

# **Development of a Nondestructive Methodology based on Near Infrared Imaging for the Characterization of Damage in Transparent and Semi-Transparent Aircraft Components**

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## **ABSTRACT**

This work aims to develop a nondestructive technique based on Near Infrared (NIR) imaging for the evaluation of transparent and semi-transparent composite materials, such as Glass Fiber Reinforced Polymers (GFRP) and laminated glass aircraft components. The NIR technique offers enhanced optical imaging of damage which cannot be detected with conventional optical inspection. The NIR imaging can be performed in reflection or transmission mode (i.e. radiation reflected from or transmitted through an object under inspection). While the NIR transmission mode is better for detecting deeper defects, it has a serious limitation for field application in real aircraft parts, since it requires simultaneous access (e.g. illumination source, cabling, etc.) of both sides of the structure. For these reasons, an innovative NIR approach, the NIR Double-Transmission Mode (NIR-DTM), has been developed. The new approach is based on the advantages of both aforementioned techniques while eliminating their deficiencies. In order to optimize the use of NIR imaging for field applications, different parameters that affect the operation of the technique were considered. These parameters include the surface geometry, the distance from the material under investigation, the inspection angle, as well as the type and intensity of excitation source. Finally, image processing and analysis tools were used to improve the inspection sensitivity and further decrease the inspection time.

**Keywords:** Near infrared (NIR) imaging, transparent materials, aircraft structures, Glass Fiber Reinforced Polymers (GFRP)

## **INTRODUCTION**

The NIR imaging is based on the recording of non-thermal radiation which is similar to the radiation in the visible (light) spectrum, and not on thermal emissions from the material's surface such as in the case of IR thermography [1,2].

The appropriate choice of an active illumination source, which is continuous and uniform, is essential for the operation of a NIR inspection system. For example, the halogen lamps are well-suited for NIR inspection since they irradiate in a wide band from the UV to the very long wave infrared spectrum (from 0.01 to 1000 $\mu\text{m}$ ). However, the fluorescent lamps are not suited for NIR inspection since they have a narrow band spectrum that is mainly limited by the visible light band. In addition, LEDs, due to their narrow spectrum at precise wavelengths, can be good illumination sources for a variety of