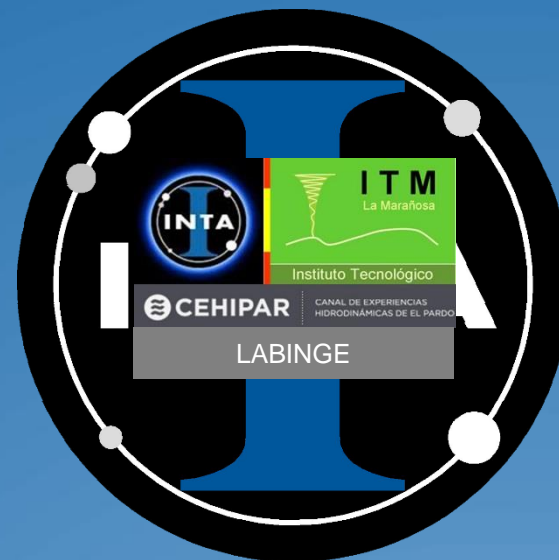


*ANTIGUA ESTRUCTURA
DE LOS CENTROS DE
I+D+i DEL Mº DEFENSA*



*NUEVA ESTRUCTURA
DE LOS CENTROS DE
I+D+i DEL Mº DEFENSA
(Ley 15/2014, de 16 de
septiembre)*

ESTRUCTURA DEL INTA (RD 925/2015, de 16 de octubre)



DIRECCIÓN
GENERAL

S.G. SISTEMAS
AERONÁUTICOS

S.G. SISTEMAS
ESPACIALES

S.G. SISTEMAS
TERRESTRES

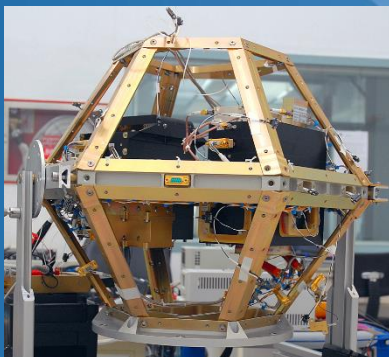
S.G. SISTEMAS
NAVALES

S.G.
COORDINACIÓN Y
PLANES

SECRETARÍA
GENERAL

S.G. TÉCNICAS

S.G. TRANSVERSALES



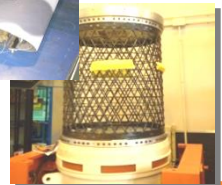
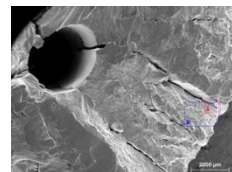
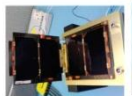
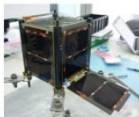
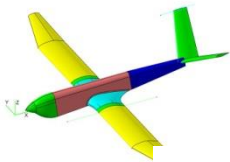
DEPARTAMENTO DE MATERIALES Y ESTRUCTURAS

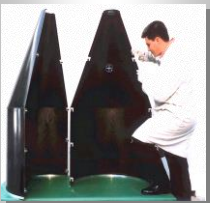
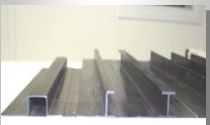
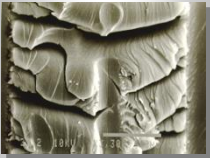
Diseño estructural

Ensayos de Estructuras

Materiales Metálicos

Materiales Compuestos





DEPARTAMENTO DE MATERIALES Y ESTRUCTURAS

→ Composite Materials Department: AMC

- Characterization of Composite Materials
- Development and Manufacturing of Prototypes
- Development of Procedures to Manufacture Structural Systems
- Study of In-service Behavior and Failure Analysis

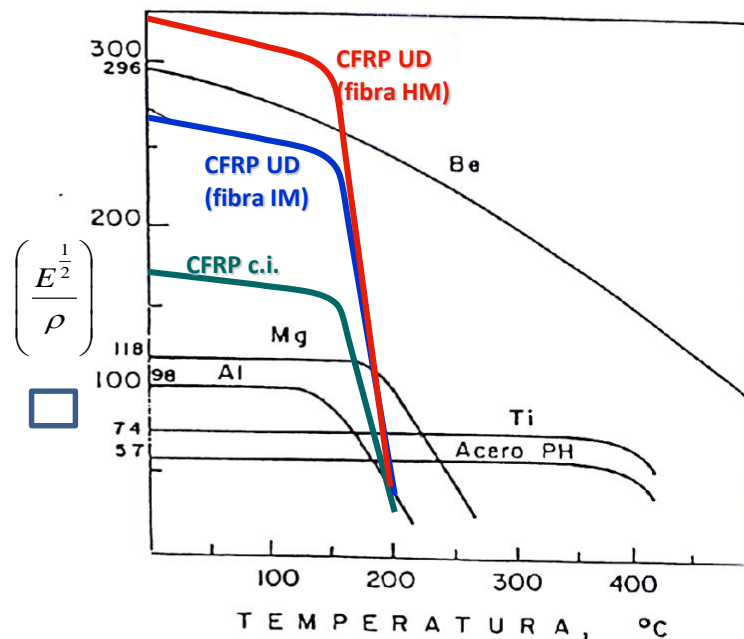
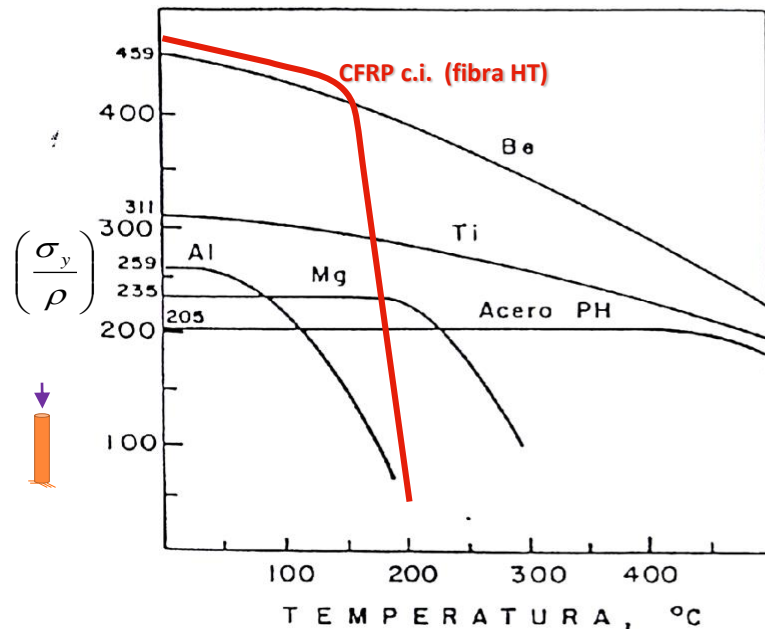
SOME GENERAL INFORMATION ABOUT COMPOSITE MATERIALS DESIGN



¿Why using composite materials with carbon fibers, CFRP?

