Project title: Development of a Robust Active Noise Control System for Locomotive Cabs

Objective on the basis of need:

With rapid urbanization, noise levels have been increasing around us, either in the form of locomotive noise, construction noise, traffic noise, industrial noise, community noise, or domestic noise, which can seriously impact our health. The World Health Organization (WHO) has identified hearing loss as a major challenge, particularly affecting the younger population. Prolonged exposure to loud sounds, especially in recreational settings, contributes to hearing loss exacerbated by environmental noise. Noise levels in locomotive cabs vary depending on the type of operation. Diesel locomotive cabs experience worse noise environments compared to electric locomotives, primarily due to the diesel engine's noise, which fluctuates with load and speed. In electric locomotives, the main noise source is the electric traction motor drive system. Continuous exposure to these noises affects locomotive pilots' concentration and decision-making. Over extended periods, this exposure can lead to fatigue and noise-induced hearing loss. There is a need to develop a robust active noise control system that enhances locomotive pilots' concentration and decision-making while reducing fatigue and noise-induced hearing loss.

Executive summary of the proposed project (in 250 words):

Continuous exposure to loud noise seriously impacts our psychological and physiological health. Noise levels in locomotive cabs vary depending on the type of operation. Diesel locomotive cabs experience worse noise environments than electric locomotives, primarily due to the diesel engine's noise, which fluctuates with load and speed. In electric locomotives, the primary noise source is the electric traction motor drive system. Continuous exposure to these noises affects locomotive pilots' concentration and decision-making. Over extended periods, this exposure can lead to fatigue and noise-induced hearing loss. The passive noise control (PNC) technique, which uses sound-absorbing or isolating materials to control locomotive noise, is ineffective at controlling low-frequency locomotive noise. To address this limitation, Active Noise Control (ANC) has emerged as a leading solution for noise reduction. In ANC systems, a signal processor generates anti-noise signals that cancel out the unwanted noise. The effectiveness of noise reduction in ANC systems depends on the noise type and the noise cancellation algorithm. The filtered-x least-mean square (Fx-LMS) algorithm and its variants are the most widely used for ANC due to its simplicity and low computational complexity. The performance of these LMS-based algorithms degrades when dealing with non-Gaussian or impulsive noises. The

proposed investigation involves developing a robust ANC system for locomotive noise. To further enhance the performance of the ANC system, robust model-driven and data-driven ANC algorithms will be developed. The final algorithm will then be implemented on a Digital Signal Processor (DSP).

Technology readiness Level (If not a new project but an advancement of existing knowhow): TRL 5

Outcomes or Deliverables:

This project finding will play a significant role in the locomotive cabin, improving the loco pilots' psychological and physiological health. The outcome of this project will be patented to protect Intellectual property in India and the globe. The findings will be presented at the leading international conferences and in peer-reviewed journals to disseminate knowledge. The findings will also initiate the building of new startups in the railway industry. The primary deliverables of the project include 1) Preliminary study of locomotive noise and its effects on locomotive pilots; 2) Development of a robust ANC algorithm for locomotive noise; 3) Incorporation of a model-driven approach in the robust ANC system; 4) Development of a data-driven ANC algorithm; 5) Hardware implementation of the proposed robust ANC algorithm.

Project aligned with which most relevant UN SDGs: Good Health and Well-Being

Duration (in years): Three Years

Exected Impact:

The outcome of this project will improve psychological and physiological health. The proposed robust active noise control system minimizes noise inside the locomotive cabin, improving locomotive pilots' concentration and decision-making, which helps reduce railway incidents and save lives.

Implementation model (self-implemented/outsourced partnership): Self-implemented

Total Budget (Recurring + Non-Recurring Expenses): 28 Lakhs