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A Case Study Report on Acoustic Impact Assessment and Mitigation of the Hyprob Research Plant

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Abstract : The activities, described in the present paper, have been conducted in the framework of the HYPROB-New Program, carried out by the Italian Aerospace Research Centre (CIRA) promoted and funded by the Italian Ministry of University and Research (MIUR) in order to improve the National background on rocket engine systems for space applications. The Program has the strategic objective to improve National system and technology capabilities in the field of liquid rocket engines (LRE) for future Space Propulsion Systems applications, with specific regard to LOX/LCH4 technology. The main purpose of the HYPROB program is to design and build a Propulsion Test Facility (HIMP) allowing test activities on Liquid Thrusters. The development of skills in liquid rocket propulsion can only pass through extensive test campaign. Following its mission, CIRA has planned the development of new testing facilities and infrastructures for space propulsion characterized by adequate sizes and instrumentation. The IMP test cell is devoted to testing articles representative of small combustion chambers, fed with oxygen and methane, both in liquid and gaseous phase. This article describes the activities that have been carried out for the evaluation of the acoustic impact, and its consequent mitigation. The impact of the simulated acoustic disturbance has been evaluated, first, using an approximated method based on experimental data by Baumann and Coney, included in “Noise and Vibration Control Engineering” edited by Vér and Beranek. This methodology, used to evaluate the free-field radiation of jet in ideal acoustical medium, analyzes in details the jet noise and assumes sources acting at the same time. It considers as principal radiation sources the jet mixing noise, caused by the turbulent mixing of jet gas and the ambient medium. Empirical models, allowing a direct calculation of the Sound Pressure Level, are commonly used for rocket noise simulation. The model named after K. Eldred is probably one of the most exploited in this area. In this paper, an improvement of the Eldred Standard model has been used for a detailed investigation of the acoustical impact of the Hyprob facility. This new formulation contains an explicit expression for the acoustic pressure of each equivalent noise source, in terms of amplitude and phase, allowing the investigation of the sources correlation effects and their propagation through wave equations. In order to enhance the evaluation of the facility acoustic impact, including an assessment of the mitigation strategies to be set in place, a more advanced simulation campaign has been conducted using both an in-house code for noise propagation and scattering, and a commercial code for industrial noise environmental impact, CadnaA. The noise prediction obtained with the revised Eldred-based model has then been used for formulating an empirical/BEM (Boundary Element Method) hybrid approach allowing the evaluation of the barrier mitigation effect, at the design. This approach has been compared with the analogous empirical/ray-acoustics approach, implemented within CadnaA using a customized definition of sources and directivity factor. The resulting impact evaluation study is reported here, along with the design-level barrier optimization for noise mitigation.

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