- CFRP gives the highest specific strength and stiffness of all engineering materials:
 - Stiffness/density and Strength/density

Adapted from P. Tarín / El titanio y sus aleaciones: Estado actual



c.i.: quasi isotropic
 UD: unidireccional
 Carbon fiber HM: high modulus, HT: high tensile strength



Composite materials

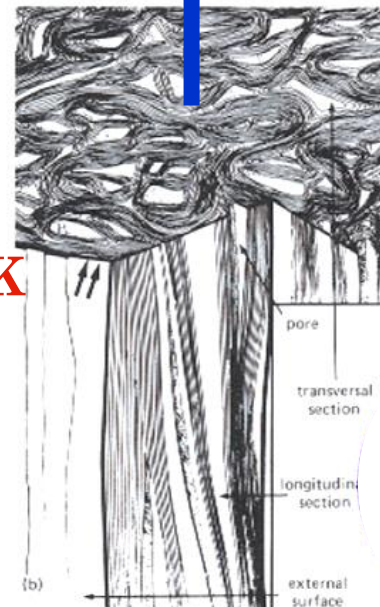
- Carbon fiber properties

- Ortotropic properties in
 - Strength, E-modulus, CTE longitudinal >> transversal
- Glass fibers: isotropic
- Aramid fibers (Kevlar): Ortotropic

$$\sigma \approx 80 \text{ Mpa}$$
$$E \approx 10 \text{ Gpa}$$
$$\alpha_k = 25 \dots 40 \cdot 10^{-6} \text{ 1/K}$$



$$\sigma = 4000 \dots 7000 \text{ Mpa}$$
$$E = 230 \dots 800 \text{ Gpa}$$
$$\alpha_k = -0,5 \dots -1,5 \cdot 10^{-6} \text{ 1/K}$$



CTE=coeficiente de expansión térmica

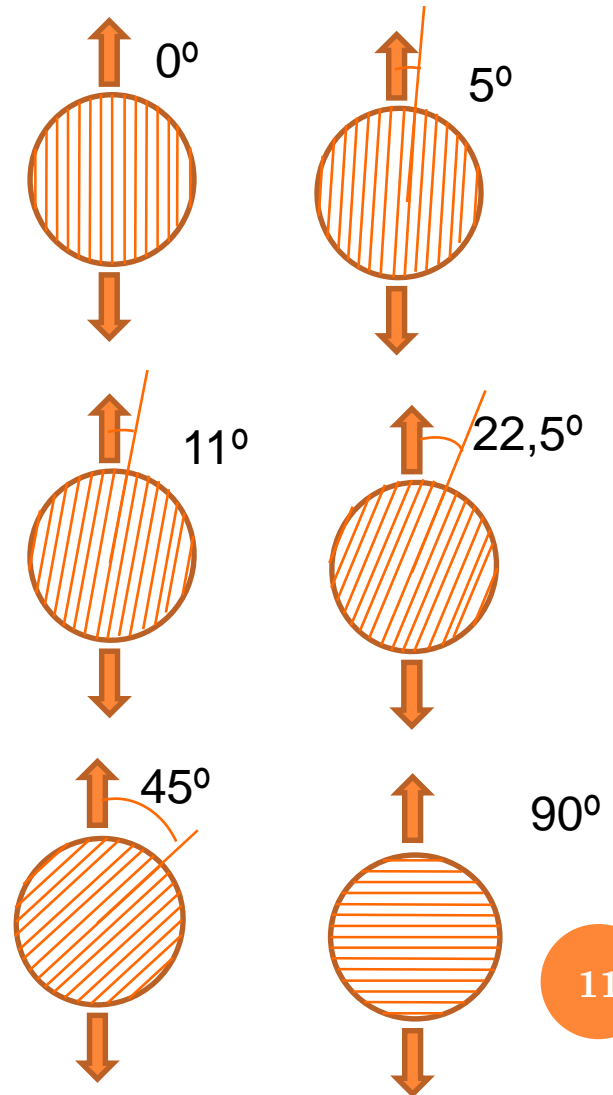
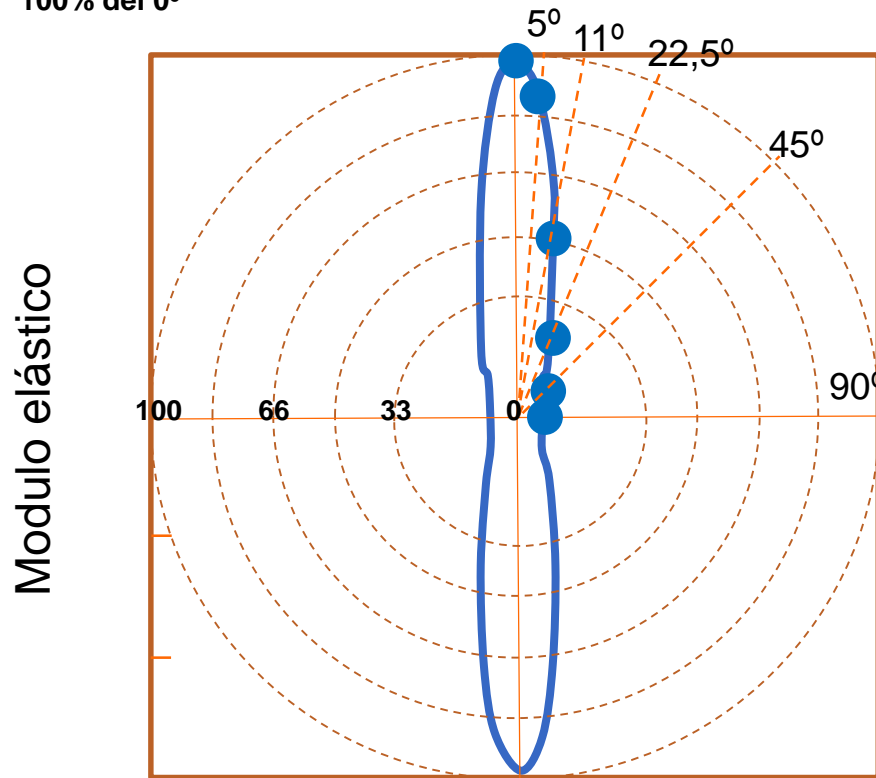
Micro structure of a carbon fiber



