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CIDAR: COMBUSTION SPECIES IMAGING DIAGNOSTICS FOR AERO-ENGINE RESEARCH

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Very high bypass ratio (VHBR) engines will realize significant environmental benefits as lower fuel consumption contributes to a reduction in CO_2, NOx and non-volatile particulate matter (nvPM)/soot emission. VHBR engine performance tests will require representative CO_2 measurement, and here we propose the use of a chemical species tomography (CST) measurement system to fully map the output CO_2 from the engine core exhaust. In addition, we propose a technique allowing the 2D measurement of exhaust nvPM concentration that will provide an increased understanding of the complex injector-to-injector fuel flow variation, which impacts the temperature distribution through the turbine. This combined technological development in the CIDAR programme will produce an innovative step change in aircraft engine diagnostics, based on real-time, in-situ photonic technologies. This will increase the EU's competitiveness in non-intrusive engine exhaust measurement systems for both engine performance evaluation and emissions quantification.

To achieve these goals, and ensure technological progress in the delivery of robust engine performance prediction and lean burn combustion operation on future VHBR engines, CIDAR will bring to TRL6 the proposed optical imaging systems for the measurement of aero-engine exhaust species. Furthermore, we will assess the systems' limitations in terms of species quantification, and incorporate self-diagnostics and control tools, allowing integration within large-scale engine test cell facilities.

Concept of nvPM/soot imaging measurement system: A high-fluence collimated pulsed laser beam is propagated through the exhaust flow. Soot along this path is heated close to its sublimation temperature and incandesces in the visible and SWIR regions, as in standard LII. The laser, scanner and camera systems will be positioned within the test cell but entirely outside of the flow. Other than the cameras, the system components will be located approximately 3.6 m above engine centre-line, on a service gantry (Figure 1). The scanning system will offer sufficient scan angle to cater for flow diameters up to 1.6 m.

Concept of CO_2 imaging measurement system: The gas concentration and plume temperature measurements are obtained using a calibration-free Tunable Diode Laser Wavelength Modulation technique that is independent of the optical power incident on the detector. A 7m diameter, 10 m tall 12 sided frame has been developed that provides mounting for 126 opto-mechanical launch (Tx) and receive (Rx) units (Figure 1). The 126 Tx and Rx are located on 12 mounting plates, defining six optical projections each containing 21 equally-spaced beams. The 126 channels each provide a measurement of path-integrated CO_2 concentration across the exhaust, allowing tomographic imaging of its distribution. These CO_2 distributions can then be used in obtaining Soot Emission Indices.

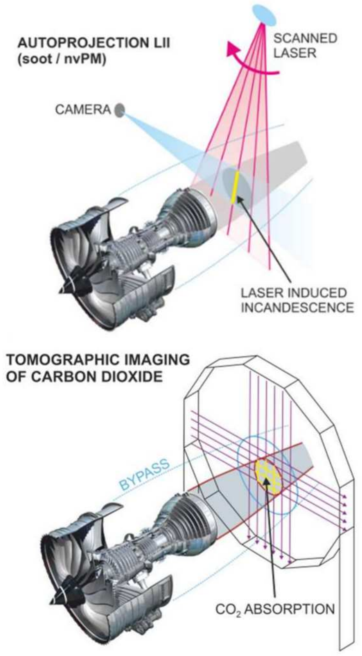

Figure 1: Schematic diagram of soot / nvPM (top) and CO_2 (bottom) non-intrusive measurement techniques.

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