# Spacecraft Conjunction Assessment optimization using Deep Learning algorithms applied to Conjunction Data Messages (CDMs)[☆]

José Javier Rosales Ruiz[*], Nicola Garzaniti[**]

**Abstract**

The lack of global regulations on space debris management during the early days of the space era until the last few decades of the $20^{th}$ century resulted in a consistent increase of space debris. Spacecraft collisions in orbit and the industry's growing interest in launching *megaconstellations* of satellites are now exacerbating the problem.

To address those concerns, multiple space organizations worldwide have implemented Space Situational Awareness (SSA) programmes with integrated Conjunction Assessment systems that allows the detection of conjunctions with an *estimated* risk of collision. While this approach has proved to be effective in the last two decades, the foreseen increment of Artificial Space Objects (ASOs) in orbit in the next decade will put any existing Spacecraft Collision Avoidance system under severe stress if the technology does not evolve accordingly to cover the new demands.

This research project focuses on the optimization of the Conjunction Assessment systems with the achievement of two primary objectives; the development of a highly scalable Deep Learning model for Time Series Forecasting (TSF) which is efficient enough to absorb the new data processing workload in a timely manner while improving the accuracy of the existing solutions, and the definition of future design requirements for Space Surveillance Tracking systems to improve the accuracy of observations.

To achieve both milestones, two state-of-the-art *Recurrent Neural Networks* models are used and evaluated in the research project in search of the most optimal solution for their capabilities to selectively weight important information from the past: *Long Short-Term Memory Networks* (LSTMs) and *Transformers*.

This solution is complemented by the development of a Synthetic Conjunction Data Message Generation (SCDMG) tool with the aim to feed the TSF model with additional virtual data (look-back windows) to address the scarcity of real data open to the public which leads to a poor forecasting performance from the model. A general overview on its limitations and use cases are also part of the scope of the research.

*Keywords:* Spacecraft Conjunction Assessment, Conjunction Data Messages, Deep Learning, Recurrent Neural Networks

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[*]Author

[**]Co-author

*Email addresses:* j.rosales-ruiz@cranfield.ac.uk (José Javier Rosales Ruiz ), nicola.garzaniti@cranfield.ac.uk (Nicola Garzaniti)