Materiales compuestos: Propiedades de Laminados

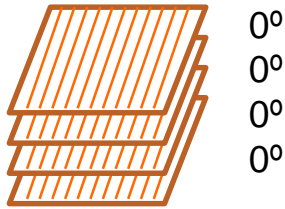
- **Laminado UD tensionado o comprimido en diferentes direcciones**

100% del 0°



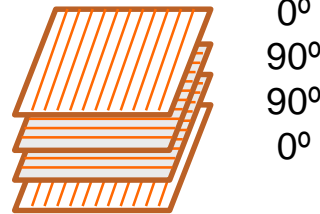
Materiales compuestos: : Propiedades de Laminados

○ Laminados típicos

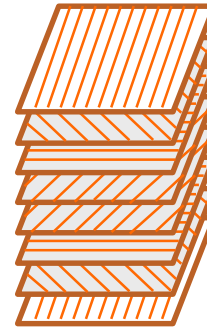


UD

$(0_2)_s$



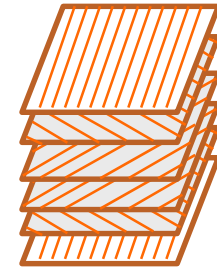
$(0/90)_s$



c.i.

$(0/-45/90/45)_s$

0°
-45°
90°
45°
90°
-45°
0°

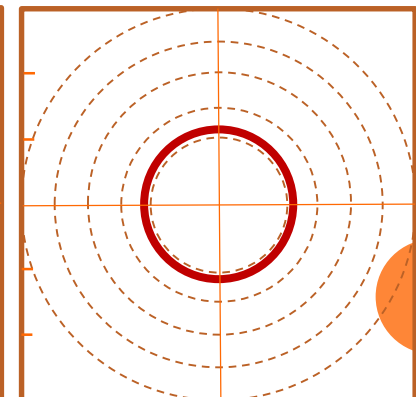
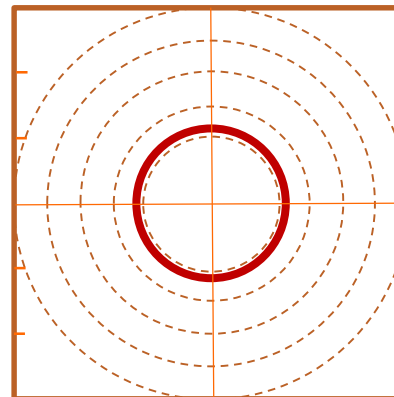
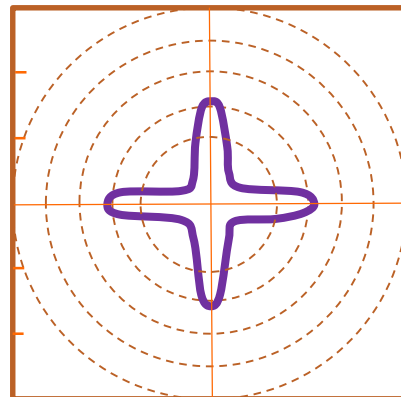
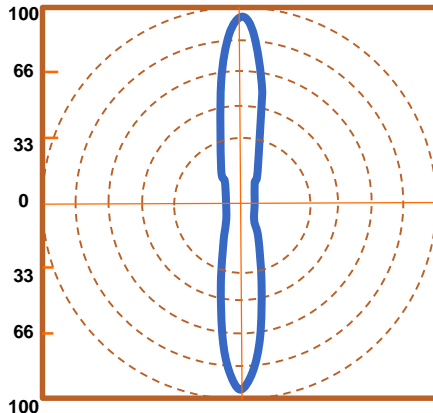


c.i.

$(0/-60/60)_s$

0°
-60°
60°
60°
-60°
0°

100%
del 0°



Rigidez (E= GPa)

Materiales compuestos: Propiedades de Laminados

- Estimación de la rigidez desde los valores del laminado en UD

$$E_{\text{cuasi-istropo}} \approx E_{UD} \cdot 0,33$$

$$E_{0/90} \approx E_{UD} \cdot 0,55$$

Según regla del 10%
de Hard-Smith

COMPOSITE PROPERTIES *

Tensile Strength	290 ksi	2,010 MPa	ASTM D-3039
Tensile Modulus	49.0 Msi	340 GPa	ASTM D-3039
Tensile Strain	0.6 %	0.6 %	ASTM D-3039
Compressive Strength	130 ksi	880 MPa	ASTM D-695
Flexural Strength	180 ksi	1,230 MPa	ASTM D-790
Flexural Modulus	40.5 Msi	280 GPa	ASTM D-790
ILSS	10.0 ksi	7 kgf/mm ²	ASTM D-2344
90° Tensile Strength	5.0 ksi	34 MPa	ASTM D-3039

* Toray 250°F Epoxy Resin. Normalized to 60% fiber volume.

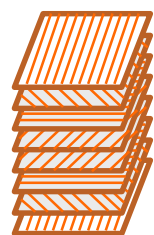
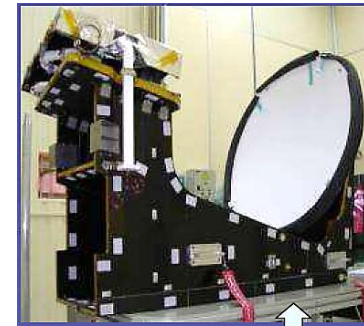
M55J/120°C cure
epoxy



Materiales compuestos: Propiedades de Laminados

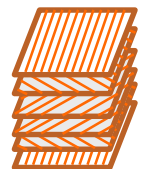
○ Coeficiente de expansión térmico, CTE= zero

- Fibras HM y UHM: **CTE₁₁**= $-1,5 \cdot 10^{-6}$ 1/K longitudinal
- **CTE₂₂**= $30 \cdot 10^{-6}$ 1/K transversal
- Para fibras de unos 500 GPa se consigue un $\alpha_k = 0$ en el plano con un apilamiento c.i.
- Muy importante para estructuras de antenas y plataformas científicas



c.i.

