# Uncontrolled reentries of manmade space objects: how to get reliable products to manage and mitigate the potential risk in the airspace and on the ground

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**Résumé**

In spite of decades of efforts, predicting the reentry time and location of an uncontrolled satellite remains a very problematic activity, being reentry predictions affected by various sources of unavoidable uncertainties. The experience accumulated worldwide suggests that a relative prediction error of ±20% should be adopted to compute the uncertainty windows associated with nominal reentry epoch predictions, in order to reasonably cover all possible error sources. However, in specific cases, more conservative prediction errors, up to ±30%, should be considered, in particular during the last 2-3 days of residual lifetime. Therefore, even predictions issued a few hours before reentry may be affected by a quite huge along-track uncertainty, often corresponding to more than one full orbital path. In consequence of this, the typical reentry prediction standard products, such as the nominal decay forecasts with the associated reentry uncertainty windows and corresponding sub-satellite ground tracks, are of no, or very limited, use for civil protection applications. In other words, the locations possibly at risk in a given area of the planet cannot be identified reasonably ahead of reentry using such kind of knowledge. For this reason, specific approaches and procedures have been devised and applied in Italy, since the orbital decay of the BeppoSAX spacecraft in 2003, to provide reasonable and unambiguous information useful for civil protection planning and applications.

After an introduction dealing with the reentry statistics, the reentry risk evaluation and the reentry prediction uncertainties, the main objectives and outcomes of a reentry prediction process will be pointed out. Then, the typical reentry prediction standard products will be discussed and analyzed, in order to prove their weakness and inadequacy whether applied to manage and mitigate the potential risk in the airspace and on the ground due to falling debris over specific locations of the planet. Finally, the strategy devised in Italy for civil protection applications will be described and applied to recent reentry prediction campaigns of noteworthy satellites: UARS, ROSAT, Phobos-Grunt, GOCE and Progress-M 27 M.

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