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MODELLING COLLISION RISK IN SPACE TRAFFIC: A NETWORK-BASED PERSPECTIVE

Abstract

Currently, the majority of objects orbiting the Earth is represented by defunct satellites and space debris. As in recent years the number of new satellites launched into space has increased, so has the frequency of conjunctions between objects and the number of fragmentation events due to explosions of abandoned spacecraft or launcher stages. Such a situation threatens the safety of space operations and clearly shows a lack of attention to the sustainability of space-based services.

In this work, we present a novel approach to study the state of the space resident population from a complex system perspective by using networks. Each object taken from a reference database is represented by a node in a network. Links are established between two nodes whenever a conjunction between the corresponding objects is possible, and a weight is assigned to them, such as probability of collision. The topology of the resulting network is then analysed to obtain a global picture of the system state of the orbital environment.

We develop further this approach and use the topology of the network as a support to define a risk index for each object as a function of parameters such as the number of conjunctions, the values of collision probability, the type of objects involved, the possibility of indirect collisions (that is, with fragments of a debris cloud), etc. With this strategy, we can classify objects and identify those contributing the most to the overall collision risk.

The evolution of the risk index is then studied, both from a temporal perspective and in response to major fragmentation events (such as the Cosmos-Iridium collision in 2009 or more recent satellite explosions). The variation of the index in the near future is used to make predictions on the state of space traffic, on the impact of debris removal and new launches, and to define guidelines to increase safety and promote a sustainable exploitation of space as a resource.