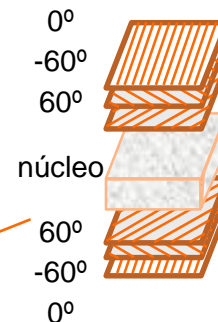
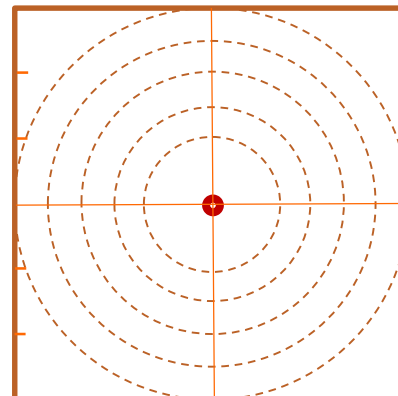
(0/-45/90/45)s



c.i.

(0/-60/60)s

CTE



Sandwich típico para reflectores con núcleo . $\alpha_k = 0$ para modulo de las fibras UHM mayor de unos 550 GPa

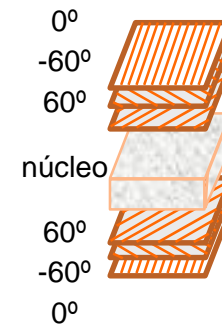
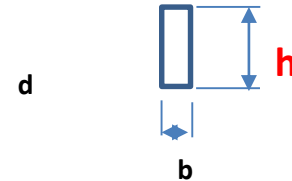
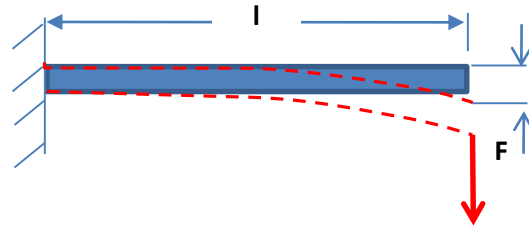
Materiales compuestos: Propiedades de Laminados

