This project delves into applied research on the fundamental mechanisms of high-intensity impulsive sound propagation, concentrating specifically on small and large calibre firearms. Present models used for noise impact studies are essentially based on linear propagation, and the large discrepancies in the prediction of sound levels linked to military sources are attributed to nonlinear propagation behaviour. The methodology rests upon the development of an in-house numerical solver based on the Nonlinear Progressive Wave Equation (NPE) and leverages on the unique opportunity to access military shooting ranges and to collect on-field acoustic measurements during live fire exercises with various weapon systems and calibres. The outcome is a toolkit to be used by Belgian Defence to make assessments of the impact of military noise emissions with respect to international and regional regulations and optimize the mitigation the measures, by shielding and/or by adapting the existing procedures. Through the use of different time and frequency domain metrics, it was shown that, although the approach based on rule of thumbs and semi-empirical corrections proposed by commercial off-the-shelf software and standards may be sufficient in certain conditions, it most certainly leads to miscalculations when compared to real measurements. When nonlinearity is accounted for in the numerical model, the nonlinear prediction of the high-frequency spectrum can outperform the linear solution by more than 30 dB, when large calibres are involved.

The effects of acoustic nonlinearity are shown to persist at least up to a distance of 300 m from the source, demonstrating that, if an accurate and physically consistent noise exposure prediction is sought, modelling firearm noise propagation in all its complexity is the recommended approach. Ultimately, the study contributes to the existing body of knowledge on environmental acoustics by shedding light on the mechanism of acoustic nonlinearity and by offering new insights into firearm noise propagation.