Development and Optimisation of THz NDT on Aeronautics Composite Multi-layered Structures

Concept and main ideas

The primary idea of the DOTNAC project is to develop a safe, contact-free, high resolution, and potentially on-site NDT tool based on terahertz (THz) waves. This tool will be easy to integrate in industrial facilities, and allowing the detection of surface, subsurface and in-depth defects in a variety of composite materials used in aeronautics.

Objectives addressed

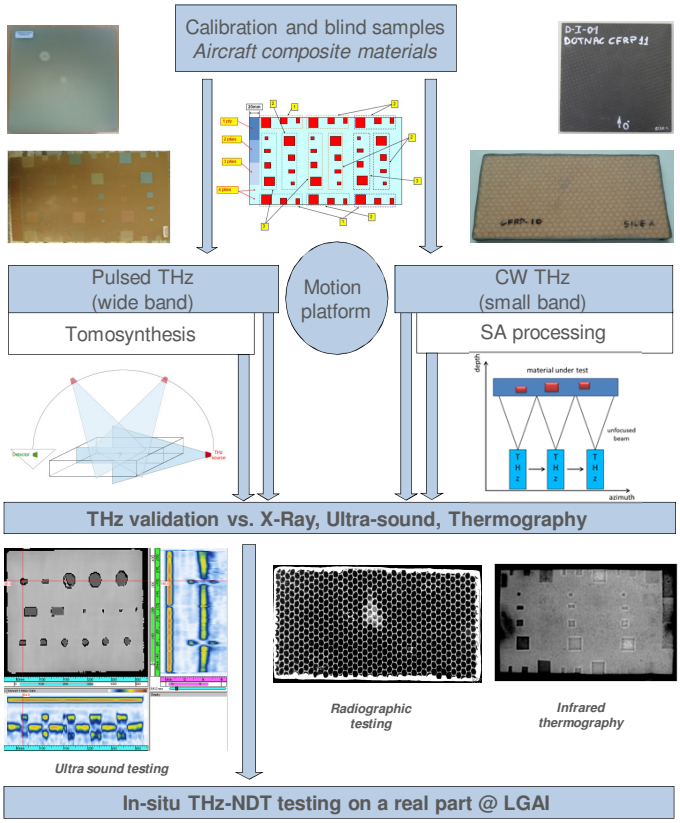
1. To create an integrated (hardware-software) and optimised THz imaging system using:
   - pulsed signals and optical fibre coupling.
   - continuous wave signals and electrical cable coupling.
2. To demonstrate, in an industrial setting, the effectiveness of a THz NDT tool.
3. To assess the performances of the two developed THz NDT tools for inspecting aeronautic composite parts.
4. To develop a user and research community for fast, high-resolution, non-invasive and non-contact inspection system for assessing aeronautic composite parts during production.

Consortium

BE	Royal Military Academy (RMA) - Leader	Signal Processing
BE	Verhaert New Products & Services	System Integration
BE	Innov Support	Dissem./Exploit.
DE	Technische Universität Kaiserslautern (UNIKL)	THz Sensor
DE	Fraunhofer Gesellschaft e.V. (Fh-IPM)	THz Sensor
FR	CNRS	Signal Processing
ES	Centro de Tecnologías Aeronáuticas (CTA)	NDT Expert
ES	Applus+ LGAI Technological Centre S.A.	NDT Expert
ES	CIMNE	Data Handling
IL	Israel Aerospace Industries (IAI)	End User

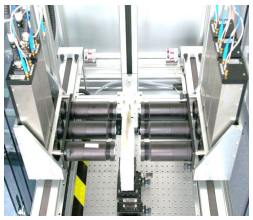
The Consortium is European, trans-national and constituted with a set of different organisations that together bring their technical know-how and research developer's complementary capabilities into the Consortium: SME's, research centres, universities and aeronautical end-users.

Methodology



Creation of a THz NDT tool

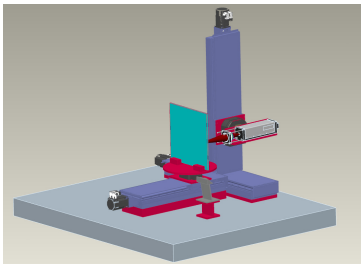
FMCW THz system



Frequency range: 100 GHz, 150 GHz, 300 GHz
Focal length of optics: 50 and 200 mm

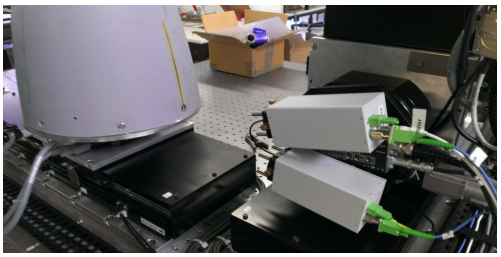
The FMCW system is an all-electronic continuous wave THz system. It consists of three scanning heads with different frequency ranges. They are used to acquire data by scanning a sample placed in front of them in reflection or in transmission mode. The range or in-depth resolution depends on the used bandwidth and the roughness of the sample surface, and varies between 0.4 mm and 3 mm (with an accuracy between 10 µm and 50 µm). The across-range resolution is Rayleigh-limited and is determined by the beam focus. Depending on the used optics, this resolution varies between 2 mm and 6 mm.

3-D motion platform



A 5-axis (3 linear and 2 rotational) synchronised motion stage accepting flat, 1-D curved and radome-like test objects. The system is characterised by a 50 µm repeatability and a 0.2° angular precision and allows 2.5 dimensional scanning.
The integration of one of the FMCW THz sensors or the pulsed THz sensor is possible in a fully modular way.

Pulsed fibre-coupled THz system



The pulsed laser system is implemented as a fibre-optical ECOPS (Electronically Controlled Optical Sampling) pump-probe set-up which contains:
- Two short-pulse lasers based on Er-doped silica glass fibres, with piezo-controlled repetition rate stabilisation;
- Synchronisation electronics to lock the pulse trains and deliberately de-tune the repetition frequency of one laser with respect to the fixed one of the other laser;
- Polarisation-maintaining fibre delivery of roughly 5 m length to the remote THz emitter/detector modules.

DOTNAC Partners

Applus+ · IAI Engineering Division, Israel Aerospace Industries Ltd · Verhaert · Innov Support · Technische Universität Kaiserslautern · Fraunhofer IPM · CTA Centro de Tecnologías Aeronáuticas Aeronautical Technologies Centre · Université Bordeaux 1 Sciences Technologies · CIMNE

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