- Incremento de la rigidez por sandwich

$$d = \frac{F \cdot l^3}{3E \cdot I}$$

$$I = \frac{b \cdot h^3}{12}$$

$$d = \frac{F \cdot l^3}{E \cdot \frac{3}{12} \cdot b \cdot h^3}$$

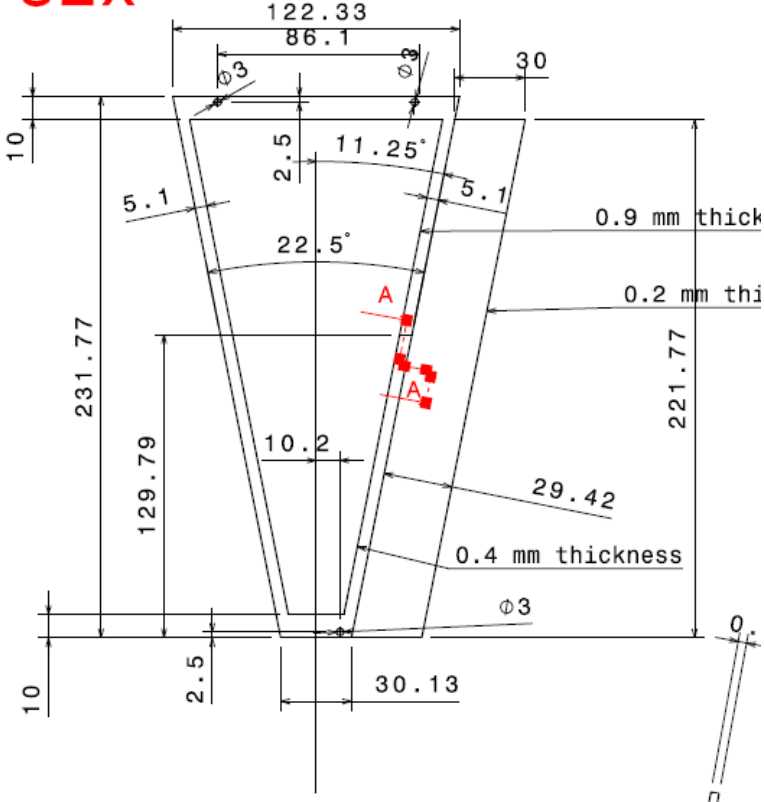


MOCK-UP OF FTD COMPOSITE DESIGN DETAILS

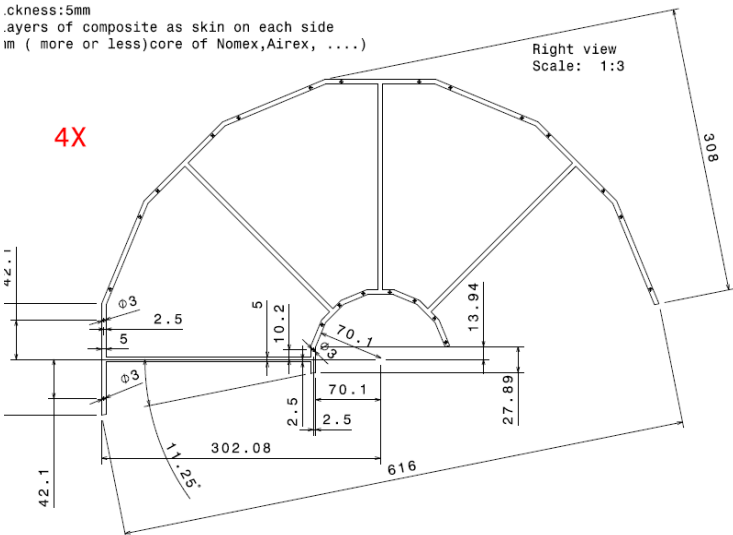


Petal design

32x



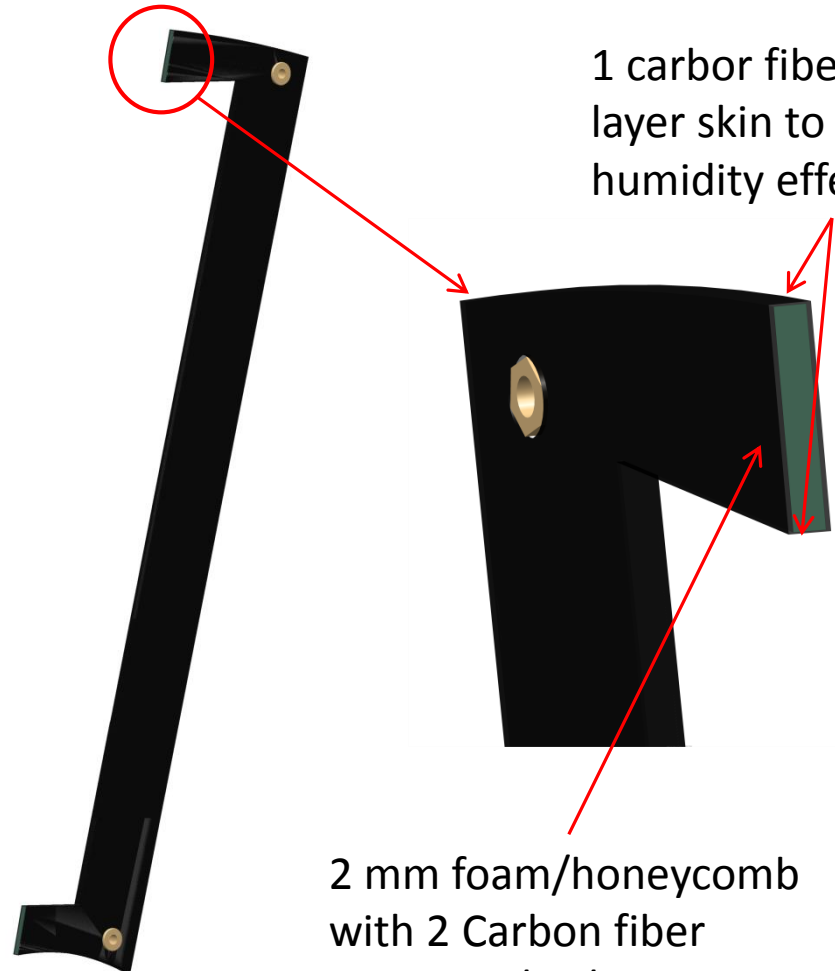
Support design



Petal with four support-positioning inserts



Petal cut



1 carbon fiber prepreg layer skin to avoid humidity effect, tbd

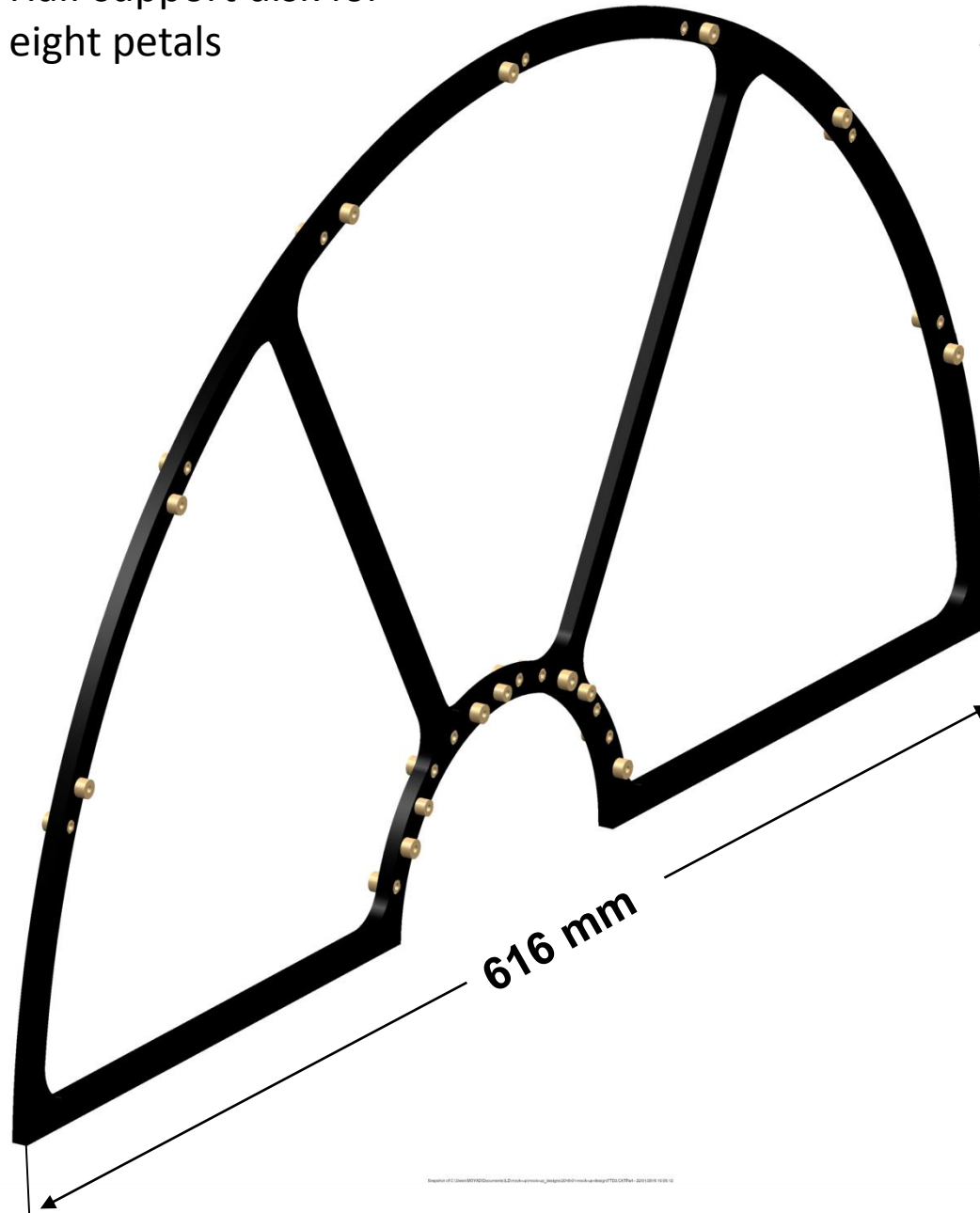
2 mm foam/honeycomb with 2 Carbon fiber skins of 0/60/-60

