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JISFA5#1 - Some experimental developments on supersonic jet noise reduction by water injection

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In order to protect the payload and the rocket structure from severe vibrations, water injection is widely used on launch pads to reduce the high noise level radiated by booster exhausts at lift-off. If this technique appears to be effective, it remains that the physics of the phenomena associated with the noise reduction of hot supersonic turbulent jets is poorly known, making the optimization of the technique and the development of predictive models particularly difficult.
Experiments on the MARTEL test facility are then carried out on jets up to Mach 3 and 2100 K in an environment acoustically representative of the launcher lift-off. These researches undertaken in a long-standing cooperation with the CNES aim to understand the noise reduction mechanisms and design the ground infrastructure of the French space centre in Kourou.
Two main phenomena lead to jet the noise attenuation. The first is associated with the decrease of the mean jet velocity by momentum and heat transfer between the liquid and the gaseous phases. The second concerns the modification of the mixing layer turbulence and subsequently of the shock cells structure.
In addition, several related phenomena have to be considered to fully address the issue: aerodynamic and acoustic interactions between the jet and the ground structure, with possible feedback loops; water diffusion, fragmentation and vaporization into the mixing layer; parasitic noise due to the impact between the gaseous flow and the water droplets; acoustic waves propagation in the two-phase media. The coupling between these different mechanisms remains partially understood and numerical models are currently not faithfully predictive.
This lecture will present a review of experimental developments in progress on the MARTEL test bench. Current experiments focus on: i) aero-acoustic scaling laws with water injection depending on jet morphology, temperature, Mach number and nozzle diameter; ii) a two-phase optical metrology development based on a simultaneous measurement of phosphorescence and fluorescence particles; and iii) some jet interaction tests with simplified launch pad structure (flat plate or plate with a hole).

Presenter(s) : PATRICK BERTERRETCHE (Institut PPRIME, UPR CNRS 3346 / ISAE-ENSMA / University of Poitiers); GILDAS LALIZEL (Institut PPRIME, UPR CNRS 3346 / ISAE-ENSMA / University of Poitiers); ROMAIN BOUJU (Institut PPRIME, UPR CNRS 3346 / ISAE-ENSMA / University of Poitiers); PIERRE BELTRA (Institut PPRIME, UPR CNRS 3346 / ISAE-ENSMA / University of Poitiers); FLORIAN MOREAU (Institut PPRIME, UPR CNRS 3346 / ISAE-ENSMA / University of Poitiers); EVA DORIGNAC (Institut PPRIME, UPR CNRS 3346 / ISAE-ENSMA / University of Poitiers); HADRIEN LAMBARE (Centre National d'Etudes Spatiales); YVES GERVAIS (Institut PPRIME, UPR CNRS 3346 / ISAE-ENSMA / University of Poitiers)

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