- **CTE ~ 0**
- **High stiffness due to sandwich construction**
- **Will be cut from plane sandwich panels**



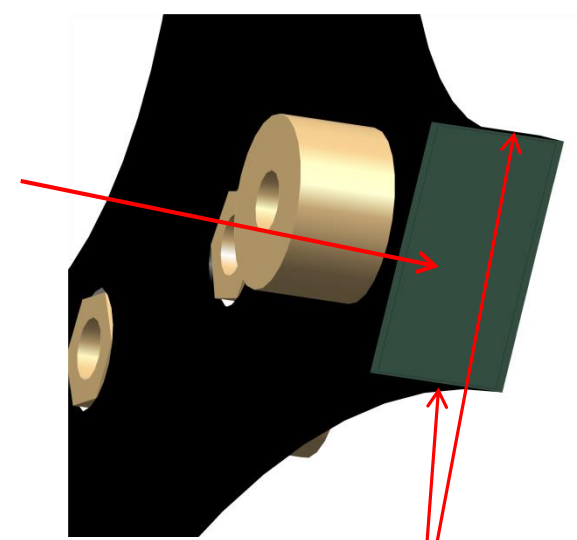
Half support disk for
eight petals

5 mm thickness
foam/honeycomb with
2 Carbon fiber skins of
0/60/-60

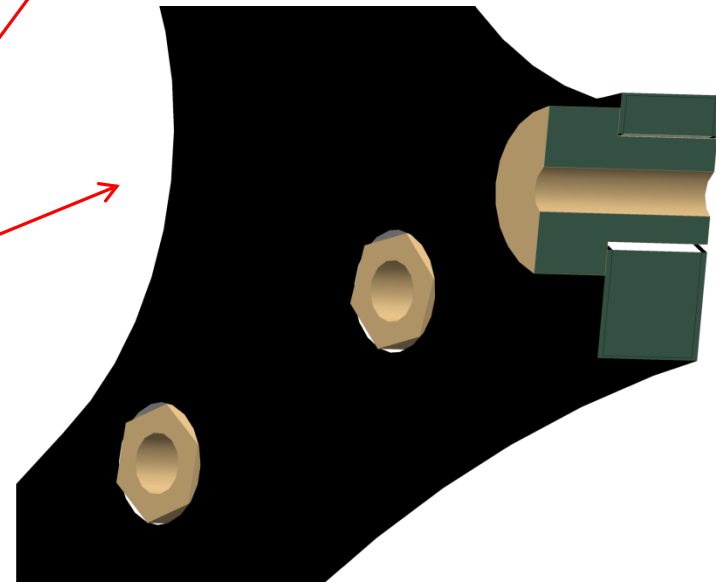


Disk transversal cut

5 mm thickness
foam/honeycomb with
2 Carbon fiber skins of
0/60/-60

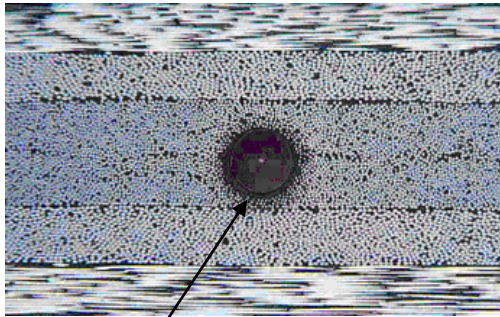


1 carbon fiber prepreg layer skin
to avoid humidity effect



INTA EXPERIENCE IN STRAIN
AND TEMPERATURE
MONITORING WITH
INTEGRATED FIBER OPTIC
SENSORS

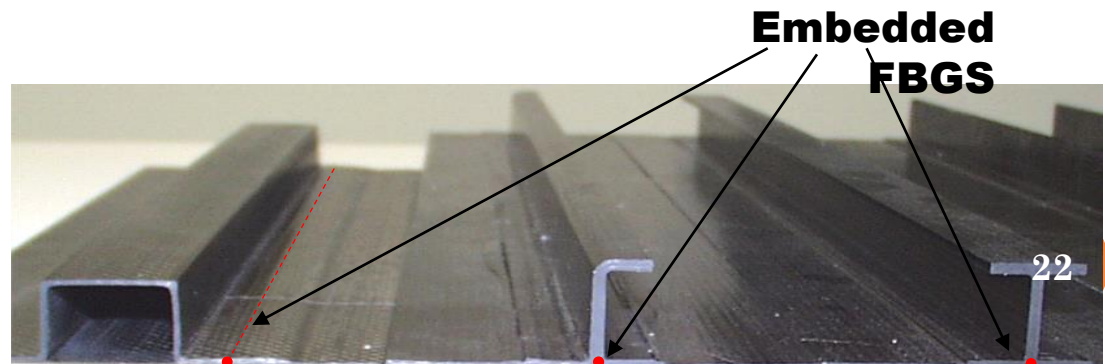
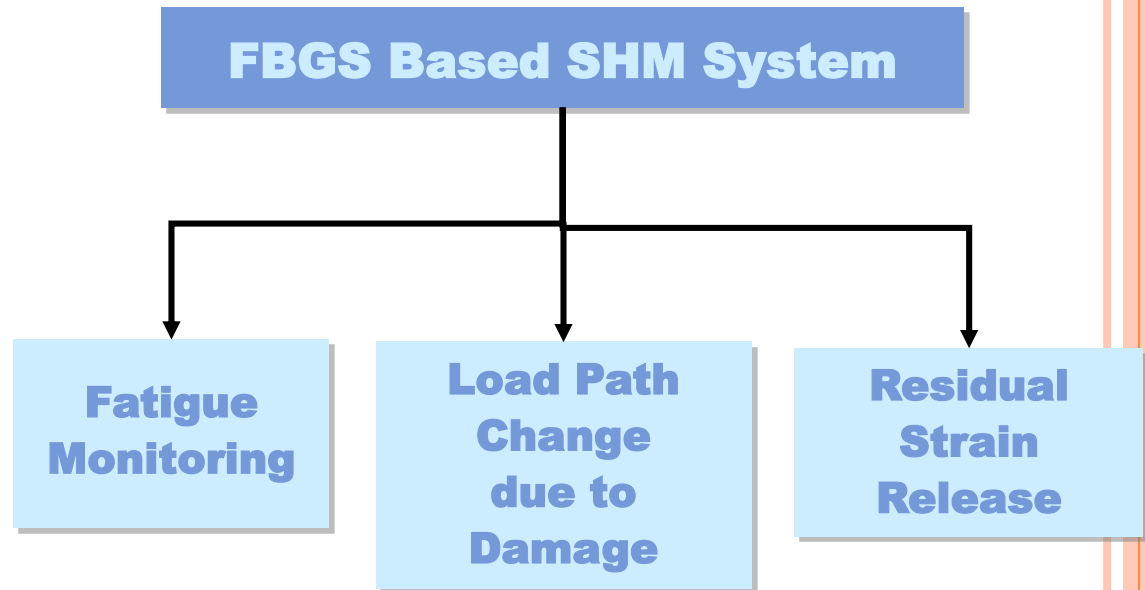




Fibra óptica

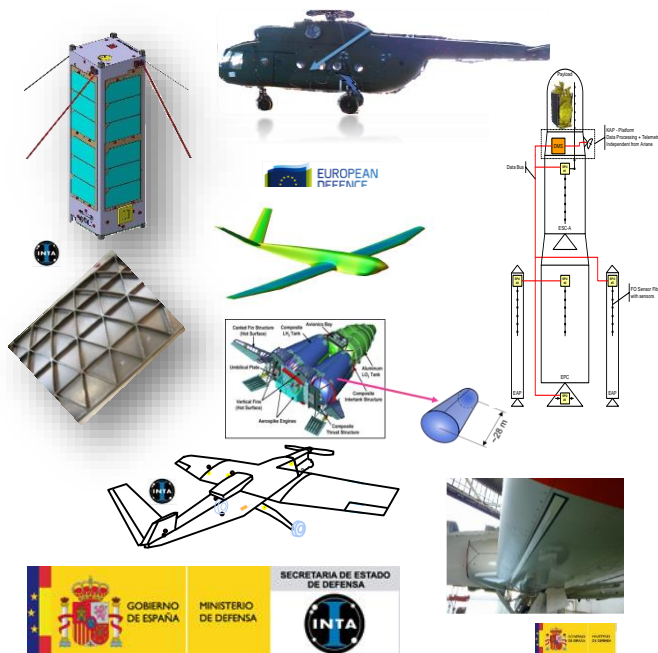


FBGS Based SHM System



Líneas de I+D en SHM de Sistemas y Estructuras Aeroespaciales utilizando Sensores de fibra óptica (FBGS, LPG, distribuidos)

Monitorización de cargas en vuelo y fatiga

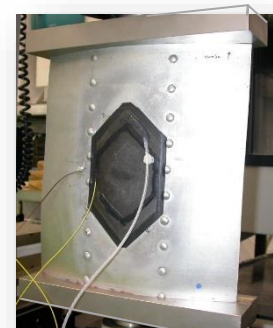


Detección de daño debido al cambio de carga



EADS CASA ESPACIO

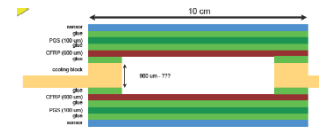
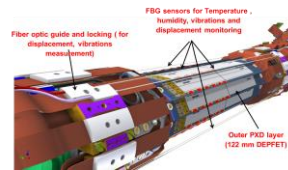
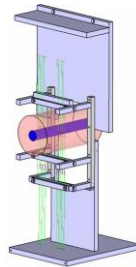
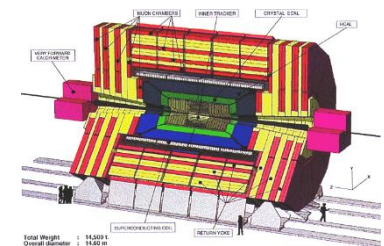
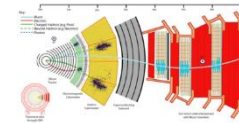
Relajación de deformaciones residuales



EUROPEAN DEFENCE AGENCY

Área de Materiales Compuestos

Monitorización de estructuras en ambientes de alta radiación



CMS tracker, PGD cooled composite bridge

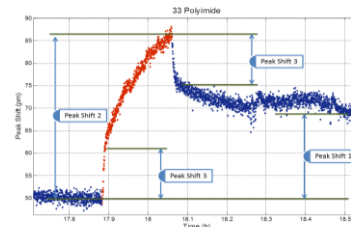


Selección y caracterización de sensores

- Ensayos en ciclotrón bajo radiación de protones
- **15,5 MeV. 10 Mrad dose**
- Evaluar sensores aptos para el CERN y KEK

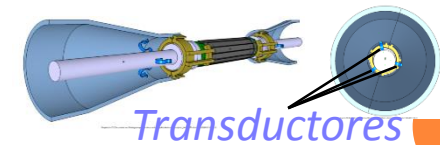
Instrumentación

- Integración estructural de sensores
- Medición del comportamiento durante la radiación



Aplicaciones

- Monitorización del posicionamiento
- CMS en el LHC/ CERN
- BELLE II en el KEK

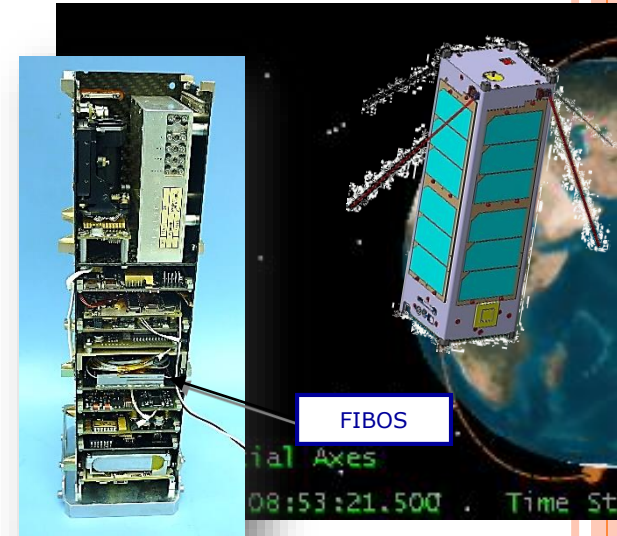
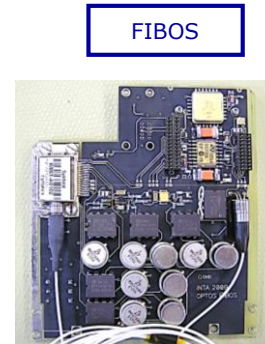


THANK YOU FOR YOUR
ATTENTION



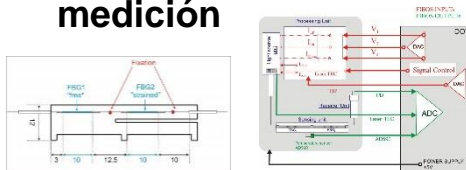
Verificación de sensores de fibra óptica tipo Bragg en el espacio

Proyecto OPTOS-FIBOS



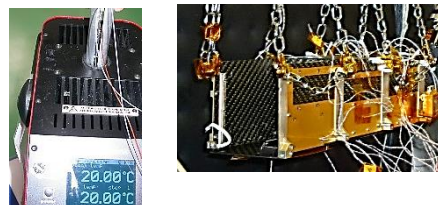
Selección y caracterización del sistema

- Caracterización transductor
- Diseño de sistema de medición



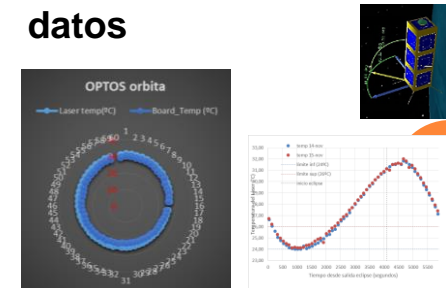
Instrumentación

- Instrumentación FIBOS
- Calibración T en ambiente
- Calibración T en vacío



Ensayos en orbita

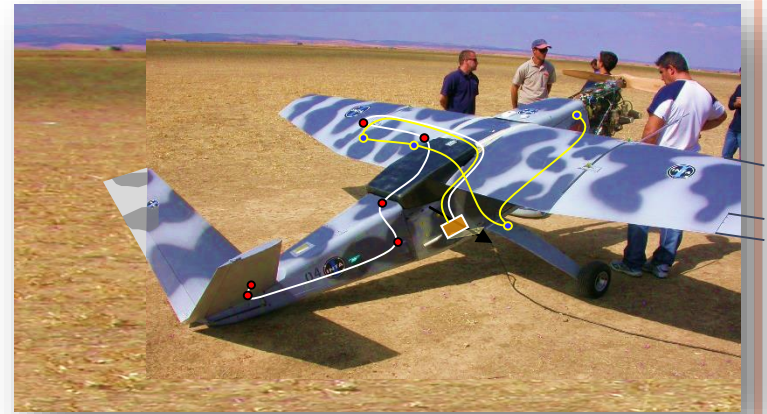
- Optimización del software
- Definición de puntos de medida en orbita
- Evaluación de los datos



SHM en el UAV SIVA

Ensayos en vuelo para

- Certificación
- Optimización del diseño
- Detección de daño

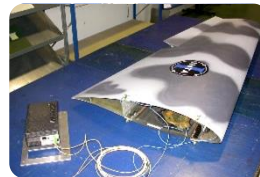


Selección y caracterización del sistema

- Caracterización sensors: -55°C y 80°C
- Ensayos de adhesión
- Desarrollo equipo
- Desarrollo de la técnica de SHM

Instrumentación

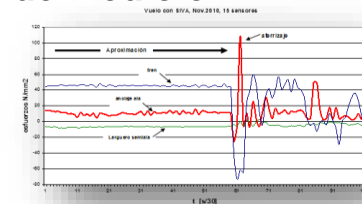
- Integración de sensores
- Sensor harness
- Interrogador embarcable



Primeros ensayos en UAVs de medición de cargas en vuelo en Europa

Ensayos en vuelo

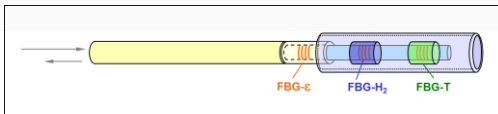
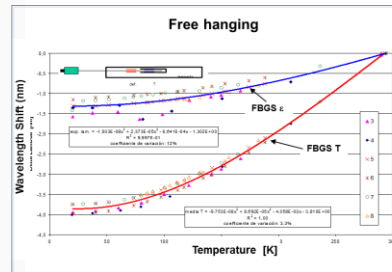
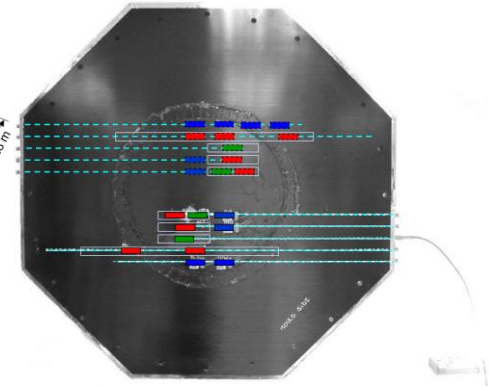
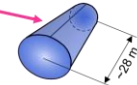
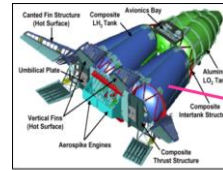
- Medición de deformaciones en puntos críticos
- Verificación de diseño
- Validación del sistema de medición



Resultados presentados en revistas y congresos

Monitorización de tanques de LH₂ de futuras lanzadores reutilizables

Proyecto CryoFos / ESA

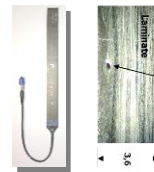
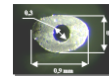


Desarrollo del sistema

- Recubrimientos de Pd
- Sputtering
- Devanado
- Sensor de T criogénico
- Técnica de medición

Integración

- Estructural
- Ensayos criogénicos a nivel probetas



Demostrador Ensayos en LH₂

- Ensayos sensor suelto e embebido en CFRP

